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*Research Article*

# Students' Perceptions of the Classroom Learning Environment and Engagement in Cooperative Mastery Learning-Based Biology Classroom Instruction

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Literature confirms that students' engagement in biology is necessary predictor of their learning outcomes. However, how to do so is less certain. Therefore, this study investigated whether students taught biology using Cooperative Mastery Learning (CML) had different perceptions of learning environment and engagement when compared to those taught using Conventional Teaching Methods (CTM). A sample of 298 students (151 male and 147 female) in 7 intact biology classes was used. A modified What Is Happening In this Class (WIHIC) and Student Engagement Questionnaire (SEQ) were used to collect data. Data were mainly analyzed using the multivariate analysis of variance and simple correlation analysis. The findings indicated a statistically significant difference for all WIHIC and SEQ scales with students in CML scoring higher than students in CTM classes. Students' perceptions of WIHIC scales were statistically significantly associated with SEQ scales. The findings provide important information about how students' exposure to CML can help them be more engaged in biology classes. Hence, the CML is a practical instructional strategy with significant implications for teachers, biology syllabus designers, and curriculum planners.

## 1. Introduction

Students' engagement in biology is a necessary predictor for their learning outcomes. This is because low student engagement in academic activities can lead to school failure [1, 2]. However, how to do so is less certain. Therefore, this study investigated whether students taught biology using Cooperative Mastery Learning (CML) had different perceptions of learning environment and engagement compared to those taught using Conventional Teaching Methods (CTM).

There is a body of empirical researches to support the potential of using CML as an instructional strategy to complement Conventional Teaching Methods for enhancing students' learning outcomes [3–5]. According to previous research, CML has the potential to engage students in the learning process and encourage participation through a more interactive learning environment (Ghoreishi et al., [5, 6]). Also, as an instructional strategy, CML can motivate students [4], and the content learned through CML is more likely to be retained [7]. Besides, other researchers asserted that the CML has potential for teaching difficult and abstract science concepts, and both academic achievement and interpersonal relationships are likely to be enhanced through the use of the CML [4, 7]. Despite the great learning outcomes associated with CML in terms of increasing students' academic success, retention, and motivation, little is known regarding students' perception of the classroom learning environment and engagement in the CML-based instructional strategy.

### 1.1. Theoretical Background

*1.1.1. Cooperative Learning.* Cooperative learning (CL) is an instructional strategy in which students work together in a small heterogeneous group of four to six students to help one another understand academic content, develop learning skills, enjoy the learning process with their peers, and be monitored by the teacher as a facilitator on a regular basis [8]. It is a pedagogical practice that assists students in forming and maintaining academic and social relationships as well as achieving common objectives [9]. It helps students create and sustain academic and social bonds while also working toward common goals [10]. During CL, students are divided into four or five groups based on sex, academic aptitude, and other factors, to help one another grasp academic information, build learning skills, enjoy the learning process with their peers, and be monitored by the facilitator/teacher on a regular basis [10], guided by face-to-face engagement, positive interdependence, individual accountability, group processing, social skills, cooperative learning support social engagement, and inclusion [11]. The theoretical foundation of CL is that learners learn from each other's concepts that they might not learn straight from the educators. Therefore, effective learning takes place when the students are socially engaged in the teaching and learning process. During cooperative learning, learners seek assistance, complete their work, present their ideas, take their tasks seriously, and help the group run smoothly by looking after one another [11].

*1.1.2. Mastery Learning.* Mastery learning (ML) is a teaching approach in which students are given the opportunity to master one aspect of a lesson before moving on to another [12]. To do this, the subject matter is divided into distinct segments, each with its own set of goals. According to Blessing and Olufunke [13], before moving on to new unit materials, the teacher analyzes the students after each portion to determine which students demonstrate mastery (usually 80 percent) and which students require additional assistance. Enrichment assignments are given to students who demonstrate mastery of the content, whereas remedial tasks are offered to students who do not demonstrate mastery. This cycle of learning and testing continues until mastery is achieved.

*1.1.3. Cooperative Mastery Learning.* Cooperative Mastery Learning (CML) is an instructional strategy that combines both cooperative and mastery learning strategies in teaching [4, 5]. Therefore, as a combination of the teaching strategies, it motivates the students by appealing to both their cognitive and affective domains. The teachers who adopt CMLS divide subject lessons into small units with each one having its objectives, and then, students work through each unit together in organized groups.

Before moving on to new learning subject matter, the students must show mastery of the unit through assessment, typically with a score of 80% [14]. Those who fail to achieve subject matter mastery receive remediation through peer tutoring, monitoring in small groups discussion [4]. Students are placed into small diverse groups of similar ability for this reason. Each group is assigned to a master peer coach who will teach and reteach them until all members of the group have demonstrated mastery on the formative test. Due to its interactive nature, the CML is an effective teaching method as it involves having students work in teams or groups on the problem under conditions. Besides, it assures both positive interdependence and individual accountability. To this end, the success of one or a group of students helps others to succeed as well (Keter & Ronoth, [15]).

Social learning theory [16] and social constructivism theory [17] can both be used to explain the efficacy of CML. According to social learning theory, most human behaviour are learned through observational modeling, in which an individual constructs an idea of how a new behaviour is performed by watching others. With social constructivism, individuals construct their knowledge in a social environment by emphasizing the importance of interactions and incorporating the role of other actors and cultural development. Thus, knowledge is built through interactions and discussions then refined and collaboratively developed into a common idea with a shared meaning [18].

