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Research Article

The Contribution of Using Cooperative Learning Methods on Students' Achievement and Retention in Secondary Schools during Chemistry Lesson

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This investigation was made necessary as a result of the inconsistently poor achievement that secondary school students have repeatedly achieved on chemistry exams in Nekemte Administration Town throughout the years. These poor results can be credited with the reality that the majority of secondary school teachers use ineffective teaching strategies that do not encourage students' active learning through involvement. Therefore, this investigation examined the contribution of cooperative learning on high school students' chemistry achievement and retention. Quasi-experimental research with a pretest–posttest nonequivalent control group design was adopted. One hundred twenty-eight students were involved, drawn from two intact classes in two different schools. A reliability value of 0.89 for the chemistry achievement test was employed. The findings of this investigation demonstrated a significant difference between students instructed through cooperative learning and students instructed using lecture-based teaching in terms of their chemistry achievement and retention (t (126) = 5.544, $p < 0.001$) and (t (126) = 4.167, $p < 0.001$), respectively. Pretest, posttest, and retention test results of the treatment group showed a significant difference that favors the posttest ($r = 0.91$, $p < 0.001$) and retention test ($r = 0.81$, $p < 0.001$). Gender differences did not exist in chemistry achievement (t (62) = −1.243, $p < 0.001$) and retention (t (62) = −1.036, $p < 0.001$).

1. Introduction

Solving the problems that mankind is currently confronting requires the active participation of a scientifically and technologically informed society [1]. Accordingly, the goal of science instruction should be to create a population that is systematically knowledgeable in science and able to use their understanding in order to create cognizant judgement vis-à-vis the products of science and technology in their daily lives having the capacity to analyse public discussions and render more careful judgments on controversial socioscientific concerns [2]. Several nations thus started initiatives to promote the growth of natural science at high school and tertiary levels [3–5].

Unfortunately, because of the low performance of children in school sciences, expectations have seldom been met. [6]. Chemistry student performance in the majority of schools has consistently been low in various nations (e.g., [1]). Achieving the national goals for scientific and technological progress may be negatively impacted by the students' consistently poor performance in chemistry. Ethiopian secondary school pupils do poorly in science, particularly chemistry, as compared to other courses [6]. Most research came to the conclusion that instructors' selected methods of instruction were mostly the reason for the poor performance of students [1]. Based on the findings of the research, most chemistry students receive instructions through inefficient methods, while some succeed on exams despite having severe misconceptions about certain chemical reactions [7–10]. The traditional method of instruction that is frequently used to teach chemistry has not been able to meet the needs of contemporary students. This method prevents educators from sharing knowledge without the students' active involvement [4, 5].

The utilization of ineffective teaching strategies is one of the elements identified as being blamed for inconsistent poor achievement [2, 11]. They insisted that instructors may control the variable of teaching strategy to raise retention and achievement rates. It is not more successful to teach chemistry when teachers employ explanatory techniques that are essentially teacher-centered. Fatokun et al. [12] showed that 60% chemistry teachers in secondary schools in Nigeria employ lecture-based delivery of teaching, which includes teacher-led experiments as well as results in students being apathetic students.

To help learners become more analytical in their thinking and to help novice learners understand ideas in chemistry, instructors must use innovative methods of instruction [13, 14]. When instructional and pedagogical circumstances demand it, cooperative learning strategies must be applied to make chemistry more relevant, enjoyable, easy, and valuable for students [9]. Engaging pupils in social interactions promotes effective learning. One of these teaching strategies is cooperative learning, which enables students to pick up knowledge from one another that they would not have acquired directly from teachers. These methods can also boost students' academic performance by strengthening their intellectual grasp of the material [14].

Cooperative learning has emerged as a prominent and productive field in educational philosophy, application, and practice. This teaching method involves teachers assigning students to small groups where they collaborate and support one another in learning academic material and achieving a shared objective. It is evident from theoretical views that cooperative efforts are necessary to maximize academic achievement and retention in addition to many other significant educational results.

Academic achievement is the term chosen to describe the real outcomes that students in a certain year of schooling attain at their specific educational institution [15]. Researchers often use semester marks, which are grades in letters derived from the semester cumulative average, to assess the progress of learners [16]. In order to evaluate students' academic success, for instance, the majority of studies worldwide employed the cumulative average for secondary schools or the GPA for education institutions [16].

Retention is a crucial learning outcome that should be attained together with other learning goals. It deals with how long students can remember and recall scientific material that has been presented for a given amount of time [17]. This component depends on how well the ideas under study are understood. Since it provides a solid basis for a nation's development, student retention is the top priority for all educational institutions [18]. The purpose of the retention exam is to assess students' long-term memory and knowledge retention skills [17]. In the past, there has been limited attention paid to student retention certain findings indicate that students have a low capacity for retention [17]. It has been stated that educators and educational institutions have not implemented a comprehensive approach to improving students' retention [17]. According to other reports, low concept mastery some of which was brought on by incorrect learning outcomes influences low student retention as well [19]. Consequently, when knowledge about a particular concept or topic is not preserved, poor performance and accomplishment may follow. According to Murniati et al. [17], low retention in high school is caused by students' poor performance in subjects related to science, like chemistry, regardless of gender. In other words, students' low science achievement and retention rate do not significantly differ from one another in science courses. Therefore, effective choice and use of cooperative instructional strategies may improve students' performance and retention abilities in chemistry.

