European Journal of Health and Biology Education
2024, 11(1), 29-41
ISSN 2165-8722 (Online)
https://www.ejhbe.com/
Research Article

Students' perceptions of learning environment and attitudinal changes in concept mapping-based biology classrooms

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Citation: Bizimana, E, & Sibomana, A. (2024). Students' perceptions of learning environment and attitudinal changes in concept mapping-based biology classrooms. *European Journal of Health and Biology Education, 11*(1), 29-41.

ARTICLE INFO

Received: 15 May 2024

Accepted: 12 Jun. 2024

ABSTRACT

Students' favorable perception of the classroom learning environment (CLE) coupled with a positive attitude towards biology are important and significant predictors of their learning outcomes in the subject. However, the attitudes of students towards biology have been worldwide reported to be subpar, a tendency that has been caused by ineffective instructional strategies adopted by teachers. The purpose of this research was to determine if biology students who received instruction through concept mapping (CM) held more positive views of CLE and had better attitudes toward biology compared to students who were taught using conventional teaching methods (CTM). To achieve this, a sample of 305 senior two secondary students (152 males and 153 females) purposively selected from six coeducational secondary schools in nine intact biology classes from Nyamagabe District, Rwanda was used. Biology attitude questionnaire (BAQ) and what is happening in this class? (WIHIC) were used in the study to gather data. Data were analyzed through descriptive statistics, a multivariate analysis of variance, Pearson correlation, and multiple regression analyses. The results indicated that for every WIHIC and BAQ scale, there were statistically significant ($p<0.05$) difference in the scores of students in CM and CTM classes. Based on the results provided, it's evident that all WIHIC measures did not display any significant disparity in students' perceptions of CLE, while BAQ scales showed a difference favoring female students in CM classes in terms of interest and enjoyment. Students' attitudes toward biology and CLE were found to be positively correlated. Teacher support and cooperation scales were statistically significant independent predictors of students' attitudes toward biology. Based on the results, it was determined that using CM rather than CTM when teaching and studying biology improves students' attitudes toward biology and their perceptions of CLE. Therefore, the study recommends among other things, the teachers' adoption of CM in biology teaching and learning process.

Keywords: attitude towards biology, concept mapping, conventional teaching method, learning environment, secondary school

INTRODUCTION

The contribution of science to the country's overall growth is widely accepted. Ogunleye and Babajide (2011) asserted that a country without a scientifically educated population cannot be expected to make rational socio-economic and political decisions. This illustrates that high-quality science education is critical to the country's social and economic development. The importance of science is anchored to biology as one of the core science subjects for science development. Biology is the study of living things and how they interact among themselves and with the environment (Ahmed & Lawal, 2020; Joda, 2019; Oluwatoyin & Gabriel, 2018).

Despite the importance of biology, the learning outcomes that were expected have yet to be realized. Students across most of sub-Saharan Africa have difficulties in learning biology topics and consequently are still plagued with poor results in the subject (Bichi et al., 2019; Bizimana et al., 2022; Joda, 2019). This scenario is the same in Rwanda as the failure rate in the subject is much higher than it is in chemistry and physics, especially in lower secondary schools (Ntawiha, 2016). This implies that if these trends in students' performance are not reversed, a future science and technology research-driven economy in developing countries would not be feasible. This implies there is a deficit in secondary school science teaching that needs to be investigated and remedied for the goal of science education to be achieved.

Previous studies' findings have revealed that students' positive learning outcomes are significantly influenced by active learning (Jeong et al., 2019; Kioupi et al., 2022). This is because the engagement it provides contributes to increased achievement (Alqasa & Afaneh, 2022), and happiness (Betti et al., 2022; Ng et al., 2020). Besides, it helps students enjoy the subject being taught (Plasman, 2018). Therefore, the provision of an active classroom learning environment (CLE) is crucial. This will engage students in the topic lesson, excite their attention, simplify the material, and make it more understandable and retainable as well as sustain learning outcomes (Kioupi et al., 2022). This is also a requirement based on biological principles and concepts as many of which are experimental and require active students to understand them (Klein et al., 2019; Odutuyi, 2015; Yagci & Guneyli, 2018).

Moreover, students' prior knowledge should be considered and expanded upon. This is because a student's ability to learn and perform as well as the teaching and learning process, all are heavily influenced by prior knowledge (Otukile-Mongwaketse, 2018; Udo & Ubana, 2016; van Riesen et al., 2019). Teachers serve as facilitators in active learning, primarily intending to assist students in constructing their knowledge based on their prior experiences. The implementation of active learning is important because learning science concepts is not just about memorizing information, concepts, principles, or theories, rather, it is about meaningful learning by having learners experience it first-hand (Ndihokubwayo et al; 2020; Tural, 2015).

This notion of learning by knowledge construction, where the learner is an active figure is commonly known as a constructivist-based pedagogy (Langley et al., 2018; Oluwatoyin & Gabriel, 2018). In constructivist CLE, knowledge cannot be simply transferred from one person to another, nor be constructed passively. Instead, the learner constructs knowledge by integrating his own experiences and knowledge, and in which knowledge is formed as a result of 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, which is an important component of the learner-centered teaching paradigm (Elliott et al., 2017).