Concerning the student's learning environment, the social constructivism theory emphasizes the importance of active participation in learning. The teacher serves as a guide who encourages students to discover principles for themselves and build knowledge by working on real-world problems. This implies that students must assume some responsibility for their education. In other words, they must participate actively in the teaching and learning process. This theory has many ideas about the role of CML especially Vygotsky's conception of the Zone of Proximal Development (ZPD) which emphasizes the benefits of interaction with more competent peers.

*1.1.4. Classroom Learning Environment.* Several educators over the years have defined the term "classroom learning environment." For instance, Fraser [19] considered it as shared perception of the students and sometimes of the teachers in that environment. According to Walberg [20], the classroom learning environment refers to the climate or atmosphere of a class as a social group that may influence what students learn. In the words of Moos and Trickett [21], the classroom learning environment is a dynamical social system that includes not only teachers' behaviours and teacher-student interactions but also student-student interactions. A few years later, Fraser and Hebert [22] submitted that it refers to the overall climate, structures, processes, and ethos in classrooms, all of which are important factors affecting students' learning.

Other researchers on the concept of classroom learning environment [23, 24] defined it as a place where students and teachers interact with one another and use a variety of tools and resources to engage in learning activities. Accordingly, Husain, et al. [25] and Maat et al. [26] observed that classrooms are specific places in schools where educational outcomes, such as understanding and application of knowledge in our daily lives, are expected to be achieved, and these places have a significant impact on students in terms of achieving these noble goals.

From the above premises, it is clear that the field of classroom learning environments has grown, as evidenced by the large number of studies, reviews, and books published in this area. As a result, many questionnaires for this field of research have been developed. One of the recent among them is What Is Happening In this Class? (WIHIC) [27]. The WIHIC incorporates relevant dimensions from previous questionnaires and combines all with constructivism-specific dimensions and other relevant factors operating in today's classrooms [26]. These scales include students' cohesiveness, teacher support, involvement, cooperation, investigation, task orientation, and equity. For this study, only six scales were used (Amponsah et al.,[25, 28]).

*1.1.5. Students Engagement.* Student engagement is defined as the level of attention, curiosity, interest, optimism, and passion they show when they are being taught or learning on their own [29]. It is the students' active participation in learning activities, as well as their desire to do so [30–33]. The concept of engagement is three-dimensional. The behavioural, cognitive, and emotional (or affective) elements of engagement outlined by Fredricks et al.[34] are widely recognized by researchers in the literature [32, 33, 35].

Participation in academic, social, and extracurricular activities, as well as positive conduct in academic tasks, and persistence within the content are the components of the behavioural dimension [34, 36]. With the help of learning environments, strong behavioural engagement leads to active learning processes [37]. The cognitive dimension is defined by the importance of learning, autonomy, and personal aspirations [38]. While interest, excitement, or negative reactions to activities, teachers, and peers are all part of the emotional dimension [34]. Thus, when organizing a lesson, teachers should take into account active learning processes as well as numerous elements, such as learners' experience, motivation, and knowledge, as student involvement does not happen by accident [39].

*1.1.6. Gender Issues.* Gender disparities in science education have long been observed and continue to exist today [40, 41]. According to recent research studies, gender inequalities in student achievement and career choices still exist [42, 43]. Besides, research on gender perception of learning environment and engagement in school subjects has produced mixed findings [42, 44]. Given these inequalities, as well as differences in how students learn biology, teachers must be aware of them and respond appropriately. Moreover, many previous studies have attempted to investigate the relationship between the learning environment in the classroom and student engagement [29, 45]. However, little is known about this relationship when the CML is used as a teaching strategy in biology. Therefore, the present study investigated the differential effectiveness of CML and CTM for male and female students in terms of classroom learning environment and engagement.

*1.2. Related Research.* Numerous previous empirical studies have attempted to investigate the students' perception of the learning environment when innovative instructional strategies are used in the teaching and learning process, namely, the use of multimedia in the mathematics classroom [29], inquiry-based laboratory activities in physical science [46], and game-based mathematics classroom (Afari et al., [47]).

Likewise, empirical studies on the association between learning environment and students outcomes both affective and cognitive outcomes were conducted in different corners of the world and at different times. For instance, Velayutham and Aldridge [48] found that there is a positive association between learning environment and students' motivation. Moreover, Ogbuehi and Fraser's [49] study findings indicated a positive association between students' perception of the classroom learning environment and students' attitude towards mathematics. Furthermore, Telli et al. [50] found a positive association between the WIHIC scales and students' attitude towards biology. Moreover, Opolot-Okurut [51] found positive associations between students' perceptions of their mathematics classroom learning environment and motivation.

Given this range of studies, mentioned above, there are no studies examining the effectiveness of exposing students to CML on students' perception of classroom learning environment and engagement that have been conducted to date. Therefore, this study fills a gap in the literature and advances research in the field of learning environments concerned with the evaluation of educational innovations by examining whether exposure to CML is effective in terms of improved learning environment perceptions. Besides, there is a lack of evidence in the literature as to whether there are any associations between students' exposure to the CML learning environment and their engagement. The current research builds on previous work in the field of learning environments by looking into whether there are any links between students' perceptions of their exposure to the CML learning environment and their engagement in biology.