Cooperative learning has a lot of benefits. Initially, cooperative learning takes advantage of resource and goal interdependence to guarantee group members' participation and interaction. It is easier to create this social atmosphere where students may learn through interaction when the teacher takes on the role of facilitator rather than lecturer. Learners that participate in cooperative learning have more peaceful relationships with their peers, as well as improved acceptance and understanding of diversity and social and interpersonal abilities. It encourages students to actively participate in the process of creating knowledge, which in turn fosters a growing interest in the field [3, 5]. In the learning process, collaboration differs from competition. Positive interdependence, or cooperation, leads to creative interactions where people support one another's educational endeavors.

On the contrary, oppositional interaction, which occurs when people hinder one another's learning efforts and cause a deterioration in relationships, is typically the outcome of competition, which is a form of negative dependency. While noncooperative practices lack the intrinsic motivation that allows students to support one another in achieving shared goals, cooperative learning is intended to provide rewards to pupil groups who collaborate to accomplish a task. Chemistry is one of the scientific courses taught in high schools where cooperative learning is most useful.

Cooperative learning utilizes a variety of methods and models. One may divide cooperative learning methods into two primary groups: formal group techniques and organized teamwork. In organized teamwork, members get rewards according to their progress in learning, and each member is held accountable, meaning that individual learning rather than collective output determines success. Student Teams-Achievement Divisions (STADs), Teams-Games-Tournament (TGT), and Cooperative Integrated Reading and Composition (CIRC) are forms of organized cooperative learning, though in various ways, all four methods include fair possibilities for achievement, individual accountability, and team benefits.

In the present investigation, Student Teams-Achievement Divisions, a single cooperative learning technique, has been used. According to Slavin [20], this methodology works best when teaching clearly defined objectives including science knowledge, theories, mathematics calculations, and implementations.

Cooperative learning is primarily rooted in social interdependence, behavioral learning, and cognitive development theory [21]. Cooperative learning leads to cognitive development, where constructivist knowledge is developed and changed through group efforts to find, understand, and interpret [22].

According to behavioral learning theory, students are more likely devote themselves to cooperation if they receive a reward for it than if there is no reward [21]. Therefore, in cooperative learning contexts, when incentives for team productivity are intentional, it is important to see both individual and team benefits. Slavin [23] distinguished between the two main theoretical stances on cooperative learning: motivational and cognitive. While cognitive theories of cooperative learning highlight the welfares of cooperation, the motivational theories place more emphasis on the rewards that motivate learners to participate in educational activities.

Cooperative learning-related motivational theories emphasize goal and reward systems. Positive interdependence, when learners believe that their achievement or failure depends on their ability to cooperate as a group, is among the elements that comprise cooperative learning. Therefore, from the standpoint of motivation, cooperative goal arrangements create a setting wherein individuals of the team can only reach their goals. Individuals of the team can only accomplish their own objectives in the occurrence that the group is successful. Hence, in order to accomplish their own objectives, learners need to motivate others to take on all the tasks necessary to make the team successful and to support each other when working on a group activity. The developmental and elaboration models of cognition are the two theories that are directly applicable to cooperative learning [23].

According to developmental theories, student participation in relevant activities improves their understanding of important ideas [24]. Students have a greater understanding of the subject matter they are studying when they engage with their classmates and have an opportunity to clarify and debate one another's points of view. In the process of working together, attempts to resolve possible disagreements may lead to the growth of deeper understanding. Elaboration theory states that explaining the subject to someone else is one of the best ways to understand it. These strategies foster elaborate thinking. These improvements have the potential to improve reasoning quality, long-term retention accuracy, and depth of knowledge. Accordingly, from both developmental and cognitive theoretical perspectives, using cooperative learning techniques produced better students' learning and retaining knowledge.

Several investigations have been carried out concerning the impact of using the cooperative learning technique on students' academic achievement. For example, Sibomana et al. [14] investigated the impact of learning together technique in terms of students' performance during chemistry lessons. Three hundred seventy-two chemistry students and the chemistry achievement test served as the study's sample. According to the findings, learners in the treatment group, who were instructed chemistry with cooperative learning techniques, differed substantially from those in the teacher-dominated groups instructed through conventional strategies. Students in the treatment group did higher than the students that used the lecture technique.

Similarly, Okoli and Okigbo [9] studied the impact of cooperative learning as a method of instruction for teaching quantitative chemistry. His findings indicated a negligible achievement variation between the genders in cooperative learning, and also, the learners in the group did better than those in the conventional classroom instruction category.

According to some further research, cooperative learning not only increases achievement but also increases learning retention, as demonstrated by students' performance on delayed tests [25]. Tran [25], for instance, presents the average percentage of learning content retention over a 24-hour period for students who were taught using various instructional strategies. According to him, students retain 50% of the content they learn in a group discussion, 75% when they are asked to study by doing, and 90% when they instruct others. The traditional teaching strategies employed in most math classrooms seem insignificant when new concepts and content need to be addressed.

Chemistry was viewed as a challenging subject by both society and students. Less or no respect and gratitude from students toward instructors, as well as their lack of social standing and worth in the community, have an impact on the caliber of instruction and learning. The most important thing for teachers to do is to successfully teach their students so they can demonstrate high-quality academic achievement [26]. When ineffective techniques are employed, students encounter serious difficulties and surely do badly in school, putting doubt on the quality of instruction. For this reason, it is important to evaluate, find, and recommend ways to increase students' academic performance and retention of knowledge. This is due to the fact that education has to be improved because its quality has been rapidly declining. Therefore, it was this worry that inspired the researchers to look into this issue.

