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Effect of Cooperative Learning on Chemistry Students' Achievement in Rwandan Day-upper Secondary Schools

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Abstract: The cooperative learning (CL) is an advanced instructional approach that uses different motivational procedures to make instruction significant and learners more responsible. This study aimed to investigate the effects of cooperative learning on students' achievement in chemistry among the advanced level in 12-year basic education schools; it engaged a quasi-experimental design with one treatment group and a comparison group (control); the first applied cooperative learning in teaching organic chemistry while in the control group, organic chemistry was taught by the conventional teaching methods (CTM). A sample of 257 students participated in the study. The data collected used an organic Chemistry Achievement Test, and its data were analyzed using SPSS version 23.0 and MS Excel 2016. The ANCOVA results showed that learners taught using cooperative learning achieved better than their counterparts in the control group ($F=78.07$, $df=1, 256$, $p<.001$) with the learning gains of 16.0% in traditional methods and 53.6% of cooperative learning approach, respectively. However, there was no statistically significant difference in gender of students. It is recommended that chemistry teachers be trained on cooperative learning and encouraged to apply it in their teaching methods to enhance students' academic achievement.

Keywords: *Academic achievement, basic education, chemistry education, cooperative learning, secondary schools in Rwanda.*

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Introduction

According to Kabutu et al. (2015), achieving quality science education for developing scientifically literate citizens is a global problem. Science instruction over the past eras has made attempts to unravel the causes of low achievement. Quality chemistry education at the basic level helps the students acquire knowledge, skills, values, and attitudes that empower them to contribute positively to the nation's socio-economic, political, and moral development (Ejidike & Oyelana, 2015; Muhammad, 2013).

Education is the foundation of sustained national development; the content and the period of the different learning cycles in every nation depend on its education vision, knowledge advances, social evolution, and employment needs. Studies have reported that most students in chemistry class learn through inefficient teaching methods, although some succeed satisfactorily on examinations but with gross misconceptions in some chemical phenomena (Omwirhiren & Ubanwa, 2016; Otieno, 2012). Chemistry as a science that is foundational to learners who wish to pursue careers in applied science and related disciplines could be taught by innovative teaching strategies that facilitate the critical thinking of students as to reduce confusion faced by new students in certain concepts such as organic chemistry (Ngozi-Olehi et al., 2018; Sibomana, Karegeya et al., 2021). This is the reason why the Rwandan education system has adopted a new curriculum, "competence-based curriculum" (Rwanda Basic Education Board, 2015b), to sensitize not only knowledge but also attitude and values of learning. In this regard, this curriculum calls teachers to use active learning techniques such as collaborative and cooperative learning. Students' active involvement in teaching and learning makes cooperative learning (CL) powerful as students build a strong and conducive climate in their classroom, enhancing their academic achievement where chemistry is not taken as difficult to teach and learn (Gabriel et al., 2018). Also, students could get help from home, school, teachers to increase their interest in chemistry subjects (Mahdi, 2014).

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Its usefulness measures the importance of an instruction approach. The importance of learning depends upon its application in day-to-day life, where the transfer of learning applies. Cooperative learning is one of the instructional approaches in which learners attain and retain learning objectives by helping each other in a social setting; it is an innovative teaching approach that uses small groups so that learners work together to maximize individual and each other's learning (Pateşan et al., 2016). It entails five fundamental elements: constructive interdependence, individual responsibility, interpersonal and social skills, interaction, and superiority of group processing. Learning circumstances are not cooperative if learners are organized into groups without constructive interdependence where students work together as an interconnected group to accomplish collective learning goals (Johnson et al., 2014). While learning cooperatively, students could be accountable for their learning and the achievement of other group associates' learning by ensuring that other members in the group complete the tasks and attain the educational outcomes (Slavin, 2014). Also, the lesson is not cooperative if learners do not share and respect peers' contributions which shows their positive interdependence which could be constructed in CL groups to allow learners work and learn together, hence promotes each group member's productivity, achievement, and retention of the learned materials as a result of members reciprocal interaction where individuals boost and facilitate each other's efforts to complete the group goals (Johnson & Johnson, 2014).