Regarding gender and students' perception of classroom learning environment, various studies using WIHIC have indicated that male and female students have different perceptions. For instance, the study of Kim et al. [52] revealed that males perceived their learning environment more favorably than females. Contrarily, Wahyudi and Treagust [53] found that female students held more positive perceptions of learning environments than their male counterparts. Moreover, the study by Telli et al. [50] indicated that females scored significantly higher than males on three out of seven WIHIC scales (task orientation, teacher support, and equity). Other related studies [54, 55] found similar results. However, no gender differences were detected in the study by Cai et al. [56], on students' perceptions of classroom learning environments, but females scored higher than boys on student cohesiveness, instructor support, task orientation, and cooperation. Similarly, Su Ling et al.[57] observed no significant differences in boys' and girls' general perceptions of the biology classroom learning environment, but male and female students differ most in their perceptions of the scale of equity and task orientation, with females having higher scores.

Despite all these researches on gender issues, there is a paucity of literature that examines whether male and female students' exposure to CML in biology classes is differentially effective. The impact of CML on students' perceptions of the classroom learning environment and engagement is poorly understood. As a result, this study is unique in that it filled a gap in the literature by investigating whether the use of CML in teaching and learning biology is equally effective for males and females.

*1.3. Purpose of the Study.* To date, there is a paucity of research examining whether the use of CML as instructional strategy in biology classes has improved student perceptions of their learning environment and whether these changes have had an impact on students' engagement in the subject. As a result, this study evaluated whether students' perceptions of the learning environment and engagement differed between those in classes that were taught biology using CML and those in classes that were taught using the CTM.

The following questions are addressed in this research:

(1) Are there any variations in perceptions of the classroom learning environment and engagement between students who were taught biology using CML and those who were taught using CTM?

(2) Is there a difference in students' perceptions of the classroom learning environment and engagement in biology between male and female students who were taught biology using the CML?

(3) Is there a difference in the effectiveness of CML and CTM exposure in biology classes for male and female students in terms of students' perceptions of the classroom learning environment and engagement in biology?

(4) To what extent does students' perception of the classroom learning environment predict their engagement in biology for students taught using the CML strategy?

## 2. Method and Materials

*2.1. Research Model.* This study employed a correlation survey design. This design, according to Creswell [58], can be used to quantify the degree of correlation between naturally occurring variables without attempting to change them. As a result, the study employed correlation and regression analysis. The survey gives information on current events or the state of two or more variables (Mugenda& Mugenda, [59]). In the current study, a survey was conducted to describe how students evaluate their biology classroom learning environment and engagement using questionnaires.

*2.2. Participants.* The research was carried out in boarding secondary schools in Nyamagabe district, Rwanda. Purposive sampling technique was used to choose two out of seven boarding coeducational secondary schools based on the following criteria: (i) boarding schools, (ii) public or government-aided, (iii), mixed school, and (iv) senior secondary two students (SS2 students). The two schools with a total of 298 SS2 students were assigned to one of the two groups. One being taught using the CML, and the other was taught using the CTM using a simple random sampling technique. The study included all seven intact classes of SS2 students from each of the chosen schools. The CML group included 144 students (73 males and 71 females), while the CTM group had 154 students (78 males and 76 females). The study's sample distribution are shown in Table 1.

Table 1: Study sample distribution.

| | Number of students | | |
|---|---|---|---|
| Sex | CML group | CTM group | Total |
| Male | 73 (24%) | 78 (26%) | 151 (51%) |
| Female | 71 (24%) | 76 (26%) | 147 (49%) |
| Total | 144 (48%) | 154 (52%) | 298 (100%) |

*2.3. Data Collection Tools.* Two instruments were used to collect data for this study, namely, a modified version of the What Is Happening In this Class? (WIHIC, [60]) questionnaire to assess students' perception of the classroom learning environment and Student Engagement Questionnaire (SEQ) to assess students' engagement in biology. The WIHIC questionnaire has 8 items in each of seven scales and was validated for use in Taiwan and Australia by Aldridge et al. [60], and it is presently the most widely used questionnaire on perception of learning environments in the world [61]. To ensure that the scales were suitable for use in our study, the WIHIC was modified. First, the WIHIC scales were examined to ensure that they were appropriate for assessing the effectiveness of CML at secondary level classrooms. Student Cohesiveness, Teacher Support, Involvement, Cooperation, Equity, and Task Orientation were chosen as the six WIHIC scales to be used in our research. The Investigation scale was left out because it was not thought to be relevant to the use of CML in the biology classroom.

In a second step, each item was examined to ensure that the language and phrasing were appropriate for use in the Rwandan context. For example, to ensure that students did not misinterpret the intent of the statement, an item on the Teacher Support scale that stated "The teacher takes a personal interest in me" was changed to "The teacher is interested in my problems." There was a total of 48 items. The WIHIC's initial five-point frequency–response scale (Almost Never, Seldom, Sometimes, Often, and Almost) was employed, with students rating how frequently the statement happened.

The second data collection tool was the Student Engagement Questionnaire (SEQ). The SEQ was originally developed by Jamaludin and Osman [37]. The questionnaire is a 5-point Likert-type scale with values ranging from "Always" to "Never" containing behavioural, cognitive, and emotional dimensions.

Although, the WIHIC questionnaire was validated in different countries with a variety of languages and educational systems [28, 60, 62, 63], and for SEQ [37, 64, 65], both the WIHIC and SEQ were validated by experts at the University of Rwanda, College of Education, to check face and content validity. These questionnaires were also made accessible to teachers in the schools, where they were pilot-tested for feedback to ensure that no statements were misunderstood by students.

Moreover, to establish the reliability of WIHIC and SEQ, the instruments were pilot-tested on 50 students (27 males and 23 females) from a coeducational school that was not part of the main study but had similar features to the sampled schools. The Cronbach Alpha reliability coefficient for WIHIC was found to be .95. It was .83; .78; .84; .79, and .70 for six WIHIC dimensions, respectively. Sample items in WIHIC include (1) I work well with other class members. (2) The teacher is interested in my problems. (3) I explain my ideas to other students.