According to the education sector development strategy of the country, chemistry is one of the important disciplines that all students must learn. The government of the study area established the national program with the goal of strengthening science and math instructions. However, the students' experience in science instruction is not inspiring [27].

Parents, educators, testing agencies, counselors, and psychologists are extremely worried about the shocking rate of poor chemistry achievement [5, 14, 28, 29] and knowledge retention [17, 25]. Moreover, parents, students, and the government have all wasted a significant amount of resources.

According to the research of Onabamiro et al. [30], only a small percentage of secondary school students, especially in Nigeria, are able to continue their education at a higher education institution. This is similar to the study area's secondary school national examination result in which the situation is equally worrisome [28]. The percentage of youth who accomplish their goals and promote to the next grade on their own is insufficient, both in terms of the total number of students enrolled and the threat that all students received passing grades through improper assistance. For example, the agency of the national examination of the study area released the secondary exam results for the previous 2 years, which clearly show the unfavorable trend. According to Hagos and Andargie [28], the proportion of students in grade 12 who reached credit in chemistry for the previous

2 years, from 2021 to 2022, was less than 50%. The figures are 49.1% and 47.7%, respectively.

According to Belay et al. [2], Gambari and Yusuf [11], and Byusa et al. [31], this poor academic achievement and knowledge retention have been attributed to the instructors' use of ineffective teaching techniques.

Based on the findings that showed Ethiopian teachers were applying teacher-centered methodologies from lower to higher grade levels across the nation, the paradigm was shifted from teacher-centered to student-centered approaches in the education system to address the issue [32]. In keeping with a cooperative learning approach that fosters strong understanding and raises student achievement, critical thinking skills, and the effective organization of information, a shift to more modern teaching methodologies is required as the nation works to bring development to its people. However, as was previously indicated, instructors' experience with using cooperative learning approaches to provide lessons in Ethiopia has been relatively limited [32]. As a result, this may cause discomfort and low academic accomplishment.

One reason for Ethiopia's educational decline, particularly in natural science at the secondary level, is the lecture style that encourages rote memorization. Cooperative learning methods of instruction should replace the traditional method of instruction [33]. Furthermore, it is noted that secondary school pupils in the research region perform poorly in scientific classes, particularly in chemistry, based on the findings of local assessments that led to this study. The most significant factor influencing students' academic performance and retention of chemistry knowledge is the teaching approach.

Even though the delivery is intended to be task-oriented, chemistry teachers are using the talk and chalk approach to focus on instructing theoretical concepts, and principals at schools are just watching and taking this into consideration because it is the standard method of teaching chemistry [34].

Similar research has been conducted in the study area and found that the instructors' use of the lecture technique, which failed to meet the needs of current students [2, 28, 29], was a key contributing factor to students' low achievement and retention [1]. This has a negative impact on the capacity of learners to engage in the process of instructing and learning. One issue is that instructing chemistry using the wrong methods makes good facilities ineffective and makes concepts difficult to understand.

Numerous studies have generally been carried out and discovered that confirm the major effect students' chemistry achievement and retention have in terms of gender. Results on the disparities between genders in chemistry achievement and retention are uncertain and inconsistent [9, 17, 25]. As a result, it needs more investigation in this area.

Similarly, to assess how cooperative learning affects student success and retention, in the past, studies have focused on looking at the application of various techniques of cooperative learning, for example, learning together, alternative instruction, and jigsaw techniques [35]. However, these studies have not examined the Student Teams-Achievement Divisions (STADs) model, without considering a knowledge gap. Therefore, this investigation explores cooperative learning practices as a way of increasing students' achievement and retention in chemistry, particularly student's team achievement division cooperative learning strategy. It further aims to ascertain if male and female gender disparities exist in chemistry retention and achievement among secondary school student knowledge in the subject area.

2. Materials and Methods

2.1. Research Design. Quasi-experimental research with a pretest–posttest nonequivalent control group design was used. This design is seen as appropriate as it enables the researcher to compare student achievement and retention before and after interventions are made to the independent variable.

2.2. Population and Sampling Technique. The researcher selected Nekemte Administration Town as the research location using a convenience sample strategy because it was easily accessible, conveniently located, and readily available. Teachers and students of chemistry in grade 11 at public secondary schools participated in this study. Next, two government secondary schools Biftu and Dalo out of the six Nekemte Administration subcities were selected at random to serve as the target population. Next, a sample of one secondary school was selected at random from each of the two subcities. Consequently, Biftu and Dalo secondary schools were chosen as a sample of the study. Two intact classes within the schools were also chosen by random selection techniques, and the two sections were simply divided into two groups at random: two for treatments and two for comparison. A total of 128 students (64 students for the experimental group and the other 64 students for the control group) constituted the sample. Each experimental school comprised two sections in which Section I was represented as the experimental group, while Section II represented the control group in grade 11 chemistry classrooms as per the directives of the headmasters of the sample schools. Subsequently, two chemistry educators who possessed identical credentials and comparable teaching experience were deliberately selected.