In a CL classroom, an individual responsibility occurs when learners ask for support, perform their work, present their thoughts, taking their tasks seriously, and help the group operate well by taking care of one another (Tombak & Altun, 2016); each individual is accountable (positive interdependence) for completing communal work and facilitating other group member's work (Sharan, 2010); group members are encouraged to ensure that all group members master the material being studied and that the achievement of the group depends on the individual learning of each member as evidence of the individual accountability (Gillies, 2016). Students cannot work effectively if socially the group is not heterogeneous and if elementary learning skills on cooperative interaction are not trained; in that case, group associates cannot work together successfully to complete their tasks.

Cooperative learning (CL) compared with competitive learning is more complex since it necessitates learners to participate in learning tasks and work together (Del et al., 2015). Therefore, collective, and interpersonal skills such as listening attentively, inquiring cooperatively, and exchanging, respectfully, need to be trained to help learners cooperate efficiently in the group, and each group associate would know how to manage the group, how to make conclusions, and how to solve conflicts that arise among group members. If these skills are not educated, CL activities are rarely effective (Slavich & Zimbardo, 2012). In an effective CL, participants should get to know, trust each other, interconnect accurately and explicitly, agree and sustenance each other, resolve struggles constructively (Karaçöp, 2016). To enhance the group processing, members in a group describe what member activities were helpful and uncooperative and make judgments about what to continue or change in improving the effectiveness of the members in contributing to the collective efforts to complete the group's goals via reflection on the instruction process (Tran et al., 2014). Students achieve and retain better and demonstrate superior learning skills if the above-mentioned basic elements are included in CL groups, students also experience more constructive interactions among group associates, and between learners and the instructor, and more affirmative self-esteem and attitudes toward the subject area (Slavin, 2014).

Different approaches to instruction are usually fastened on some learning theories. Constructivism is notable among these philosophies in recent eras; it holds the view that learning would mainly include the student by facilitating their ability to conceptualize learning contents (Yassin et al., 2018). Thus, effective learning takes place when the students are socially engaged, and the instruction methods that empower learners' subject matter conceptualization and learner to learner as well as the teacher-student communications could improve the academic achievement of learners as they can learn from each other's concepts that they might not learn straight from the educators; such instruction approaches are well suited for chemistry instruction, and one of them is cooperative learning (Sibomana, Karegeya et al., 2021).

Cooperative learning (CL) instructional strategy refers to instruction methods where students work together in a small heterogeneous group of four to six students to assist each other understand the academic content, develop learning skills, enjoy the learning process with their peers, and being monitored regularly by the teacher/facilitator. In such constructivist learning procedures, students are motivated, and motivation is a significant constituent of success in chemistry instruction (Tombak & Altun, 2016).

The socio-constructivist viewpoint on learning is usually attributed to Lev Vygotsky, although he carried out much of his study in the early part of the 20th century. We based on this theory to conduct this study. Mind in society was one of his most important works, which rapidly became very influential in developing the idea of constructivism worldwide by concerning the role of communication/social interaction, enculturation, and the Zone of Proximal Development (ZPD) (Shabani et al., 2010).

For any nation to be developed, more efforts are to be applied in science education. In the case of Rwanda, putting more effort into the development of the industrial sector where chemistry plays a more critical role, is a must to the policymakers. Chemistry is in the central position in the economic development of any nation as its study has a greater role in daily life, such as exploration of the relationship between theory and practice where organic chemistry is more applied in industries (Cooper et al., 2019). Despite the importance of chemistry, the low achievement of students in the subject still has a major concern to the educationists, and this problem has been seen as a result of the inappropriate teaching strategies applied by teachers (Byusa et al., 2020; Oginni et al., 2013).