In response to the above concern, educationists such as Jean Piaget, John Dewey, and Lev Vygotsky in the 19th century demanded that learners should be responsible for determining what to do in the classroom (Vygotsky, 1978). They, therefore, call for the adoption of a learner-centered pedagogy approach, wherein learners take more ownership of the learning process. Studies have revealed that such pedagogy enhances meaningful learning (Betti et al., 2022; Jeong et al., 2019), and develops positive attitudes toward diverse school subjects (Aldridge et al., 2013; Bizimana et al., 2022a; Oser & Fraser, 2015).

Referring to the constructivist learning theory, researchers have come up with various innovative learner-centered teaching strategies. Such strategies include a collaborative instructional approach, concept mapping (CM), cooperative mastery learning, and problem-based learning (Awofala, 2016; Bii & Chris, 2019; Nnorom & Uchegbu, 2017; Qarareh, 2017; Sakiyo & Waziri, 2016) among others. CM instructional strategy was the focus of this study.

CM was created by Novak and his colleagues as a teaching and learning method in the early 1970s. It is an instructional tool for organizing and displaying knowledge (Novak, 2011). According to Chiou et al. (2017), CM is used to show how concepts link to one another as they move from general to specific ones. Concept maps are types of graphical organizers that use keywords to describe concepts diagrammatically, helping students understand the relationships between concepts (Filgona et al., 2016).

Various research in different years and educational systems were conducted to test the effectiveness of CM (Ajayi & Angura, 2017; Machado & Carvalho, 2020; Woldeamanuel et al., 2020). They commonly concluded that CM yielded better conceptual understanding, and produced meaningful learning, which led to better students' academic outcomes. However, the improvement of students' perceptions of CLE when taught using CM, and the change in their attitudes, has received less attention.

According to Fraser (2012), CLE consists of the collective viewpoints of the learners and, on occasion, the teacher. In addition to social and cultural variables, the term learning environment is frequently used to describe the psychological or emotional climate of the classroom (Fraser, 2012). The research highlights two aspects of CLE such as physical and human. Classroom materials like furniture and electricity are considered part and parcel of the physical environment. The social and psychological characteristics of the place, where students learn from themselves, and their teachers in the same place, and the interactions, are all a part of the human environment aspect (Aluri & Fraser, 2019; Cohn & Fraser, 2016; Peer & Fraser, 2015). The current study focused on the human aspect of CLE.

Previous studies (Fraser, 2019; Hafizoglu &Yerdelen, 2019; Malik & Rizvi, 2018) have shown that CLE has a substantial role in determining the learning outcomes both cognitive and affective (Rogers & Fraser, 2022). Besides, a more pleasant CLE helps learners learn better (Malik & Rizvi, 2018). Therefore, students may value CLE in which they are supported to learn, thus, the creation of a proper learning environment is crucial.

For many decades, researchers in education have investigated how to create an effective CLE that engages and motivates students to learn. Consequently, different research carried out concluded that the way students perceive CLE varies greatly depending on factors such as student gender, instructional strategy, and subject matter (Chipangura & Aldridge, 2017). This study was set to assess whether the use of CM in the biology classroom would enhance learning environment.

Many researchers have focused their attention on the effect of how students generally weigh science and particularly biology on learning outcomes (Almasri et al., 2021; Plasman, 2018; Sushma, 2020; Vlckova et al., 2019). All of them discovered that students with positive attitudes like studying the subject, comprehend its significance, and have confidence in it, which may result in high success. However, little is known about how an instructional strategy such as CM boosts the perception of students on CLE and how this perception predicts significantly their attitudes toward the school subjects.

Attitude refers to a person's propensity to believe certain things, whether positive or negative, and to think, feel, or favor those things (Hacieminoglu, 2016 Mazana et al., 2018; Oghenevwede, 2019). In a similar vein, attitudes are mental, emotional, and behavioral dispositions toward a specific behavioral goal (Jain, 2014). Attitudes are also a person's likes or dislikes of a specific thing, person, or event (Karpudewan & Meng, 2017). According to the aforementioned authors, it combines sentiments, beliefs, and personal values that science is considered like that. Furthermore, researchers consider people's way of looking at things as an outcome of learning (Omeiza, 2019; Vlckova et al., 2019). As a result, either directly or indirectly, the learning environment has an impact on the student's attitudes. Therefore, the teaching strategy used by teachers, and the students' relationship with them and their peers, may influence changing either positively or negatively students' attitudes towards school subject learning.

According to the aforementioned premises, it is clear that the instruction methods have a significant impact on the learning environment, which in turn enhances attitudes. This is because students' positive attitudes toward a subject matter have mostly been associated with their favorable perception of the learning environment (Ferdinand & Lukas, 2020;). Again, a good learning environment influences positively cognitive outcomes among students (Aluri & Fraser, 2019. Therefore, this study assessed the effect of CM on the way students perceive CM of CLE and their feelings about biology.