Moreover, the Cronbach Alpha reliability coefficient for SEQ was .89. It was 0.89 for behavioural, .75 for cognitive, and.76 for emotional engagement. Sample items in SEQ include (1) I listen carefully to everything that is said in class. (2) I always ask the teacher about difficult content. (3) The teaching method practiced by the teacher is enjoyable. The above Cronbach's alpha coefficients of WIHIC and SEQ indicated high internal consistency [58].

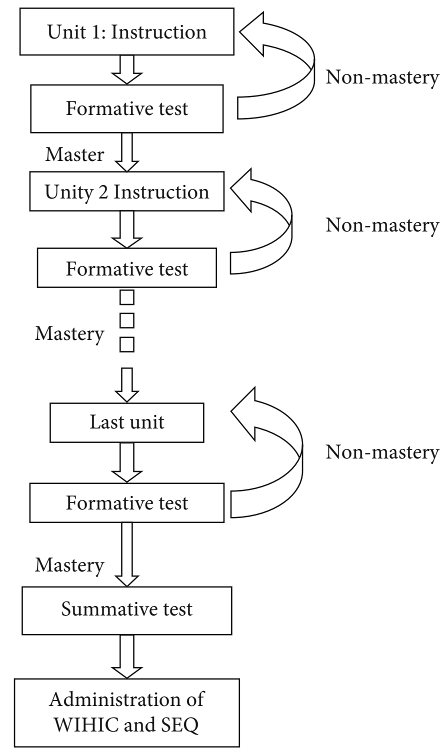


Figure 1: Diagrammatic flow of the teaching procedures in CML group.

*2.4. Data Collection Process.* Data for this study were obtained from 298 students distributed in two groups in their intact classes. The first group was taught using CML and the second using CTM. All students in both groups were taught the concept of photosynthesis in their respective intact classes with the help of their biology regular teachers as research assistants. The choice of this unit was that the photosynthesis concept was revealed as difficult to be learned by students in different countries ([66]; Skribe-Dimec& Strgar, [67]).

Only the teachers in the CML group received one week of training to prepare biology teachers to act as research assistants and to enable the use of the CML as instructional strategy. The training included the study's purpose, the implementation of CML, the content to be taught, lesson plans, and the administration of the WIHIC and SEQ. Specifically, the CML group teachers were explained the characteristics of cooperative and mastery learning strategies, as well as descriptive information about CML procedures. The focus was on grouping students to allow them to learn in cooperative learning groups, with the content divided into small topics to be covered one by one. A set of quizzes was also to be used to determine whether the objectives had been met or whether mastery had been achieved before moving on to the next topic. Those who did not achieve the expected mastery level would be remedied by their peers who had demonstrated mastery. In addition, they were given model lesson plans for the Photosynthesis unit. The training concluded with CML lesson plans microteaching. In the first three days of the week, students in the CML group received initial training on cooperative and mastery learning before beginning real teaching activities. Students were divided into small groups with a variety of abilities and taught how to work as a team, share ideas, and complete the assigned task as a group. Students learned what goals they needed to meet and what level of mastery they should expect (80 percent). Figure 1 shows the teaching procedures in CML group.

Teachers for the CTM group were briefed about the study's purpose, the implementation of CTM, the content to be taught, lesson plans, as well as the administration of the WIHIC and SEQ. Students in the CTM group were also taught the unit of photosynthesis but using traditional teaching methods, which included chalk and talk, note-taking sessions, and teacher demonstrations. It is worth noting that in all groups, the teaching activities lasted for four weeks after which, teachers administered WIHIC and SEQ questionnaires.

*2.5. Data Analysis.* Descriptive statistics (mean and standard deviation) and multivariate analysis of variance (MANOVA) were used to assess whether there were variations in the perceptions of students who were taught biology using the CML and their counterparts who were taught using the CTM. Furthermore, a MANOVA was performed to determine whether exposure to instructional methods (CML and CTM) was more successful for male students than female students. Finally, simple correlation and multiple regressions were used to investigate the bivariate association between each SEQ engagement and the WIHIC scales, as well as the joint influence of WIHIC scales [68].

Table 2: Subscale skewness and kurtosis values of the scales employed in the study.

| Scale | Subscales | Skewness value | Kurtosis value |
|---|---|---|---|
| Biology classroom learning environment | Student cohesiveness (SC) | 1.062 | .715 |
| | Teacher support (TS) | .858 | .247 |
| | Cooperation (CO) | .532 | -.191 |
| | Task orientation (TO) | .670 | .164 |
| | Involvement (IN) | 1.170 | 1.130 |
| | Equity (EQ) | .629 | .027 |
| Engagement in biology | Behavioural engagement (BE) | .009 | -.825 |
| | Cognitive engagement (CE) | -.391 | -1.119 |
| | Emotional engagement (EE) | .118 | -1.083 |

Table 3: Mean, standard deviation, and differences for students in CML and CTM for WIHIC and SEQ scales.

| | CTM mean (SD) | CML mean (SD) | F | $Eta^2$ |
|---|---|---|---|---|
| Learning environment scales | | | | |
| SC | 21.98 (2.54) | 28.02 (5.04) | 173.685* | .370 |
| TS | 21.35 (2.31) | 27.75 (4.39) | 252.407* | .460 |
| CO | 24.38 (3.78) | 28.59 (5.12) | 83.964* | .221 |
| TO | 23.75 (3.22) | 28.98 (4.85) | 95.405* | .244 |
| IN | 24.44 (2.51) | 28.25 (4.62) | 80.617* | .214 |
| EQ | 22.25 (3.30) | 27.72 (4.31) | 151.733* | .339 |
| Engagement scales | | | | |
| BE | 18.74 (2.41) | 21.12 (3.62) | 51.194* | .147 |
| CE | 14.63 (3.08) | 18.12 (2.18) | 125.543* | .298 |
| EE | 14.36 (3.12) | 21.22 (3.57) | 312.048* | .513 |

*$p < 0.01$.