2.3. Data Collection Procedure. Prior to the collection of data, the Jimma University College of Education and Behavioral Sciences' ethical review board granted ethical clearance (Ref: CEBS/Rp-1359/15). Using this ethical clearance, authorization was obtained from secondary school chemistry instructors and students to participate willingly and to anonymize their identities at the town administration level. Two teachers with the same qualification and same experience in teaching chemistry were selected from two schools and trained for 6 days on how to implement cooperative learning (STAD) for experimental groups using the PowerPoint presentation. Based on pretest results, groups of students with varying ability levels were formed; two poor achievers, one medium achiever, and one high achiever were chosen. There were eight groups in total, each consisting of four distinct individuals. Throughout the experimentation phase of this study, the tutors used two different methods of instruction. While students in the control groups got normal education, the experimental groups were treated using the STAD cooperative learning approach.

The researcher for this study began an intervention at two government secondary schools in February 2023 which lasted for two consecutive months and ended in March 2023. Cooperative learning was used to teach the three chemistry units—Fundamental Concepts in Chemistry, Atomic Structure and Periodic Table, and Chemical Bonding and Structure—to the experimental group's students. Additionally, both groups were given the identical chemistry textbook and content. The chemistry teachers at the two secondary schools also instructed students for the same amount of time in two different classrooms during the same timetable period. This was done in the morning session.

Chemistry is taught as one of the basic courses at all secondary school levels. It takes place four times a week for40 min each block. The two secondary schools' experimental groups received instructions for 40 min during the Monday morning session, whereas the control groups received the same instruction on Thursday during the morning session. A posttest was administered following the intervention's 8 weeks. The purpose of the posttest was to evaluate how well the intervention affected the participants' understanding of the subject covered in the three chemical units. Participants' answers to the exam items were scored. For analysis, the scores were noted. Four weeks later, the same retention exam was given to evaluate the sample participants' ability to retain the information. Finally, the data collected from 128 students were divided into categories. Statistical techniques, including independent sample t-tests and paired sample t-test analyses, were used to sort and compare the test results.

Students in the comparison group received the same curriculum and material in chemistry. These groups were ensured to acquire the same chemistry material and were also given identical exercises, activities, worksheets, and homework assignments. It took the same amount of time to finish each unit. However, the teacher's explanation, teacher-led questions and answers, and teacher-provided blackboard summaries were used to instruct these groups. The teacher also marked and commented on the assignments and in-class work completed by the students. However, no deliberate arrangements were made for learners to debate and clear their doubts, since it was customary for them to get comments one-on-one in these traditional sessions.

2.3.1. Intervention Phase (Implementation of the STAD Model of Cooperative Learning). The Student Teams-Achievement Divisions (STAD) model of cooperative learning was the intervention used. Due to its wide applicability and history of use in a variety of subjects from lower grades to higher institutions, STAD of cooperative learning is a practical choice for learning together [20]. However, the main justification for choosing the STAD cooperative learning model is that it has every component that is necessary for cooperative learning [20]. The STAD concept was implemented in five stages: teamwork, presentation in the classroom, quiz, evaluation and discussion of the quiz, and team appreciation.

(1) First Stage (Classroom Presentation). At this point, the researchers gave students a presentation of the information. They accomplished this by first defining the goals and then instructing pupils. If students want their team to win team awards, the researchers urge them to assist their colleagues in learning the content. The teacher instructed the class to support one another in giving it their all throughout this phase.

(2) Second Stage (Team Work). In the subsequent phase, the investigators assisted students in establishing diverse groups consisting of four individuals. The researchers urged students to do the assigned assignment in their diverse teams in order to meet the predetermined objective. This STAD stage's objective was to force students to study in groups.

(3) Third Stage (Quiz Conduction). At this point, students completed their own quizzes. Students were not permitted to assist one another while the quiz was being administered by the researchers. Students' independent work was stressed.

(4) The Fourth Stage. During this phase of the intervention, the researchers graded the quizzes and held a discussion to get additional information.

(5) The Fifth Stage. The STAD model ends at this step. At this point, the teams with the highest average score receive rewards from the researchers.

2.4. Control of Extraneous Variables. In this study, the investigators tried to reduce the impact of extraneous variables, which would have affected the results of the study. For instance, to minimize the communication/interactions of the experimental and control groups, which create a threat to internal validity, the researcher selected two secondary schools, because it was necessary to have distinct treatment diffusion for the experimental and control groups. In an experiment, researchers must maintain as much separation between the two groups as possible. For instance, if two groups of students from the same high school are engaged in an experiment, it may be challenging. The researcher also used the same pretest (before the experiment) and posttest (after the experiment) for both the experimental and control groups, covering all of the chosen chemical units in the same amount of time to reduce the influence of extraneous variables.

2.5. Instrumentation. The tools employed in this investigation to gather information were a pretest, posttest, and retention test. There were one hundred multiple-choice questions on chemistry in secondary schools on the teacher-made chemistry achievement test (CAT). This exam included four alternatives: A–D, with one choice being the right response, whereas the other three were distractors (wrong responses). Students were instructed to choose the right response by pointing to the matching letter. The purpose of the chemistry unit was to guide the construction of the chemistry achievement test. Conceptual enquiries from the grade 11 chemistry textbook's were chosen from three units Fundamental Concepts in Chemistry, Atomic Structure and Periodic Table, and Chemical Bonding and Structure make up the test.