Moreover, long-standing current studies have indicated that gender disparities persist in the field of science education (Jia et al., 2020; Stevenson et al., 2021). Besides, students' attitudes toward learning science, biology included are significantly influenced by their gender (Bizimana et al., 2022c; Manishimwe et al., 2023; Nnenna &Adukwu, 2018). Moreover, Uchegbue and Amalu (2020) found that gender differences still exist in terms of students' performance and that these differences are mostly caused by instructional methods. Therefore, biology teachers need to be aware of these variations in how learners study biology and react accordingly.

Furthermore, researchers have noted gender disparities in how learners perceive CLE. For instance, Fraser (2012) found that male and female students perceive their CLE differently. Peer and Fraser (2015) looked into sex variations in students' perceptions of CLE. According to this study, in general, male students had to some extent more positive perceptions of CLE than the female ones. In the other different context, Fraser et al. (2010) conducted a cross-national investigation on Indonesian and Australian secondary science teaching environments. The researchers found that CLE was perceived differently by male and female students.

In other studies by Cohn and Fraser (2016) and Rogers and Fraser (2022), it was found similar findings in which females hold a higher perception of CLE than their male peers. Although, in these studies, female students displayed more positive attitudes, whereas, in other studies, males did, all of them concluded that the observed sex disparities are caused by the instructional strategies used by teachers. Hence, it looks as if the effect of gender on students' attitudes, plus their CLE perceptions is still inconclusive. Therefore, there is a need for further research to expand and clarify to enrich this controversial situation.

While there has been extensive research on gender issues, there has been insufficient investigation of whether CM has varying impacts on male and female students in terms of their attitudes towards biology and learning environments. Because it addressed this gap in the literature, our study is unique. In order to address this, this study examined how students perceived CLE and their views toward biology in relation to CM and conventional teaching methods (CTM). The research also examined the impact of gender on students' perceptions of CLE and their attitudes toward biology, as well as the correlation between the learning environment and students' attitudes toward biology. This would serve as guidance for policymakers and biology teachers looking to improve biology instruction. Moreover, the results of this research may help educators pinpoint the essential elements that foster a positive learning atmosphere in the classroom and better attitudes toward biology.

Research Objectives

1. To determine the effectiveness of CM in improving students' perceptions of CLE and their attitudes toward biology.
2. To investigate the difference in students' perceptions of CLE and attitudes towards biology between male and female students taught biology using CM.
3. To investigate the differential effectiveness of CM and CTM instructional strategies on male and female students' perceptions of CLE and their attitudes toward biology.
4. To examine the relationship between the students' perceptions of CLE and their attitudes towards biology.

MATERIALS & METHODS

Research Design

This research used a pre-test-post-test non-equivalent comparison group design, which is a quasi-experimental method (Creswell, 2014). Thus, given that the students were taught in their original intact classes, the design for the study was fit and appropriate. As a result, by using intact classes, it was possible to run experiments in an experimental group class, while the other classes were used as a control group. **Table 1** illustrates the design of this study.

Table 1. Research design layout

Groups	Pre-test	Treatment	Post-test
Experimental group	WIHIC & BAQ	X_1	WIHIC & BAQ
Control group	WIHIC & BAQ	X_2	WIHIC & BAQ

Note. X_1: Concept mapping & X_2: Conventional teaching methods

Research Participants

The focus of the study was Nyamagabe District, Rwanda. The choice was based on the fact that this district was ranked at the top among others with students who performed poorly in biology in the 2018 lower national examination (REB, 2018), and it is the third to have a large number of students enrolled in secondary among eight districts in the province (Ministry of Education, 2012). Six co-educational secondary schools out of 46 schools were purposively selected because they were boarding ones, public or government-aided, mixed schools, and having enrolled students in lower secondary school

Table 2. Sample distribution by study groups & gender

Gender	CM	CTM	Total
Male	74 (24.26%)	78 (25.57%)	152 (49.84%)
Female	77 (25.25%)	76 (24.92%)	153 (50.16%)
Total	151 (49.51%)	154 (50.49%)	305 (100%)

National Examination. After purposive selection of the schools to participate in the study, a simple random assignment of the selected schools (intact classes) to the study groups was conducted in which, four of them were assigned to the experimental (CM) groups and the five of them were assigned to the comparison group (CTM). The participants' age ranged from 12 to 15 (mean [M]=13.52, standard deviation [SD]=0.77). **Table 2** indicates the distribution of the sample among the study groups.

Data Collection Instruments & Validation

The measurement of the student learning environment before and after the intervention was done using Aldridge et al. (1999) validated form of the "what is happening in this class? (WIHIC)". Seven scales formed the initial WIHIC having eight items in each one. These include student cohesiveness (SC), teacher support (TS), involvement (IN), investigation (IS), task orientation (TO), cooperation (CO), and equity (EQ). WIHIC was selected since it has been the most widely utilized (Fraser, 2012). Besides, in many countries, it has been used in leave-alone cross-national investigations and different subjects such as mathematics and chemistry (Amponsah et al., 2018; Chipangura & Aldrige, 2017).