Besides, one of the roles of education in any country is to produce educated individuals who might be knowledgeable in different fields. In this vein, Rwanda introduced the system of Nine Year Basic Education (9YBE), which is six years of primary level and three years of secondary (lower level) in 2009, and Twelve-Year Basic Education (12YBE) which is the advanced level of the previous one in 2012, these different years of basic education (day schools) were put up to promote quality education countrywide (Nizeyimana et al., 2020). However, the category of 12YBE learners is still being taught by ineffective teaching methods, although the CBC has been introduced by the Government (Byusa et al., 2020).

There has been an outcry of quality education among 9&12YBE countrywide, and the people concerned are students, teachers, headteachers, stakeholders in education, and the community. For the socio-economic development of Rwanda, the Rwandan Government invests heavily in teaching science and technology. However, the fundamental concern in science schooling has been the emphasis on presenting information through passive learning, or chalk and talk, where learners receive instruction inactively throughout classroom activities and feel that chemistry knowledge is fixed and that no additional action is required (Byusa et al., 2020; Chee & Tan, 2012).

Since we are passing through the modern era, science educators are creating intense changes in curriculum and instructions. This study was a continuation of this preparation in which researchers investigate the effects of cooperative learning on students' academic achievement in Rwandan secondary schools by testing the following research null hypotheses: H_{0a}: There is no statistically significant difference between the achievement mean scores of students taught organic chemistry using cooperative learning and those taught organic chemistry using conventional teaching methods. H_{0b}: There is no statistically significant difference in the achievement mean scores between female and male students taught organic chemistry using cooperative learning.

Methodology

Research design

This study employed a quantitative research approach, utilizing a quasi-experimental research design under the Matching-Only Pretest-Posttest Control Group Quasi-experimental design (Fraenkel et al., 2012). Matching means that subjects in each group were matched (on certain variables; experimental or control groups) but not randomly assigned to groups. This research design involved intact classes of senior five-day school students who take chemistry as one of the core subjects from different schools in two districts. Furthermore, this design is often preferred in educational research, mainly when experimental and comparison groups constitute the naturally assembled groups or intact classes (Subedi, 2016). Therefore, a quasi-experimental research design was deemed suitable for this study, especially that it was meant to fit into naturally/already existing school structures without interrupting the regular school timetable.

Research participants

In this study, the target population was all students of senior five (S5) from day schools (12YBE) of Kamonyi (one of eight districts of South province) and Rusizi (one of seven districts in the Western province) Districts which have chemistry as a core subject. The study then was composed of 128 students in the experimental group and 129 students in the control group. Thus, 257 made up of 157 females and 100 males from ten schools of Kamonyi and Rusizi, participated in our study. The sample was chosen with the inclusion criteria of day students and was 257 from ten intact classrooms as clusters (cluster sampling). Ten clusters from ten-day schools were assigned into two groups, experimental and control groups. Each group with five clusters was assigned according to their academic performance in national examinations (each with high performing, moderate, and low performing schools).

The five clusters from each group were based on school average performance of the 2018 national examinations where one high performing school (above 75% pass rate), two moderate performing schools (from 50% to 74%), and two low performing schools (below 49% pass rate). After allocating schools into experimental and control groups, all students from each of the selected classrooms were part of the sample according to groups. Their chemistry teachers (five teachers in each group) were also part of the study. The choice of senior five chemistry students was motivated by the fact that they were not only non-examination class but had also learned chemistry for over four years and especially the introduction to organic chemistry while in senior three; more on that the units (topics) of intervention are planned in the first term of senior five. After carrying out all the procedures explained above, among 257 senior five chemistry students ranging from 16 to 23 years (Mean = 18.40; SD = 1.36) were selected, including the ten chemistry teachers for the selected classrooms.

Sample characteristics

Among the ten teachers (three females and seven males) involved in the study, 6 (one female and five males) were holders of a bachelor's degree in chemistry with education; 4 (2 females and two males) were holders of a bachelor's degree of chemistry without education; and among these four, two of them have a postgraduate diploma in education. The experimental group consisted of two female and three male teachers, while the control group consisted of one female and four male teachers. The average years of teaching experience in the experimental group was 7.2 while that of the control group was 7.6; these averages of teaching experience and qualifications of teachers in the experimental group were almost the same as that of the control group and give evidence that teacher participants were almost at the same level in terms of teaching experience and professional qualifications.