The chemistry achievement test underwent both content and face validation in this investigation. To determine the chemistry achievement test's content validity, a table of specifications was produced. Additionally, when creating the test plan, consideration was given to how long it would take to cover each topic and what kinds of behaviors would be anticipated. The chemistry achievement test was created using a test blueprint and was taken using questions based on the application, understanding, and knowledge domains of Bloom's categorization system. Consequently, more questions were assigned to themes with a broad scope. The chemistry achievement test questions were verified by two qualified secondary school chemistry educators who have been instructing for more than 15 years, along with two chemistry lecturers from a particular university's college of natural science. The knowledgeable chemistry instructors were invited to go over the test's items and alternatives, evaluate if they follow the lesson plan's objectives and the subject matter, and judge whether the questions and options are clear and easy. Evaluation specialists from the study area confirmed it by describing the appearance of the CAT, the format in which the test items were delivered, the way in which they were typed, and the general layout of the exam. All advice from specialists and skilled educators in the field of chemistry was considered before taking the CAT.

2.6. Pilot Test. The validity of the instruments was evaluated and confirmed using two participant groups. The treatment and control groups were randomly allocated to these intact classes. The chemistry achievement test was given to two PhD scholars who have been teaching chemistry in a university and two secondary school chemistry teachers in order to verify its validity. The intent of the test is to evaluate the test's potency, the test items' relevance, clarity, and time required for completion.

The four academics thus closely examined and carried out item- and dimension-level analyses. They took all of the items without reducing their number after conducting a thorough study and making the necessary adjustments. While concentrating more on content and construct validity during their investigation, certain words and phrases were added, altered, corrected, and even removed to better match the context.

Forty possible participants were considered after the four scholars. These students were in grade 11. The instruments were administered to 40 of the chosen chemistry students who did not participate in the main research. The goal was to get student input on the suitability of the test construction, the degree of challenge of each item, and the amount of time required.

Reliability was established once the chemistry achievement test's validity was examined. These participants were similar to the study's target group but did not participate in the final data collection. These respondents were not the same as potential participants for validity checks.

As a result, two randomly selected groups of grade 11 secondary school students received 128 questions. All 128 of the provided questions were correctly completed and returned. Pilot test data from the instruments were computed using SPSS version 26. After applying Kuder–Richardson's formula 20 (KR20) to examine the first test result, a reliability measure for internal consistency of 0.89 was found. The test employed to collect data for research projects should have a reliability coefficient of at least 0.70, or may be higher.

2.7. Data Analysis. After being cleaned, the quantitative results were inserted twice into version 26 of SPSS. The quantitative data were examined utilizing both inferential and descriptive methods. Throughout the study, two-tailed values and the 0.5 α level were applied. The assumptions of the validation of the mediation analysis was achieved, and all parametric statistical criteria were satisfied. Additionally, the academic performance and information retention of the learners who were instructed through the STAD cooperative learning technique were compared with individuals who were instructed through the conventional approach using an independent means t-test. To identify influence of the intervention of the experimental group of students, a paired sampling t-test was used. In addition, Cohen's d was employed to assess effect size.

3. Results

3.1. Demographic Characteristics of Participants. This section included a brief discussion of the independent variable (pretest, posttest, and retention test) results of the chemistry achievement exam, which were collected from 128 students. Males made up ($N = 64$, 50%) and females made up ($N = 64$, 50%) of the total subjects. This implied that the proportion of male and female students was equal.

3.2. Contribution of the Cooperative Learning Approach to Chemistry Achievement. This section examined the effect of cooperative learning on the chemistry achievement scores of 11th-grade students in the intervention and control groups. Consequently, a t-test for independent samples was calculated.

The treatment group that learned chemistry through cooperative learning had posttest average scores of students' chemistry achievement that was ($M = 70.30\%$), and for the control group, which received traditional instructions in chemistry, it was ($M = 60.34\%$). Experimental group of students ($M = 70.30$, $SD = 10.471$) edemonstrated chemistry achievement levels that were statistically significant compared to the control group ($M = 60.34$, $SD = 9.832$) (t (126) = 5.544, $p < 0.001$).

Despite the statistical significance of our t-statistic, our effect is not practically significant, and it is necessary to apply our understanding of impact sizes to determine whether the effect is significant. Effect size may be manually calculated by obtaining a t-value and translating it to an r-value because SPSS does not directly calculate effect size. Consequently, the r-value showed 0.196, where the impact sizes indicates that benchmarks were relatively small. This indicates that there was a small disparity in the cumulative average among the learners in the treatment and control groups in chemistry. From this result, it could be inferred that even though there was a substantial disparity, the effect is not large, with the experimental group performing relatively better (Table 1).

This result substantiated the outcomes of Rabgay [29], Belay et al. [2], Okoli and Okigbo [9], and Sibomana et al. [14], in which they showed that cooperative learning increased students' achievement. Consequently, the observed significance level for the t-test ($p < 0.001$) is sufficient evidence to reject the null hypothesis since the results showed the mean scores of students educated chemistry with CL and those instructed with a usual teaching approach vary significantly.

Table 1: Results of an independent means t-test comparing the posttest results for students in the control and experimental groups ($N = 128$).

Test	Groups	N	df	Mean	SD	t-cal	t-cr	p-Value	α-Value	Cohen's d
Posttest	Experimental	64	63	70.30	10.471	5.544	1.660	0.000	0.05	0.196
	Control	64	63	60.34	9.832	—	—	—	—	—

Mean difference is significant at $p < 0.05$.

Table 2: Contribution of training to the experimental group of students' chemistry achievement ($N = 64$).