The validated WIHIC was modified to guarantee the scale appropriateness in the study. To begin with, it was determined whether WIHIC measures could be used to evaluate the efficacy of CM in secondary school classes. Thus, SC, TS, CO, IN, TO, and EQ were all measured on WIHIC's six-item subscales. The scale of "IS" was therefore excluded as it was not pertinent to the use of CM in biology classrooms. Moreover, to ascertain that WIHIC could work smoothly in Rwanda, the language and wording of each WIHIC scale were also examined. It is important to note that since its creation, numerous variants of WIHIC have been utilized through a variety of international investigations and greatly increased the academics in the field of education (Chipangura & Aldridge, 2017). There was a total of 48 Likert-type items that asked students to respond on a five-point scale (1=almost never, 2=rarely, 3=sometimes, 4=often, and 5=almost always) on which students rate how frequently the statement occurred.

Biology attitude questionnaire (BAQ) was another study instrument. Based on the scales developed by Prokop et al. (2007) and Zeidan (2010), BAQ scales were adapted after getting permission from those scholars to use and modify their scale items. BAQ scales were selected, as follows: Zeidan (2010): items 13-19 and Prokop et al. (2007): items 1-12 and items 20-30. BAQ intended to measure students' enjoyment of biology lessons (enjoyment), interest in biology (interest), career interest in biology (career), and the importance of biology (importance). As a result, thirty BAQ scales in total were distributed among the four axes, as follows: nine scales on interest, six scales on career, five scales on importance, and ten scales on enjoyment.

Although WIHIC and BAQ were validated in numerous nations with a variety of linguistic and educational systems: Aldridge et al. (1999) in Taiwan, Amponsah et al.(2018) in South Africa, Khine et al.(2020) in UAE, Alzubaidi et al. (2016) in Jordan, Zeidan (2010) in Palestine, WIHIC and BAQ were presented to experts in science education from the University of Rwanda, college of education for face and content validation. As a result, it was possible to determine whether the language was suitable and easily understood by student respondents. It also made it possible to clarify ambiguous things and verify that the items measured what they claimed to measure by rewording them and double-checking them.

WIHIC and BAQ were pilot-tested using a different coeducational school study with similar identities to the sampled schools in order to verify that the instruments could be used in relevant data collection, ensure that the instruments' items are valid and reliable, and determine whether the study subjects could understand the instructions on the instruments. This pilot study involved 50 students (23 females and 27 males). The alpha coefficient of Cronbach for the entire WIHIC was 0.96. It was found to be 0.77, 0.79, 0.78, 0.84, 0.79, and 0.72 for the six WIHIC sub-scales, respectively. Moreover, ,Cronbach's alpha for the entire BAQ was 0.92. It was 0.80, 0.76, 0.92, and 0.97 for BAQ scales, respectively. Thus, the instruments were satisfactory and had acceptable reliabilities (Creswell, 2014).

Data Collection Procedures

The study involved 305 senior two secondary students in six co-educational boarding secondary schools from which data were collected. Biology teachers in these schools gave a hand in this study serving as research assistants. As for the students, they were taught in their different groups (CM and CTM). The former in CM group were trained on the usage of CM strategy separately from those in CTM group within one week. WIHIC and BAQ questionnaires were given to both groups as a pre-test before any instructional activity. The teaching activities in each group lasted for four weeks after which the students in each group took WIHIC and BAQ as post-tests. The students in CM group were exposed to a week of training on CM instructional activities, whereby they learned concept map creation before teaching activities could begin. The teaching procedures were created using the standardized procedures of Novak and Gowin (1984). The intervention took four weeks in which students constructed concept maps based on the learned photosynthesis content. The teacher assistants helped students to answer their questions related to their concept maps. Besides, students were provided with computer-made concept maps created on each subtopic of photosynthesis as a reference for cross-checking. The teaching activities in CM classes lasted for four weeks for a total of 16 hours.

CTM students' group was introduced to the same unit serving as the experimental one. Teachers utilized their regular teaching practices, which normally included chalk and talk, note-taking sessions, and teacher demonstrations, presentations, and discussions. Besides, throughout the treatment period, the research assistants were supervised to ensure smooth learning and proper execution of teaching strategies/methods and procedures in all classes. In the week following the treatment, research assistants administered the two-hour WIHIC and BAQ as post-tests. To make a follow-up of the change with time, a pre-test was administered once. Moreover, the same applied to a post-test both in connection with WIHIC and BAQ.

Analysis of Data

The research used descriptive statistics, specifically M and SD, to examine possible variations in students' attitudes toward biology and their perceptions of CLE when taught using CM and CTM. A multivariate analysis of variance (MANOVA) was used to assess whether statistically significant differences existed between the students in CM and CTM groups. The independent variables were CM and CTM groups, while the dependent variables included the scales of SC, TS, IV, TO, CO, and EQ, as well as those related to career, importance, and enjoyment.