Research procedure

The research and innovation unit granted the ethical clearance (Ref: 03/DRI-CE/056/EN/gi/2020) at the University of Rwanda College of Education (UR-CE) before data collection. It was used to seek permission at the district level and consent with teachers and students to voluntarily participate and anonymize their identification. Teachers from the experimental group (senior five chemistry teachers from five schools) were gathered and trained on implementing cooperative learning (CL) using the PowerPoint presentation and demonstration videos. We started intervention in February 2020 and stopped by Covid-19 in March 2020; then, we resumed in November 2020 up to March 2021. Students from the experimental group were taught organic chemistry (three units which are alkanes, alkenes, and alkynes; halogeno-alkanes/alkyl halides) using the CL approach, while those from the comparison group were taught the same topics using conventional teaching methods (CTM). They used normal teaching and learning routines. Thus, we did not induce them in any instructional materials; these topics were planned to be taught in all five senior schools to learners who take chemistry as one of the core subjects during the period of data collection.

In all the advanced levels of secondary school where chemistry is taught as one of the core subjects, chemistry is taught seven periods per week and within 40 minutes a period; thus, the topic of alkanes was taught within ten periods; alkenes and alkynes within 22 and alkyl halides within 17 periods as prescribed by the Rwandan advanced level Chemistry syllabus (Rwanda Basic Education Board, 2015a, p. 119).

Instruments of data collection and analysis

The Chemistry Achievement Test (CAT) was developed to assess the scholastic achievement of students before and after treatment. The CAT was composed of 35 multiple choice questions about organic chemistry in senior five of secondary schools; the test had two sections; the first was composed of 25 multiple-choice items with options from A to D, one of which is the answer, and the remaining three options are the distracters (incorrect answers); learners were asked to select the correct option by indicating the letter bearing it. The second was of 10 questions where students were asked to respond by True or False. The CAT was developed according to the objective of the organic chemistry unit in the senior five (S5) chemistry curriculum, syllabus, and student textbooks (Rwanda Basic Education Board, 2015a). The test comprises questions on the concepts drawn from the topics selected in the unit, which are alkanes; alkenes and alkynes, and halogeno-alkanes (alkyl halides).

The Chemistry Achievement Test was face and content validated. To establish the content validity of CAT, a table of specifications (Test blueprint) was constructed. The Test BluePrint was constructed by considering the period to cover each topic and the expected behavioral outcomes of each topic. Thus, the topics (subunits) that are large in scope attracted more questions than those that are relatively small in scope. In addition to the specification table, the CAT items were presented to two experienced chemistry teachers who have taught S5 students over five years and two lecturers of chemistry from the University of Rwanda, College of Education (UR-CE). The experienced chemistry teachers were requested to critique the items and options for the test, examine and assess whether the test conforms to the subject matter content and the instructional objectives and whether the items are clear and free from ambiguity. Evaluation experts from UR-CE face validated the CAT by describing its appearance, the format for presenting the test items, their typing, and the general outlook of the test. All suggestions from both experienced chemistry teachers and experts were considered in the final formulation of the CAT before its administration. The CAT was also piloted before being used in collecting data.

Both stability and internal consistency of CAT were estimated in this study. To determine the reliability, estimate of CAT, two sets of scores were generated for the students during test and re-test processes to check the Pearson Product Moment Correlation Coefficient method with the aid of SPSS version 23.0, and the stability estimate of .824 was obtained. This implies a strong positive relationship between the first and second administration of CAT. Hence, the instrument was consistent and reliable enough for this study. We used MS Excel 2016 and SPSS version 23.0 to analyze the data. We marked each student from each group by assigning one score for the question answered correctly and a zero score for the question answered wrongly. We then summed up the total scores for each student. The percentage and averages were computed for descriptive results and inferential statistics to measure the effect of the mean difference. We have also computed the sum of students who performed each question to provide insight into the difficulty of CAT. To signify the probability values when score means are different, we computed effect size (Magnusson, 2021) and normalized learning gains (Hake, 1998). Cohen d effect size is computed by taking the difference between post and pre-test scores over the average standard deviation. At the same time, normalized gains are calculated by the difference in means over the difference between the highest score and pre-test score (Ndihokubwayo et al., 2020).