Tests	Mean	SD	95% confidence interval of the difference		t-Value	df	p-Value	Cohen's d
			Lower	Upper				
Pretest	27.88	5.884	−45.753	−39.091	−25.45	63	0.000	0.91
Posttest	70.30	10.471						

Mean difference is significant at $p < 0.05$.

Table 3: Results of an independent means t-test comparing the experimental and control groups' chemistry retention test scores ($N = 128$).

Test	Groups	N	df	Mean	SD	t-cal	t-cr	p-Value	α -Value	*Cohen's d*
Retention test	Experimental	64	63	54.31	13.116	4.167	1.660	0.000	0.05	0.12
	Control	64	63	44.70	12.972					

Mean difference is significant at $p < 0.05$.

3.3. Contribution of Intervention on Experimental Group of Students' Chemistry Achievement. Chemistry achievement scores for the experimental group of students was 27.88 on the pretest and 70.30 on the posttest out of a possible 100 (100%) points. According to the average results, the intervention or training increased the students' chemistry achievement.

The effect size value of the data of the experimental condition of students' chemistry achievement was a large effect size ($r = 0.91$). Given our effect size value of 0.91, it is possible to conclude that there was a large effect, as evidenced by the disparity obtained during the result of the initial test and after the posttest.

Given our effect size value of 0.91, it may be inferred that there was a significant impact and a notable variation in terms of pretest scores attained before and after the posttest results after intervention.

Moreover, the posttest result demonstrated the effectiveness of the intervention/training. The negative number, known as the t-value, shows that the pretest outcome for the first circumstance had a lower average outcome compared to the next posttest score ($t\ (63) = -25.45$, $p < 0.001$) (Table 2). Therefore, it is possible to infer that the training or intervention provided to the experimental groups improved the achievement in chemistry. The findings of this investigation also consistence with Altun [36] who discovered a considerable variation among the pretest results gained before and after the posttest result after intervention. Likewise, the findings of this investigation also consistence with Geletu [5], which suggested that treatment effects favor posttests with higher mean scores than pretest scores. These findings demonstrated that the experimental group's outcomes after receiving cooperative learning interventions differed statistically significantly.

3.4. Contribution of Cooperative Learning to Students' Chemistry Retention. This part identified the effect of the cooperative learning strategy on students' chemistry retention of 11th-grade students in the experimental and control groups. Consequently, a t-test for independent measures is calculated.

The treatment group that learned chemistry through cooperative learning had delayed posttest mean scores of students' chemistry retention of ($M = 54.31\%$), whereas the control group that learned chemistry through traditional teaching had delayed posttest average scores of ($M = 44.70\%$). Students in the treatment group ($M = 54.31$, $SD = 13.116$) showed substantially greater levels of retention of chemistry than the nonexperimental group ($M = 44.70$, $SD = 12.972$) ($t\ (126) = 4.167$, $p < 0.001$).

It is often advised to use effect size computation to determine the magnitude of the change because the difference was statistically significant. Thus, the students' chemistry retention's r-value was discovered ($r = 0.121$), where the effect sizes reflect these benchmarks were small. This indicates that there was a small distinction in the cumulative average in chemistry between the students in the treatment and control groups. This findings suggest that, despite being statistically substantial, there was a small variation across the student groups in the treatment and control groups, with the treatment group performing relatively healthier in terms of chemistry retention than the control group (Table 3).

Similar outcomes from investigations carried out by several academics were found in this study. As an illustration, the study supports the results of [17] showing that students instructed with cooperative learning methods retain knowledge more effectively than those instructed through conventional approaches. According to Tran [25], cooperative learning yielded higher long-term achievements compared to standard lecture-based teaching

Table 4: Paired sample t-test result of students' chemistry knowledge retention after training for the treatment group ($N=64$).

Tests	Mean	SD	95% confidence interval of the difference		t-Value	df	p-Value	Cohen's d
			Lower	Upper				
Pretest	28.30	5.705	−29.603	−23.272	−16.688	63	0.000	0.81
Retention test	53.84	10.756						

Mean difference is significant at $p<0.05$.

Table 5: Comparing experimental group of male and female students' chemistry achievement ($N=64$).

Gender	N	df	Mean	SD	t-cal	t-cr	p-Value	α-Value
Males	33	32	68.73	11.633	−1.243	3.18	0.219	0.05
Females	31	30	71.97	8.961				

Mean difference is significant at $p<0.05$.

methods. Similarly, according to Sari et al. [37], cooperative learning strategies promote students' active participation and the overall academic retention of the students.

3.5. Contribution of Training to the Experimental Group of Students' Chemistry Retention. Regarding chemistry retention, pretest and posttest results from 100% was 28.30 and 53.84, respectively. The mean results reveal that the students' chemistry retention result were improved after intervention/training.

The eta square value of the data of the experimental condition of students' chemistry retention was a large effect size ($r=0.81$). Given our effect size value of 0.81, it is possible to conclude that there was a high effect, as evidenced by the disparity obtained during the result of the initial test and after the retention test.

Additionally, the retention test result indicated the effectiveness of the intervention or training, as indicated by the negative t-value, which shows that the initial situation pretest result's mean was lower compared to the retention test (t (63) $=-16.688$, $p<0.001$) (Table 4). Thus, it may be concluded that the instruction or intervention provided to the treatment group of students improved the students' ability to retain chemistry knowledge.

3.6. Gender Difference between Experimental Groups of Chemistry Achievement. The male and female mean disparity between learners' chemistry achievement at the identified high schools is examined in this section to see if it is significantly different. Thus, the t-test analysis for independent samples was calculated below.