The effect sizes were computed using Thompson's (1998) recommendations in order to assess the degree to which the two study groups (CM and CTM) differed in attitudes and learning environment. The effect sizes were calculated by dividing the difference in the averages of the two groups by the combined standard deviation. As per Cohen (1988), effect sizes indicated by values between 0.10 and 0.29 are categorized as small, those falling within the range of 0.30-0.49 are classified as moderate, and values exceeding 0.50 are deemed large.

To investigate gender-based differences in CM group, MANOVA was computed on a sample of 77 female and 74 male students. The dependent variables in this study were the two sets of scales, specifically the six WIHIC and the four BAQ, whereas the independent variable was sex (male or female). F values and effect size were calculated for each comparison in order to determine potential differences between male and female students. In addition, the two-way MANOVA was employed to examine the efficacy of CM in terms of differences for students of both sexes. Furthermore, Eta2 statistics were used to determine the strength of association for each effect (CM, sex, and interaction) for each WIHIC and BAQ scale.

The preference of MANOVA test over the series of ANOVA tests was to reduce the type error I because MANOVA indicates the overall relationship between the set of dependent variables and independent variables. Apart from that, the use of MANOVA enables one to analyze several dependent variables simultaneously and multivariate tests are more powerful, especially when small differences in several of the variables combine to produce a significant result. This may also result in significant MANOVA results but non-significant analysis of variance (ANOVA) results (Stevens, 2002).

Furthermore, to determine the association between each learning environment and attitude scales, together with the joint influence of WIHIC scales, Pearson correlation and multiple regression analyses were also used (Subiyakto et al., 2020). Cohen's criteria were used to interpret the strength of the observed correlations, where $r=0.10-0.29$ was considered to be a small correlation, $r=0.30-0.49$ a moderate correlation, and $r\geqslant0.5$ a strong correlation (Cohen, 1988). The multiple regression (R) analysis was used to provide information about the association between BAQ scales and WIHIC scales. The standardized regression coefficients (β) were calculated and analysed in the identical activity to determine WIHIC scales that made a distinct and significant contribution to the variability in attitudes. Concerning the interpretation of the effect size, Cohen et al.(2018) indicate the following guidance: 0.0-0.1=weak effect, 0.1-0.3=modest effect, 0.3-0.5=moderate effect, and >0.5=strong effect. The use of multiple regression analysis followed the recommendation criteria of Pallant (2020). The version 21.0 of statistical package for the social sciences (SPSS) was used to conduct the data analysis. An alpha level of 0.05 was employed for all inferential statistical analyses to establish significance.

The normality of the study variables was checked with Kolmogorov-Smirnov test of the distribution. Data analysis indicated that Kolmogorov-Smirnov test results showed a normal distribution of the pre- and post-WIHIC and BAQ scale data with $p>0.05$. The results of the test showed that the data were normally distributed (Landau & Everitt, 2017). Consequently, all 305 research participants' data were used for further analysis.

RESULTS

Effectiveness of Concept Mapping on Learning Environment & Attitudes Toward Biology

The study first examined the effectiveness of CM in improving students' learning environment and attitudes toward biology. To achieve this, the mean and SD scores for pre- post-WIHIC and BAQ scales were computed and compared. A one-way MANOVA with repeated measures was used to examine differences between pre-and post-test scores on BAQ and WIHIC scales.

Because the multivariate test (Wilks' lambda) revealed significant pre- and post-test differences overall, the univariate ANOVA for each WIHIC and BAQ scale was recorded and interpreted (last column of **Table 3**).

According to the results in **Table 3**, students' mean scores increased after CM and CTM had been used in teaching and learning biology. However, the mean post-test scores of the students in CM group were higher than those in CTM group. The data presented in **Table 3** shows that there were statistically significant changes ($p<0.05$) in learning environment scores for all WIHIC scales and BAQ scales between the pre- and post-test. The effect sizes for all WIHIC scales range from 0.17 to 0.47, which indicates a moderate effect. For the four BAQ scales, the effect sizes range from 0.20 to 0.29, which indicates a small effect. The results suggest that integrating CM into teaching and learning created a more favourable learning atmosphere in biology classrooms and enhanced students' attitudes.

Gender Differences in Perceptions of Classroom Learning Environment & Attitudes toward Biology in Concept Mapping Group

The study examined how different genders perceived CLE and their attitudes toward biology among the sample of students who were taught using CM. To achieve this, data were analyzed using the student t-test (**Table 4**).