## 3. Results

*3.1. Normality of the Data.* The subscales' skewness and kurtosis values, which are used to establish whether or not a study's data have a normal distribution, were calculated. Table 2 shows the skewness and kurtosis values acquired during the analysis.

The skewness and kurtosis values of the subscales of the scales were between -1.96 and +1.96, as shown in Table 2. Data were confirmed to have a normal distribution [69].

*3.2. Differences in Exposure to CML and CTM.* To determine whether there were any differences in perceptions of the classroom learning environment and engagement between students who were taught biology using CML and those who were taught using CTM, a MANOVA was used, with the six WIHIC and three SEQ scales serving as the dependent variables and the study groups (CML and CTM) serving as the independent variables. Table 3 summarizes the findings.

According to the mean and standard deviation provided in Table 3, the mean scores of students in the classes taught using the CML were higher than those of those taught using the CTM for each of the six WIHIC scales and the three SE scales. The effect sizes ranged from .214 to .460 for the six WIHIC scales. The effect sizes for the three SEQ scales ranged from .147 to .513. Figure 2 illustrates the difference between students taught using the CML and those taught using the CTM in terms of perceptions of the classroom learning environment and engagement in biology.

*3.3. Differences between Males and Females for Students Taught Using CML.* Regarding the differences for male and female students who were taught using the CML in terms of perceptions of the classroom learning environment and engagement in biology, a subsample of 144 including 73 male and 71 female students was used. The MANOVA was used to compare the group means (for males and females). Table 4 shows the MANOVA results.

According to the MANOVA results in Table 4, there was no statistically significant gender difference in students' evaluations of their classroom learning environment in CLM classes. However, there were statistically significant differences in students' engagement between males and females for behavioural engagement ($F_{(1,142)} = 8.348$, $p < .05$), effect size = .056, and emotional engagement ($F_{(1,142)} = 6.639$, $p < .05$), effect size = .045. Both measures show statistically significant

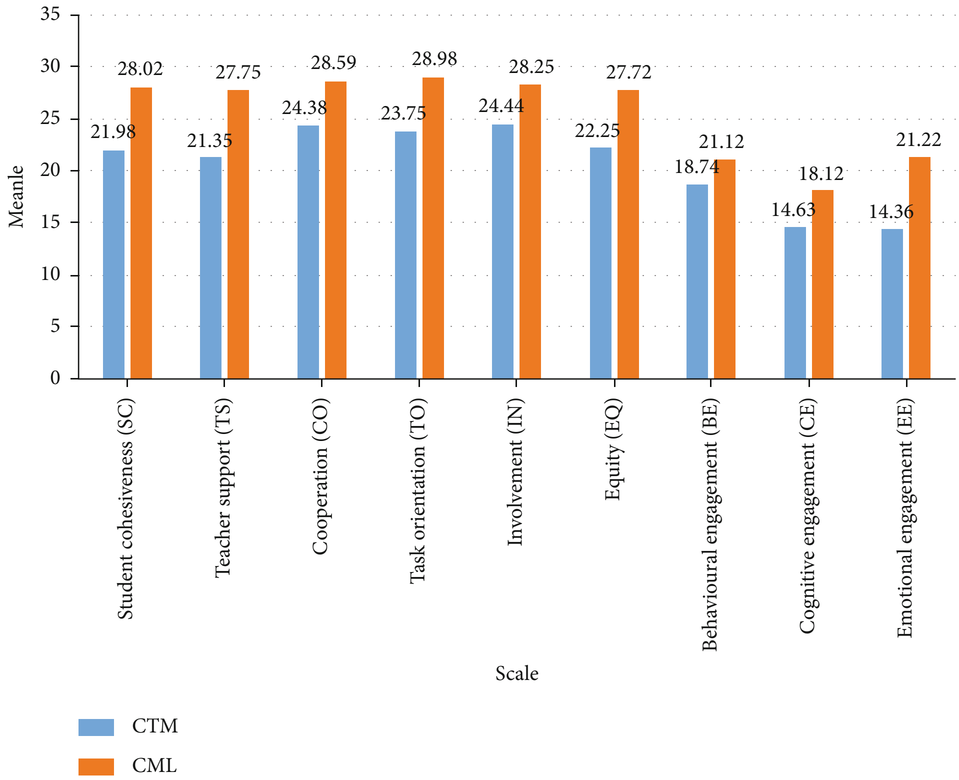


FIGURE 2: Mean scores for students who were taught using CML and those taught using CTM for the scales of the WIHIC and SE ($N = 298$).