For both female and male students in the treatment groups, the posttest mean score for chemistry achievement was ($M=$ 71.97) and ($M=68.73$), respectively. The female experimental group outperformed the male group ($M=68.73$, SD $=8.961$), with a mean score of 71.97; SD $=11.633$ (t (62) $=-1.243$, $p>0.001$). However, there was no observable change. This may be the result of the cooperative groups' constructive interactions and positive interdependence between males and females, which foster comprehension and raise motivation and awareness in this discipline.

The result of this study agrees with research by Okoli and Okigbo [9], Geletu [5], and Achor and Bileya [38], who all support the opinion claims there is no disparity in academic success between genders in chemistry. Similarly, Sibomana et al. [14] discovered that exposures had an equivalent positive impact on genders' of the treatment group. Consequently, there were not any appreciable differences in genders of the experimental group, who attended cooperative learning strategies as treatments in terms of their average performance outcome (Table 5).

However, the results contradicted the findings of the research by Ekwam et al. [39]. Ekwam et al. [39] stated that there was a gender gap in science success because boys outperformed girls.

3.7. Impact of Cooperative Learning on Male and Female Students' Knowledge Retention. Regarding students' knowledge retention in high school in chemistry, this part investigated the existence of a substantial mean variation between the genders. Thus, the t-test analysis for independent samples was calculated below.

The experimental groups' average scores on the retention test for chemistry retention were ($M=56.06$) for female students and ($M=52.67$) for male students. Girls did better than boys in the experimental group ($M=56.06$, SD $=$ 13.132), with an average score of 52.67; SD $=13.085$ (t (62) $=-1.036$, $p>0.001$). Nevertheless, the average scores of the retention test in chemistry do not significantly differ in terms of gender. The result of this study consistence with research by Okoli and Okigbo [9], and Nzewi [40], Oludipe [41], who all support the opinion claims there is no disparity in academic retention between genders in chemistry (Table 6).

In contrast, Murniati et al. [17] found in their independent research that there was a substantial variation of an average knowledge retention in scientific disciplines in terms of gender.

Generally, there is still no agreement regarding gender's contribution to academic retention of science-related information, despite these conflicting studies supporting and contradicting it. However, the current investigation has not

Table 6: Comparing experimental group of male and female students' chemistry retention ($N = 64$).

Gender	N	df	Mean	SD	t-cal	t-cr	p-Value	α-Value
Males	33	32	52.67	13.085	−1.036	3.18	0.304	0.05
Females	31	30	56.06	13.132				

Mean difference is significant at $p < 0.05$.

shown any statistically significant impact of gender in terms of students' retention.

4. Discussion

This investigation examined the contribution of the cooperative learning method to secondary school students' chemistry achievement and knowledge retention.

The findings of this investigation revealed a substantial variation among the experimental and control groups of students in chemistry achievement ($t\ (126) = 5.544$, $p < 0.001$). Nevertheless, the magnitude of the difference ($r = 0.196$) was small. This indicates that there was a small disparity in the cumulative average among the learners in the treatment and control groups in chemistry achievement. From this result, it could be inferred that even though there was a substantial disparity, the effect is not large, with the experimental group performing relatively better.

This result corroborates other studies that found cooperative learning improved the attainment of learners [3, 5, 29]. This result further supports the findings of Sibomana et al. [14], who discovered a substantial disparity in the achievement average scores of the learners attending cooperative learning compared to those receiving instruction in traditional methods of teaching. Consequently, the observed significance level for the t-test ($p < 0.001$) is sufficient evidence to reject the null hypothesis since the results showed the mean scores of students educated chemistry with CL and those instructed with a usual teaching approach varied significantly.

The findings of the t-test were performed in pertinent groups to identify if the achievement on the pretest and posttests differed significantly after intervention. After analysis, the mean pretest score was determined to be 27.88, while the mean posttest score was discovered to be 70.30. Given that the significance level is determined ($p < 0.001$), the results of the posttest show a substantial variation from the pretest ($t\ (63) = -25.45$, $p < 0.001$). Using Cohen's d, one can determine the effect value, which is ($r = 0.91$). This value indicated the effect size is large.

The results of this investigation showed a substantial disparity in chemistry retention between the treatment and controlled groups ($t\ (126) = 4.167$, $p < 0.001$). But the variation between them was small ($r = 0.121$). This indicates that students of the treatment group performed well in achievement compared to the teacher-dominated group. Furthermore, students' retention average scores after a delayed posttest indicated learning together (CL) is fruitful in improving their retention, whereas the lecture-based instruction approach had the slightest impact on their chemistry retention. The STAD cooperative learning approach that was applied to the chemistry students participating in the experimental groups might have contributed to this result.

Similar outcomes from investigations carried out by several researchers were found in this study. For instance, Sari et al. [37], and Tran [25] claimed that students taught through the cooperative learning approach produced better long-term achievements than students taught with traditional techniques.

There are other possible explanations for the increase in students' academic retention ratings. These explanations are mostly features of the CL approach that supported efficient learning. First, Vygotsky and Cole [22] attribute this to the socially conscious learning environment of the CL method, which promoted efficient learning. Moreover, the experimental group's learning environment allowed students to collaborate, exchange ideas, and aid one another in their academic endeavors.