Table 3. Mean, standard deviation, & difference (effect size & MANOVA with repeated measures) between pre- & post-test scores on each WIHIC & BAQ

		Mean		Standard deviation		Difference	
Scale	**Group**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Effect size**	**F**
Learning environment scales							
SC	CM	2.05	4.09	0.96	0.79	0.341	155.48*
	CTM	1.46	3.48	0.80	0.64		
TS	CM	1.64	4.04	0.59	0.89	0.476	273.78*
	CTM	1.52	3.28	0.72	0.52		
IV	CM	1.32	4.43	0.46	0.79	0.174	63.61*
	CTM	1.22	3.65	0.45	0.91		
TO	CM	1.35	4.41	0.48	0.71	0.256	103.74*
	CTM	1.44	3.59	0.60	0.81		
CO	CM	1.35	4.15	0.48	0.83	0.373	178.83*
	CTM	1.32	3.27	0.54	0.84		
EQ	CM	1.47	4.10	0.76	0.79	0.240	95.13*
	CTM	1.37	3.54	0.57	0.89		
Attitude scales							
Interest	CM	2.82	3.45	0.84	0.82	0.298	127.72*
	CTM	2.76	2.88	0.85	0.71		
Career	CM	3.05	3.88	0.81	0.87	0.278	115.91*
	CTM	2.99	3.02	0.77	0.52		
Importance	CM	2.83	3.86	0.74	0.80	0.207	78.62*
	CTM	2.69	3.01	0.78	0.67		
Enjoyment	CM	2.98	3.77	0.69	0.91	0.249	100.01*
	CTM	2.86	2.92	0.62	0.66		

Table 4. Mean, standard deviation, & sex difference (one-way MANOVA & effect size results) for students in CM group for each WIHIC & BAQ scales

	Sex				Difference between males & females in CM classes	
Scale	**Male**		**Female**			
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	**F**	**Effect size**
WIHIC scales						
SC	4.35	0.71	4.51	0.66	2.268	0.015
TS	4.37	0.75	4.54	0.65	2.107	0.014
IV	4.40	0.75	4.44	0.75	0.85	0.001
TO	4.41	0.75	4.55	0.67	1.421	0.009
CO	4.45	0.62	4.42	0.71	0.080	0.001
EQ	4.43	0.77	4.49	0.70	0.258	0.002
BAQ scales						
Interest	2.86	1.26	3.40	1.32	6.525*	0.042
Career	3.29	1.28	3.46	1.25	0.677	0.005
Importance	2.86	1.30	3.18	1.34	2.155	0.014
Enjoyment	2.81	1.29	3.40	1.32	7.696*	0.049

Note. *$p<0.05$

In **Table 4**, the last column presents the absence of statistically significant differences between sexes ($p>0.05$) in how students perceived CLE. In terms of attitudes towards biology, there were notable differences between male and female students who were taught using CM method for enjoyment ($F[1, 149]=7.696$, $p<0.05$) and interest ($F[1, 149]=6.525$, $p<0.05$) scales. Females outperform males on the interest and enjoyment scales. For these scales, the effect sizes were very small.

Differential Effectiveness Concept Mapping for Different Sexes

The researchers used a two-way MANOVA with repeated measures to analyse the differences between males and females in their perceptions of CLE in CM in biology classes. Each scale was individually interpreted using univariate ANOVA as the multivariate test using Wilks' lambda criterion showed significant variations for main effects and the interaction (**Table 5**).

Table 5 displays the results, which indicate that on every WIHIC and BAQ scale, there were statistically significant differences between CM and CTM groups. According to Eta2 values, the variance scores accounted for by CM and CTM instructional strategies were between 0.174 and 0.476 for WIHIC, and 0.207 and 0.298 for BAQ scales.

In terms of whether there were disparities in CM and CTM exposure between male and female students, **Table 5** shows that there were no statistically significant differences between males and females for all WIHIC scales and BAQ scales. This implies that both males and females perceived equally these

Table 5. Two-way ANOVA results for CML & CTM groups & genders for each classroom learning environment & attitude scales

Scales	Group		Sex		Group×sex	
	F	Eta^2	F	Eta^2	F	Eta^2
WIHIC scales						
SC	155.480**	0.341	1.033	0.003	1.391	0.005
TS	273.780**	0.476	1.261	0.004	1.507	0.005
IV	63.610**	0.174	0.707	0.002	0.217	0.001
TO	103.740**	0.256	0.605	0.002	0.648	0.002
CO	178.830**	0.373	1.097	0.004	1.964	0.006
EQ	95.130**	0.240	0.642	0.002	0.023	0.000
BAQ scales						
Interest	127.720**	0.298	3.507	0.012	5.355*	0.017
Career	115.910**	0.278	0.890	0.003	0.119	0.000
Importance	78.620**	0.207	0.480	0.002	3.198	0.011
Enjoyment	100.010**	0.249	1.304	0.004	11.488*	0.037

Note. *p<0.05 & **p<0.01

Table 6. Correlation & multiple regression analyses for associations between students' attitudes & classroom learning environment scales

Scale	Interest		Career		Importance		Enjoyment	
	r	β	r	β	r	B	r	β
SC	0.281**	-0.097	0.241**	-0.110	0.202**	-0.104	0.292**	-0.007
TS	0.348**	0.375**	0.320**	0.462**	0.270**	0.391**	0.358**	0.440**
IV	0.211**	-0.011	0.128*	-0.083	0.103*	-0.084	0.169**	-0.034
TO	0.249**	-0.022	0.169**	-0.107	0.165**	-0.021	0.203**	-0.112
CO	0.305**	0.191**	0.252**	0.169**	0.201**	0.126*	0.272**	0.172**
EQ	0.216**	-0.026	0.176**	-0.012	0.129*	-0.048	0.168**	-0.099
Multiple regression (R)		0.385**		0.365**		0.303**		0.396**
R^2		0.148		0.133		0.92		0.157

Note. *p<0:05; **p<0.01; & n=151

scales. In the same way, there was no statistically significant interaction between instruction and sex for all WIHIC and BAQ measures.