Findings/ Results

The data results from this study indicate that the achievement mean scores of learners in the experimental group at the post-test level (74.1%) were greater than the achievement mean scores of those in the control group (68.2%), as Table 1 displays. It implies that cooperative learning has positive effects as it increases students' academic achievement. The normalized learning gain for the control and experimental group from pre-test to post-test were 16.0% and 53.6%, respectively. Note that the control group was taught by conventional teaching methods (CTM) while the experimental group was taught by the cooperative learning (CL) approach.

Table 1. Descriptive statistics

Parameters	**Control group (Pre-test)**	**Control group (Post-test)**	**Experimental group (Pre-test)**	**Experimental group (Post-test)**
Average score	62.1%	68.2%	44.3%	74.1%
Minimum score	34.3%	31.4%	0.0%	62.9%
Maximum score	88.6%	94.3%	60.0%	85.7%

After checking the homogeneity of control and experimental groups' scores at the pre-test stage using Levene's test of equality of variances, it was found that the variances were statistically different. Thus, we employed an analysis of covariance (ANCOVA) to test the groups' statistical differences. We had two independent factors [groups (control-experimental) and gender] and one dependent variable (post-test scores) since the pre-test variable was held as a covariate.

Table 2 displays inferential statistics from univariate analysis. It clearly shows that students' scores from pre-test to post-test increased significantly ($p<.001$) with an effect size of 0.22. At the same time, the same statistically significant difference was realized between control and experimental groups ($p<.001$) with an effect size of .23 in favor of the experimental group, while they were 4.12 and 53.6%. These results show that the statistical significance was meant to show the effect of CL over CTM. However, the study revealed no statistical significance between male and female students after teaching intervention ($p=.861 > .05$). Eventually, there is no significant interaction between groups and gender ($p=.867 > .05$). Thus, in terms of posttest results, boys and girls perform equally in both control and experimental groups.

Table 2. Tests of Between-Subjects Effects

Dependent Variable	**Source**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Post-test scores	Corrected Model	8853.096[a]	4	2213.27	24.04	.000	0.27
	Intercept	24485.13	1	24485.13	265.99	.000	0.51
	Pre-test scores	6542.72	1	6542.72	71.07	.000	0.22
	Groups	7187.13	1	7187.13	78.07	.000	0.23
	Gender	2.842	1	2.84	0.03	.861	0.00
	Groups * Gender	2.598	1	2.59	0.02	.867	0.00
	Error	23197.22	252	92.05			
	Total	1332278	257				
	Corrected Total	32050.31	256				

a. R Squared = .276 (Adjusted R Squared = .265)

The histogram shows the distribution of students in each interval of scores (see Figure 1). Although some students (3%) in the control group have the highest scores (90-100), 14% of students still could not get the average score (50) at the post-test stage. Contrariwise, all students in the experimental group at the post-test stage gained more than 60%.