TABLE 4: Mean, standard deviation, and sex difference for students taught using the CML for each classroom learning environment and engagement scales.

| Scale | Sex | | | | Difference between male and female students in CML classes | |
|---|---|---|---|---|---|---|
| | Male | | Female | | | |
| Learning environment scales | Mean | SD | Mean | SD | F | Eta$^2$ |
| SC | 27.85 | 5.08 | 28.21 | 5.04 | .184 | .001 |
| TS | 27.63 | 4.49 | 27.89 | 4.32 | .123 | .001 |
| CO | 28.81 | 4.91 | 29.17 | 4.81 | .198 | .001 |
| TO | 27.99 | 4.55 | 28.52 | 4.73 | .479 | .003 |
| IN | 27.93 | 4.81 | 29.28 | 5.37 | 2.528 | .017 |
| EQ | 27.51 | 4.41 | 27.94 | 4.25 | .367 | .003 |
| Engagement scales | | | | | | |
| BE | 20.44 | 3.69 | 22.14 | 3.37 | 8.348∗ | .056 |
| CE | 17.92 | 2.33 | 18.34 | 2.03 | 1.332 | .009 |
| EE | 20.48 | 3.67 | 21.99 | 3.33 | 6.639∗ | .045 |

differences, with female students outperforming male students.

*3.4. Differential Effectiveness of Instructional Strategies for Different Sexes.* A two-way MANOVA was used to examine whether being taught with CML and CTM in classes was differentially effective for male and female students in terms of perceptions of the classroom learning environment and students' engagement in biology. The independent variables were the groups (CML and CTM) and gender (male and female), while the dependent variables were the WIHIC and SEQ scales. The two-Way MANOVA/ANOVA findings are shown in Table 5.

The results of the two-way ANOVAs are shown in Table 5 for all six WIHIC scales and three SEQ scales, statistically significant ($p < .05$) differences were detected between students taught using the CML and those taught using the CTM in both cases. According to the Eta$^2$ data, the amount of variance in scores accounted for by CML and CTM teaching strategies ranged from .214 to .460 for WIHIC scales and .147 for SEQ

Table 5: Two-way MANOVA/ANOVA results for CML and CTM groups and gender for each classroom learning environment and engagement scales.

| Scale | Two-way MANOVA/ANOVA results: Exposure to CML and CTM F | Eta$^2$ | Sex F | Eta$^2$ | Exposure to CML and CTM x sex F | Eta$^2$ |
|---|---|---|---|---|---|---|
| Learning environment scales | | | | | | |
| SC | 173.685* | .370 | .006 | .000 | .011 | .000 |
| TS | 252.407* | .460 | .084 | .000 | .029 | .001 |
| CO | 83.964* | .221 | .026 | .000 | .821 | .003 |
| TO | 95.405* | .244 | .370 | .001 | .308 | .001 |
| IN | 80.617* | .214 | .459 | .002 | .288 | .001 |
| EQ | 151.733* | .339 | .000 | .000 | .109 | .000 |
| Engagement scales | | | | | | |
| BE | 51.194* | .147 | .695 | .002 | 7.077* | .024 |
| CE | 125.543* | .298 | .034 | .000 | .465 | .002 |
| EE | 312.048* | .513 | .021 | .000 | 5.606* | .019 |

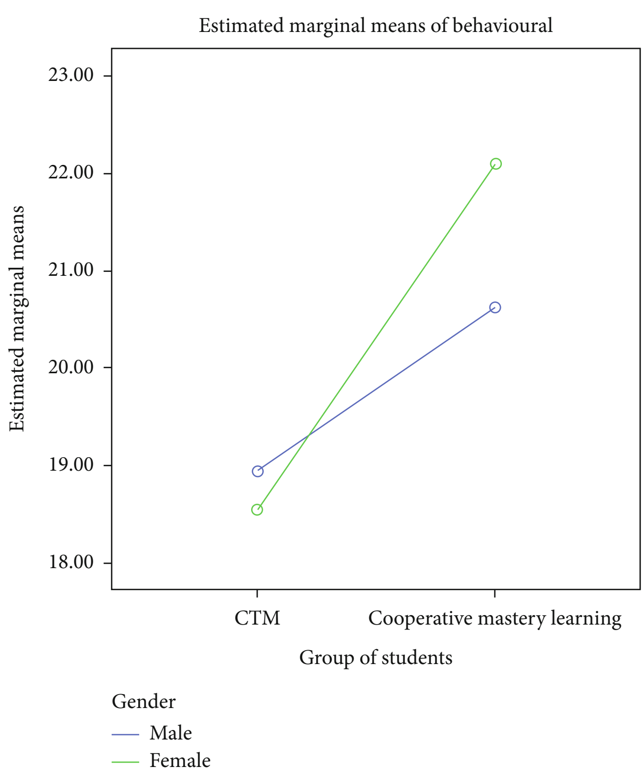


Figure 3: Interactions between treatment and sex for behavioural engagement.

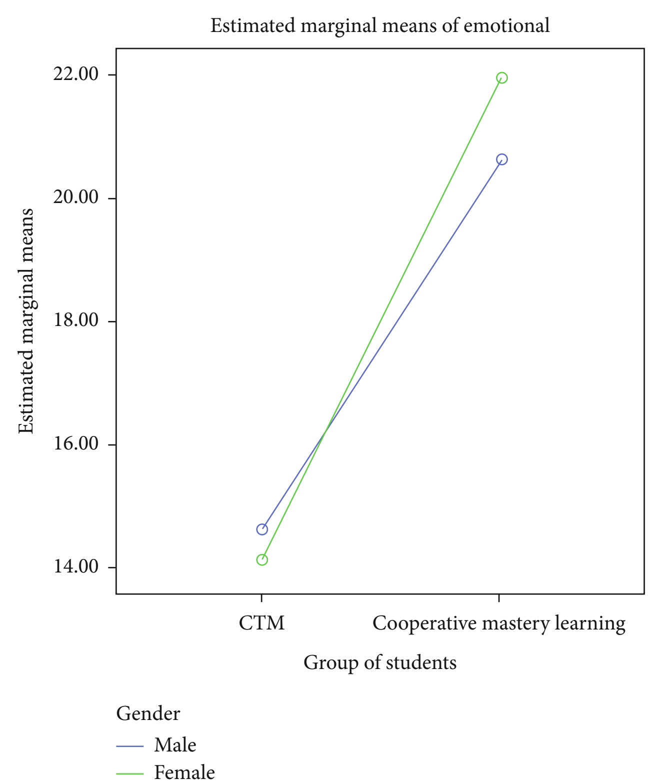


Figure 4: Interactions between treatment and sex for emotional engagement.

scales. In terms of whether there are differences between males and females regardless of CML and CTM exposure, the results in Table 5 show that there are no statistically significant differences between males and females.