The lack of interaction between gender and instructional strategies suggests that they did not have a combined effect on students' perceptions of WIHIC scales. Nonetheless, for two of the four BAQ scales–enjoyment (F[1, 301]=11.488, p<0.05) and interest (F[1, 301]=5.355, p<0.05)–a significant interaction between sex and instruction was discovered. The analysis of the significant interaction between instruction and sex (p<0.05) for interest and enjoyment is that females perceived more positive interest and enjoyment in CM class than in CTM class. However, males perceived less positive interest and enjoyment in CM class than in CTM class. This implies that CM was more effective for females than males for interest and enjoyment scales, while CTM was nearly equally effective for both sexes. According to the effect sizes, the variance accounted for was 0.017 and 0.037 for interest and enjoyment, respectively.

Students' Attitudes Association & Classroom Learning Environment

Using Pearson correlation coefficient (r) analysis, the relationship between each WIHIC and BAQ scale was ascertained. Also, multiple regression models were employed to analyse how BAQ scales, serving as dependent variables, are influenced by WIHIC scales, which act as independent variables. Furthermore, to identify WIHIC scales that significantly account for and explain the variance in students' attitudes toward biology, the standardized regression coefficients (β) were observed. Table 6 displays the findings.

In Table 6, it is evident that there was a statistically significant positive correlation between each of WIHIC and BAQ scales. Thus, CM classes showed more positive results in terms of interest, career, importance, and enjoyment scales. The Pearson correlation coefficient (r) ranged from 0.21 to 0.34 for interest, from 0.12 to 0.32 for career, from 0.10 to 0.27 for importance, and from 0.16 to 0.35 for enjoyment. As a result, the r-value association between WIHIC and BAQ scales yields mostly moderate effect sizes.

Multiple regression (R) shows a significant multiple correlation of 0.385 for interest, 0.365 for career, 0.303 for importance, and 0.396 for enjoyment for WIHIC scales (p<0.01). R2 values indicate that 14.8% of the variance in interest, 13.3% of the variance in career, 9.1% of the variance in importance, and 15.7% of the variance in the enjoyment of biology can be attributed to CLE.

On the assessment of the standardized coefficients of regression (β), TS and CO were statistically significant predictors of students' attitudes toward biology. The data indicates that students prefer biology classes when the teacher is supportive in the classroom. Additionally, classes with high levels of CO help students adopt and develop a favourable attitude toward biology.

DISCUSSION

The effect of CM on students' perceptions of CLE and attitudes toward biology among selected lower secondary school students in Rwanda was the purpose of this study. To achieve this, a modified WIHIC questionnaire and BAQ were administered before and after the intervention.

On the one hand, the results indicated that both the experimental (CM) and comparison (CTM) groups experienced an enhancement in their perceptions of CLE and attitudes. It was noted that students in CM classes consistently achieved higher mean scores on all four BAQ scales and all six WIHIC scales than did students in CTM group. Furthermore, on all six CLE scales, students in CM classes showed significant higher mean scores. Students in CTM classes scored lower than those in CM classes on all four attitude scales, with a significant difference between them. The findings corroborate numerous previous studies that assessed innovative teaching strategies in different institutions of education and contexts and discovered the constructive effects that these strategies have on the way students perceive CLE and attitudes toward different subjects (Amponsah et al., 2018; Bizimana et al., 2022c; Cai et al., 2021; Chipangura & Aldridge, 2017; Su Ling et al., 2020). Equivalently, the findings concur with those of Alqasa and Afaneh (2022), Betti et al. (2022), and Plasman, 2018) who recently found that students who learn in an active setting seem happier and enjoy the content being taught.

The students' positive perception of CLE and attitudes when taught using CM, can be tentatively attributed to the strategy's facilitation of student engagement in both teaching and learning activities. Likewise, scholars like Chipangura and Aldridge (2017) found that active learning enhanced the environment of learning as positive attitudes of students toward the school subject. On the contrary, students who are exposed to passive teaching approaches such as CTM may find CLE discouraging, competitive, and unsupportive, thus developing a negative attitude toward the subject (Srivani et al., 2022). The explanation is that when students are actively involved, CLE becomes more favorable to learning, and they can maximize their learning, leading to higher levels of satisfaction. Moreover, numerous studies indicated that students' attitudes toward school subjects were enhanced by active learning (Bizimana et al., 2022a; Chipangura & Aldridge, 2017; Jeong et al., 2019; Kustyarini, 2020; Leksuwankun et al., 2022; Manishimwe et al., 2023). The reason for this is that active learning effectively boosts students' pride and confidence in their learning process.