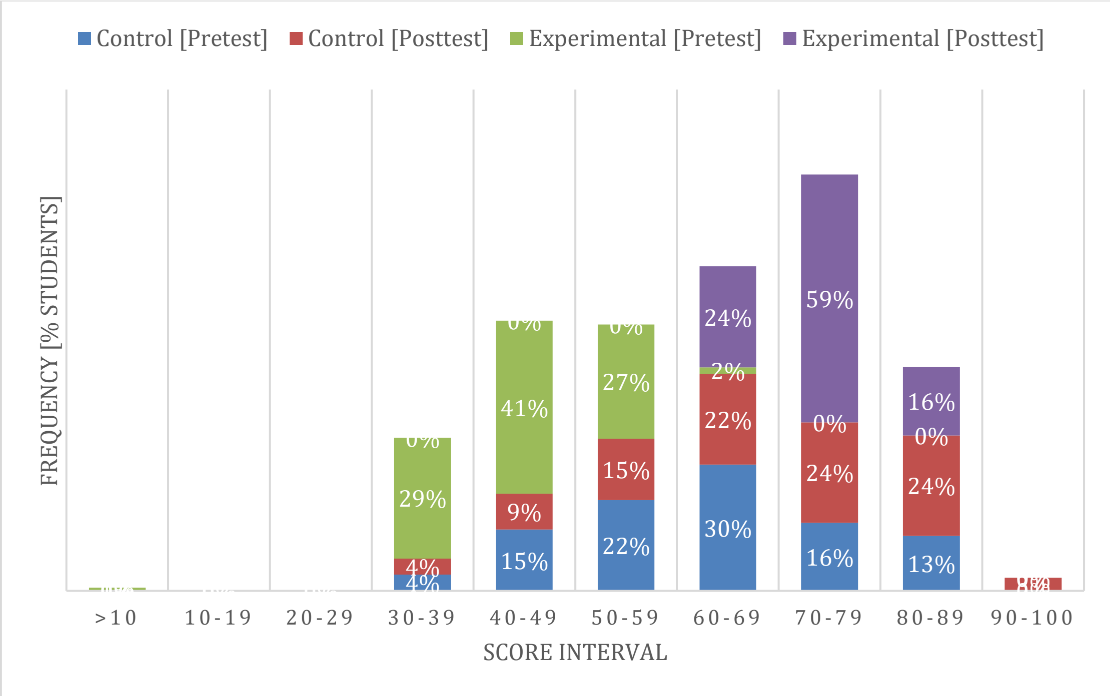

Figure 1. Students distributed into the score range. Note: score range is ten intervals along 100% scores. The % numbers in the graphs are the percentage of students in each score range/interval for each group.

Figure 2 shows the number (%) of students who performed well in each item of CAT. It is well shown that many students were able to perform the CAT questions after being taught by the cooperative learning approach. Contrariwise, the ineffectiveness of CTM is shown by the overlap of students who were not taught through CL both at pre-and post-test stages. For instance, items 4, 11, 12, 16, 17, 19, 26, and 32 were performed by few students after being taught by CTM (see Figure 2). Such results explain the ineffectiveness of traditional methods. The fact that students in the control group well-performed items 5 and 8 (78% for item 5 and 74% for item 8) than those in the experimental group (75% for item 5 and 72% for item 8) may be due to their characteristics. Both items test the recall, the first level of Bloom's taxonomy—item 5 [the reaction between propene and Oxygen is called: a) substitution, b) combustion, c) saponification, and d) esterification] and item 8 [the number of carbon atoms in a Hexyne molecule is: a) 8 b) 9 c) 5 d) 6] that anyone can answer despite the intervention offered.