The relaxed atmosphere in the classroom, where students feel free to voice their opinions, ask questions, and get help from one another, is another aspect that may be responsible for the higher test scores. According to Rabgay [29], students can get a deeper comprehension of the topic they are studying by interacting with one other, exchanging ideas and perspectives, and offering and receiving assistance from group members.

Conversely, some investigations (e.g., [42]) demonstrated that the traditional lecture approach and the cooperative learning strategy had comparable effects in terms of retention on mathematical concepts. Likewise, Moreno [43] discovered no distinction in the retention of students between a conventional approach and the Jigsaw cooperative learning approach. This discrepancy in retention results may be the result of findings from several studies emanated from disparities in environmental factors, awareness, infrastructure, access, and environmental factors, among other things.

The findings of the t-test, which were performed in pertinent groups to confirm whether the outcomes of the initial test and the delayed posttest, vary significantly after intervention. It was discovered that the mean pretest score was 28.30 and the mean delayed posttest score was 53.84. Using Cohen's d to calculate the effect value, the effect size was ($r = 0.91$). The calculated effect size was greater than 0.80, and it was evident that the extent of the difference was large. As shown from the result above, it can be inferred that CL had a substantial influence on the result of the treatment group.

Regarding the disparity in chemistry achievement of students' gender of the experimental group, the findings indicated that there was not any statistically substantial disparity in the average of the chemistry achievement result of students' gender ($t\ (62) = -1.243$, $p > 0.001$). This recommends that irrespective of the teaching strategy, no gender variation existed in terms of their achievement.

The results of this investigation agree with those of Sibomana et al. [14] and Okoli and Okigbo [9], which indicated no substantial variation concerning an average achievement rating of students' gender who were educated chemistry by an inquiry-based instructional approach. Table 5 shows that the impact of gender, score level, and cooperative learning on learners' academic achievement did not differ significantly.

The contribution of implementing the cooperative learning method to knowledge retention of the treatment group of male and female students' exams is the other focus area of the investigation. The research findings suggest that there was no substantial variation in terms of genders with regard to their knowledge retention (t (62) = −1.036, $p > 0.001$). It suggests that there was no discernible disparity in genders' mean scores of the delayed posttest in secondary schools in chemistry.

It is possible to infer from the results that, when taught with cooperative learning, students' retention of chemistry information might be improved irrespective of gender disparities, since the current methodology proved to be more successful in this respect. The inference is that gender had no impact on the instructional strategy to increase participants' retention of the subject matter.

The results of this investigation are consistent with those of Okoronka [44] and Oludipe [41], who discovered in their separate study that the average knowledge retention rates for both male and female students do not substantially fluctuate when students are trained through cooperative learning.

In contrast to the results of this study and the previously mentioned findings, discovered that gender had a major impact on students' retention of the science field. In addition, Ezeudu [45] found that male students retained more information in scientific classes than female students. But the result of this study revealed no gender difference existed in terms of their knowledge retention in chemistry.

5. Conclusions

The result of this study was conferred along with the findings of other studies as follows. This study aimed to determine how cooperative learning practices affected students' academic achievement and knowledge retention in secondary school chemistry subject.

The findings of this investigation disclosed a substantiated disparity concerning the experimental and control groups' academic achievement (t (126) = 5.544, $p < 0.001$). Compared to the control group, the treatment group did better; nonetheless, extent of disparity was small ($r = 0.196$).

The results of this investigation showed that chemistry retention is substantial across the control and experimental sets of students (t (126) = 4.167, $p < 0.001$). Students in the treatment group did higher than the control group, with a relatively small effect size ($r = 0.121$).

According to the study's findings, the average disparity between gender respondents concerning their achievement (t (62) = −1.243, $p > 0.001$) was not substantial. Similarly, the findings of this investigation indicated that there was not any mean variation in chemistry retention that was a substantial variation in terms of gender (t (62) = −1.036, $p > 0.001$). In general, male and female students who used cooperative learning methodologies did not vary in terms of their mean academic achievement and knowledge retention scores, suggesting that the method of instruction is not gender sensitive. When the method is applied, both males and females were taking part equally in class activities.

Accordingly, this study recommended that cooperative learning seems to improve the academic achievement of learners and retaining of knowledge compared to conventional teaching methods. Consequently, in order to improve students' academic performance and retention of subject matter, teachers should use cooperative learning methodologies while teaching chemistry and other challenging and complex ideas in the subject. It is important that we motivate female students to pursue science-related careers. They can serve as mentors in cooperative science classes as well.

Data Availability

The corresponding author has access to the data utilized in this investigation. Therefore, upon making a valid request, it can be made available.

Additional Points

Limitations. Generalizations from this study are challenging, though, because of the small sample size and the fact that it was limited to two learning environments: two secondary schools with 11th-grade chemistry teams and one school subject. Moreover, since the convenience sample may not be representative of the population, using it might constitute a research restriction. Reexamining the study's findings thus requires taking these drawbacks into consideration.

Ethical Approval

The Institutional Review Board of Jimma University's College of Education and Behavioural Sciences authorized the ethical review and approval.

Consent

The subjects gave written, informed permission to take part in this investigation.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors' Contributions

Melkamu Duguma Simesso came up with the study idea, gathered and processed the data, and wrote the article. Tariku Sime Gutu made contributions to the study from the proposal's conception to the manuscript's review and approval. Starting with proposal preparation and continuing through article review and final approval, Wudu Melese Tarekegn participated in the study. The article's submission was reviewed and approved by all authors.

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