The findings also indicated differences that were not significant ($p>0.01$). This result is consistent with that of Bizimana et al. (2022c), Chipangura and Aldridge (2017), and Su Ling et al. (2020). However, the finding contradicts that of Peer and Fraser (2015). The scores for BAQ, interest, and enjoyment were statistically significant ($p<0.05$). That is to say, the females outscored the males. The findings confirm earlier studies (Deieso & Fraser, 2019; Rogers & Fraser, 2022), which discovered significant differences between males and females with females having higher scores. However, the findings contradict that of Peer and Fraser (2015) in which males reported more positive attitudes than their peers in science and Mathematics classes.

The results showed that there was an insignificant interaction for the six WIHIC scales when it came to the one between instructional strategy and sex ($p>0.01$). Similar findings were also found by Bizimana et al. (2022c), and Deieso and Fraser (2019). However, two of the four BAQ scales (interest and enjoyment) showed a statistically significant interaction. The findings imply that females had a more positive attitude in classrooms exposed to CM, but males expressed a more positive attitude when taught using CTM. The findings support those of Otor and Achor (2013) who found that when given CM instruction, female students exhibited better attitudes towards chemistry than male students. However, the finding contrasts that of Abdulkarim and Raburu (2013) who discovered that regardless of gender, CM improved students' attitudes towards biology.

The results of the Pearson correlation coefficient showed a substantial association between BAQ scales and WIHIC scales. This result is consistent with earlier studies (Afari et al., 2013; Taylor & Fraser, 2013; Yang, 2015). Moreover, the multiple regression analysis showed that the TS and CO scales were the only WIHIC scales that significantly contributed to the variance in the students' attitudes. Similar research findings were found by Fraser and Raaflaub (2013). On the other hand, Taylor and Fraser (2013) found that the SC and TO were the only WIHIC scales that were significant determinants of students' attitudes. According to these WIHIC scales (TS and CO), collaboration was more common in the classrooms of CM students, and their teachers assisted them in their learning. This may increase students' active participation in biology lessons. Previous studies have shown that active participation improves achievement (Bekkering & Ward, 2021; Mokiwa & Agbenyeku, 2019), which in turn enhances students' attitudes toward the subject (Manishimwe et al., 2023).

CONCLUSIONS & RECOMMENDATIONS

Based on the findings of this study, it was concluded that both CM and CTM improve significantly the students' perceptions of CLE. However, statistically significant variations in the perception of CLE and students' attitudes were seen, with those in CM showing more positive attitudes than those in CTM classes. The study also concluded that the difference in students' perception of CLE that was observed for all six WIHIC and only two of BAQ scales between males and females exposed to CM was statistically insignificant. Again, the study revealed a significant interaction effects of instruction and sex for two BAQ scales (interest and enjoyment), and the six scales of WIHIC correlated with BAQ scales in a positive and significant manner. Finally, the only relevant scales that were discovered to predict attitudes toward biology were the TS and CO scales. As a result, it is suggested that using active teaching approaches such as CM can be beneficial in creating a good classroom atmosphere and attitudes concerning biology. The relationship between instructional strategy exposure and both sexes in the learning atmosphere and attitude may help teachers. This may be for a better understanding of how to develop the learning atmosphere in the classroom and how each sex views it. This, in turn, helps teachers design intervention programs to address equity issues. Moreover, using CM enhances the way students perceive their learning environment and improves attitudes toward biology regardless of gender. Consequently, administrators in schools ought to assess the prerequisites to develop teachers professionally to better utilize CM in teaching and studying biology and other subjects.

The study has demonstrated learning environment and attitude towards biology may be enhanced through students' exposure to CM. This makes this study a significant and unique contribution to the field of biology education. Furthermore, this study holds significance in the areas of educational environment and biology instruction as it is the pioneering research to investigate the impact of CM exposure on students' learning environment in biology lessons. Moreover, the ways that sex and CM exposure interact with the learning environment and attitude towards biology can help understand how males and females perceive CLE. Therefore, schools can use this knowledge to guide intervention programs that address equity concerns in biology or other science education.

Notes on contributors: This article is a collaborative effort, and each co-author has played an integral role in all stages of the study, contributing their expertise and insights. All authors agree with the publication of the article.

Funding information: This article has been independently conducted, and no external funding has been sought or received for its completion.

Disclosure of interest: The authors declare that they have no competing interests associated with the research presented in this article. There are no financial or personal relationships that could potentially bias or influence the interpretation of the findings.

Ethics approval: The authors stated that an official letter was received from University of Rwanda-College of Education (UR-CE), Unity of Research and Innovation approved on 17 October 2022 (No 493/07/02/05). The letter was given to the study area district education officer and obtained a letter of permission from the district to get access to the school authorities, Biology teachers and students. Written informed consents were obtained from the study participants.

Availability of data: All data generated or analyzed during this study are available for sharing upon request. Interested parties are encouraged to direct their inquiries to the corresponding author, who will facilitate the provision of the data in a timely and appropriate manner.

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