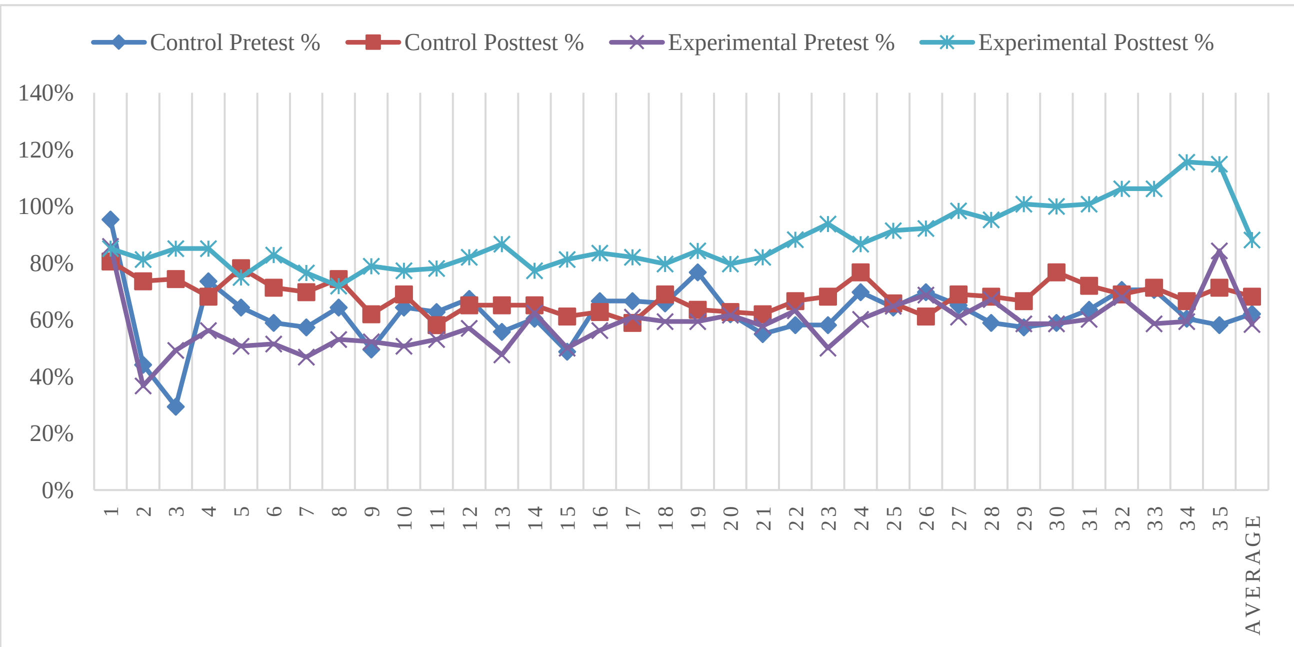

Figure 2. Students' understanding of organic chemistry concepts. Note: the horizontal axis displays CAT items while the vertical axis displays the percentage of students.

Discussion

This study revealed a significant difference between the achievement mean scores of chemistry students exposed to cooperative learning (CL) and those taught with conventional teaching methods (CTM) in organic chemistry concepts. The post-test analysis of students' achievement means gain scores showed that CL was most potent in enhancing students' academic achievement while the CTM was least effective in enhancing students' achievement abilities in the organic chemistry concept. This might have been due to the scaffolding and stability provided in the cognitive structures of the experimental groups of chemistry students by CL. This result corroborates the findings of Canelas et al. (2017), Horowitz et al. (2013), and Çağatay and Demircioğlu (2013), which demonstrated that CL increased students' understanding and achievement abilities. Therefore, the observed significance level for the t-test ($p<0.001$) is enough evidence to reject the null hypothesis that there is no statistically significant difference in the mean scores of learners taught organic chemistry using CL and those taught with conventional teaching methods.

A second hypothesis that there was no statistically significant difference between male and female students' score was retained. The findings revealed that both males and females benefited equally well from the exposures. This achievement may be dedicated to training (Ndihokubwayo et al., 2019) offered to Rwandan teachers for inclusiveness of education as articulated in the CBC framework (Rwanda Basic Education Board, 2015b) to sustain the curriculum expectations. A similar survey study revealed that factors such as availability of teaching and learning materials, distance covered by day school learners from home to school, and absenteeism of learners affect the academic achievement of students in Twelve-Year Basic Education in Rwanda (Sibomana, Nicol et al., 2021).

Cooperative learning instructional strategy has been approved to improve students' academic success in chemistry worldwide; for example, in a study conducted in the United States (US) by Canelas et al. (2017) found that cooperative learning teaching approaches allow students to develop their critical thinking, enhance scholastic achievement and practice the transferable skills valued by employers; these findings are not far from that of Yeung and Coe (2015) in the United Kingdom (UK). In addition, the study of Sunggingwati (2018) in Indonesia also revealed that this innovative teaching method increases students' achievement in an EFL context while in the Philippines, Gamit et al., (2017) reported its effectiveness in mathematics; this qualifies cooperative learning to be effective, not only in chemistry but in other subjects. In Nigeria, Yusuf (2014) revealed that CL in teaching chemistry concepts enhances students' achievement and reduces their anxiety. Also, CL has been approved to enhance students' achievement in other subjects such as biology. Such practice was seen in a study conducted in Kenya by Muraya and Kimamo (2011).