Regarding the learning environment scales, there is no statistically significant interaction between exposure to CML and CTM and sex emerged. However, the results in Table 5 indicate that a statistically significant interaction between exposure to CML and CTM by sex existed for two of the three SEQ scales, specifically behavioural ($p < .05$) and emotional ($p < .05$) engagement. Thus, the independent explanation of the differences between the sexes in exposure to CML and CTM was only valid for cognitive engagement. For the other SEQ scales (behavioural and emotional

Table 6: Correlation and multiple regression analysis for associations between student engagement and classroom learning environment scales.

| Learning environment scales | Classroom learning environment-engagement association | | | | | |
|---|---|---|---|---|---|---|
| | BE | | CE | | EE | |
| | $r$ | $\beta$ | $r$ | $\beta$ | $r$ | $\beta$ |
| SC | .348** | -.061 | .232** | -.130 | .257** | -.166 |
| TS | .256** | -.268 | .167* | -.309 | .243** | -.172 |
| CO | .366** | .268* | .111 | -.037 | .303** | .224** |
| TO | .217** | -.057 | .172* | -.012 | .214** | .020 |
| IN | .187* | -.033 | .192* | .092 | .178* | -.022 |
| EQ | .386** | .569* | .296** | .639** | .318** | .474** |
| Multiple regression ($R$) | | .458** | | .345** | | .357** |

*$p < 0.05$; **$p < 0.01$; $N = 144$.

engagement), the amount of variance accounted for was .014 and .016, respectively. The interpretation of the interaction of treatment and gender ($p < .05$) for behavioural and emotional scales (Figures 3 and 4) is that in biology classes taught using the CML, females perceived a greater sense of behavioural and emotional engagement than the males. Male students, on the other hand, experienced a greater feeling of behavioural and emotional engagement in classes taught using the CTM than their female counterparts.

*3.5. Association between the Perception of the Classroom Learning Environment and Student Engagement in Biology for Students Taught Using the CML Instruction Strategy.* The bivariate association between each SEQ and the WIHIC scales was investigated using simple correlation analysis. Besides, multiple regression models were utilized to examine the combined impact of WIHIC scales (as independent variables) and specific SEQ scales (as dependent variables). Additionally, standardized regression coefficients ($\beta$) were investigated to determine which of the WIHIC scales contributed individually and significantly to the explanation of the variance in students' engagement. The results are shown in Table 6.

The results in Table 6 show that the correlation between each of the WIHIC and the SEQ scales was statistically significant ($p < .01$). This suggests that the behaviour, cognitive, and emotional engagement scales were more positive in CML classes. The correlation coefficient ($r$) ranged from .187 to .386 for behaviour, from .172 to .296 for cognitive, and from .178 to .318 for emotional engagement. According to Cohen [70], an effect size (as measured by $r$-values) of .10 is regarded small, .30 is considered medium, and .50 is considered large. Therefore, when the $r$-value is used, the effect sizes for the association between the WIHIC and SEQ scales are predominantly in the medium range [70].

Multiple correlation analysis found a significant multiple correlation of .458 for behavioural engagement (BE), .345 for cognitive engagement (CE), and .357 for emotional engagement (EE) for the set of WIHIC scales ($p < .01$). The standardized regression coefficients ($\beta$) were assessed to see which of the classroom learning environment scales likely contributed to these multivariate correlations. According to the beta weights, cooperation (CO) and equity (EQ) were significantly associated with students' engagement. This shows that when students perceive classes to be more cooperative and teachers to treat the former equitably, they engage in biology more favorably.

## 4. Discussion

This study examined whether differences exist between students taught biology using CML and those taught using CTM in terms of perceptions of their learning environment and engagement in biology. Students' perceptions of their classroom learning environment were assessed using a modified WIHIC questionnaire, while the Student Engagement Questionnaire (SEQ) was used to assess students' engagement in biology. The findings revealed that the mean scores for all six WIHIC scales and all the three SEQ scales for students in CML classes were constantly higher than for students in CTM classes. Besides, the scores for all six WIHIC scales were statistically significantly ($p < .01$) higher for students in CML classes. Moreover, the scores for all three SEQ scales were statistically significantly ($p < .01$) higher for students in CML classes. These findings show that students in CML classrooms had better student-to-student relationships, teacher support, and participation in teaching and learning activities, as well as more cooperation among classmates, than students in CTM. The results of this study corroborated numerous other empirical studies that have examined innovative teaching strategies in various educational settings and found positive impacts that these strategies have on students' engagement in different subjects (Afari et al., [29, 46, 47]).

The only explanation of students' positive engagement in biology when taught using the CML is that this strategy allowed students to actively participate in the teaching and learning process. This is supported by Burke and Fedorek [71, 72], and Hava [64], who reported that the use of active teaching and learning instructional strategies can enhance students' engagement in the subject content taught. On the other hand, students who only learn through traditional methods may find it tedious and ineffective [73], thus, less engaged in the learning of the subject. Besides, Sherab [65] stated that students' behavioural and cognitive engagements were enhanced through the promotion of active learning.