The performance may be due to the way we designed our teaching intervention. For instance, while the experimental group was taught using CL, the control group was taught using CTM. Lectures characterized the CTM (in the comparison group classrooms), the unstructured group works, chalk and talk, and the question-and-answer techniques. The commonly observed practice was having students sit in rows and columns while listening to a teacher's lecture, after which a class exercise was given, followed by the evaluation of students' work. When the time was not enough to give and mark a class activity, homework was given, and students' work was to be checked before the presentation of the next lesson.

In the CL approach (experimental group), every lesson began with a teacher's short presentation by recalling what was previously taught and introducing new material to the entire class. After the teacher's presentation, students were split into different heterogeneous groups of 4 to 6 students, depending on the size of the class. These groups were heterogeneous in chemistry ability, gender, and any special needs to enable the less-able students to seek clarification from the more knowledgeable students without fear and enhance the learning by scaffolding. In line with socio-constructivism, the CL approach was meant to enable students to construct new knowledge based on their prior knowledge with support from peers and social interactions (Vygotsky & Cole, 2018). Hence each student gets the opportunity to justify his/her ideas or reasoning to peers until consensus among group members was reached. After group discussions, students were given tasks in class exercises or quizzes to strengthen their planning capacity, managing and monitoring their works within the group. Quizzes were given every week while class exercises and/or homework assignments were given for every lesson; the facilitator (teacher) was passing at every group during class tasks, helping in case need be and monitoring the participation of every group member. If students were asked to present, every group member was ready to answer questions, and the award or recognition was for all group members.

Learning cooperatively is one of the extensive and productive areas of theory, practice, and research in chemistry instruction when it is effectively applied (Oludipe & Awokoy, 2010). Contemporary wisdom regarding the instruction of chemistry identifies a need for teaching methods that will stimulate the learner. Such a method should inspire the learner to become cognitively engaged in understanding the topic being taught. This point of view can be justified from the socio-constructivist perspective (Vygotsky & Cole, 2018) on learning which has become one of the most influential learning theories and contrasts the lecturing method (Ramsook, 2018).

Conclusion

Constructed on the findings of this study, it is concluded that cooperative learning was highly potent or effective in promoting in-depth learning of organic chemistry and enhancing the achievement abilities among chemistry students.

There was a statistically significant difference between a group of students taught with cooperative learning and those taught with conventional teaching method (F=78.07, df=1, 256, p<.001). Cooperative learning (CL) was effective in enhancing chemistry students' academic achievement of organic chemistry concepts than conventional teaching methods (CTM). Specifically, our study revealed that either CL approach or CTM allow both males and females to perform similarly.

Recommendations

In this study, there is evidence that cooperative learning enhances students' academic achievement than conventional teaching methods. Therefore, chemistry teachers and educators should adopt a cooperative learning approach in teaching organic chemistry and other abstract and difficult concepts in chemistry to promote and enhance students' educational achievement. Education stakeholders should organize Continuous Professional Development (CPD) to acquaint chemistry teachers with cooperative learning for holistic learning. Further studies should focus on checking the retention to track the continuous performance and potential of the CL approach. They should also further analyze our CAT for conceptual learning over rote memorization.

Limitations

This study was limited by using only day school students as the sample and did not cover all districts (it was conducted only in two districts over thirty of Rwanda). Therefore, these limitations lead well to future research.

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Authorship Contribution Statement

Sibomana: Concept and design, drafting manuscript, data acquisition and analysis, interpretation. Karegeya: Critical review of manuscript, statistical analysis, interpretation, supervision and final approval. Sentongo: Editing, reviewing, interpretation, supervision and final approval.

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