Moreover, this study examined whether differences exist for male and female students who were taught biology using CML in terms of perception of the learning environment. The finding showed that for all WIHIC scales, the differences were not statistically significant ($p > .01$). This finding is in line with that of Chipangura [29]. However, the finding contradicts that of Huang [54], Kaya et al. [55], Telli et al. [50], Wahyudi and Treagust [53], and Wolf and Fraser [46].

The scores for two of the three SEQ scales, behavioural engagement and emotional engagement, were statistically significantly ($p < .05$) greater for females than for males. The findings support previous research that found significant disparities between males and females in terms of learning environment perceptions and engagement [74] with females reporting more behaviourally engaged than male students during classroom interactions. However, the result contradicts that of Chipangura and Aldridge [75] who found that males were more engaged than females.

The rationale for the behavioural and emotional characteristics was that girls scored higher than boys in courses exposed to cooperative learning instructional strategies, such as CML, but male students scored higher than female students in classes exposed to CTM [4]. In CML classes, however, there was minimal difference in how males and females perceive their sense of engagement in biology. Nevertheless, there were a few occasions where females had slightly more positive attitudes (behavioural and emotional). These results are consistent with the observation by Khan and Masood [5] and Keter [4] who noted that the CML encourages participation and enhances student motivation in biology and chemistry, respectively, irrespective of gender. Furthermore, this finding backs up a previous study [76] that found gender variations in cooperative learning preferences, with girls responding more positively to cooperative work than boys. Thus, this female students' peer orientation (the degree to which females prefer to work in groups) might have influenced their high behavioural and emotional engagement than males in this study.

Furthermore, the study investigated whether exposure to CML in biology classes was differentially effective for male and female students in terms of perception of classroom learning environment and engagement in biology. The key finding for differences between sexes regardless of the instructional method was that no statistically significant differences were found between males and females for all environment scales. This finding is similar to that of Cai et al. [56] and Su Ling et al. [57] who found no gender differences in students' perceptions of classroom learning environment. However, the finding contradicts that of Chipangura [29], Telli et al. [50], and Wahyudi and Treagust [53] who found that female students held a more positive perception of the learning environment than their male counterparts.

Concerning the interaction between exposure to teaching method and sex, results indicated that no statistically significant interaction existed for all six learning environment scales. However, a statistically significant interaction existed for two of three engagement scales (behavioural and emotional). The results indicated that in classes exposed to CML, females were more engaged than males, while in classes exposed to CTM, males were more engaged in biology than females. The finding contradicts the observation by Keter [4] who noted that CML encourages motivation of students regardless of gender.

Finally, the study investigated whether, for students who were exposed to CML, there was a relationship between students' perception of the learning environment and their engagement in biology. The results of simple correlation showed that all six learning environment scales correlated significantly with three engagement scales with the exception of cooperation and cognitive scales. The multiple regression analysis of the set of WIHIC scales with each of the SEQ scales revealed that the cooperation and equity scales contributed significantly to the explanation of variance in students' engagement. This pattern of association is consistent with previous research that has investigated the relationship between student's perceptions of the classroom learning environment and their outcomes [47, 75, 77–80].

Furthermore, cooperation and equity scales were strong and independent indicators of student engagement in biology. Similar research has found that such scales of the classroom learning environment influence the variability of specific learning outcomes [28, 62, 78, 81]. According to the two classroom learning environment scales (cooperation and equity), students in CML classes are more likely to collaborate and believe their teachers treat them fairly. This increases their engagement in biology lessons. Previous research has shown that student engagement influences active learning [37, 65], which enhances achievement [82, 83], the use of deep learning strategies [64], and the retention of the knowledge learned [84].

## 5. Conclusions

The study investigated whether students taught using the CML instructional strategy differed in terms of perceptions of learning environment and engagement in biology compared to students taught using the CTM. Based on the findings, the following conclusions are reached: (1) statistically significant ($p < .01$) differences in perception of biology classroom learning environment were observed with students in CML classes scoring higher than those in CTM classes; (2) no statistically significant difference in students' perception of the classroom learning environment was observed for all classroom learning environment scales between male and female students. However, for engagement, it was observed for two of the three engagement scales; (3) there were statistically significant interactions and sex for the two scales of engagement (behavioural and emotional); (4) six classroom learning environment scales correlated significantly and positively with the two engagement scales (behavioural and emotional); and (5) cooperation and equity scales were only significant independent predictors of behavioural and emotional engagement in biology.

## 6. Recommendations

As a result, the findings may provide important information about how the use of the CML instructional strategy can enhance the biology classroom learning environment and boost students' engagement. The association between exposure to instructional strategies and sex in the learning environment and engagement contributes to our understanding of how teachers could use the classroom learning environment and how each sex perceives it to direct intervention programs to address equity issues. Besides, the use of the CML enhanced students' perception of the learning environments and increased students' engagement in biology. Therefore, school authorities should evaluate the need for professional development to assist teachers in improving the use of the CML in teaching and learning biology as well as other science subjects.

Furthermore, because this study only included lower secondary students in Nyamagabe district, the generalization of the findings may be limited. As a result, additional research in other science areas and at different grade levels is advised. Finally, additional research should be conducted to investigate the impact of CML on other outcomes like attitudes, interest, and other topic areas.

## Data Availability

The data that support the findings of this study can be obtained from the corresponding author on reasonable request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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