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EFFECT OF TASK-BASED LEARNING ON STUDENTS' UNDERSTANDING OF CHEMICAL REACTIONS AMONG SELECTED RWANDAN LOWER SECONDARY SCHOOL STUDENTS

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Abstract. *This study intended to measure the effect of Task-Based Learning (TBL) on lower secondary school students' understanding of chemical reactions. The study employed a quasi-experimental pre and post-test research design with eight intact classes of 369 students purposively selected from eight schools in two districts in Rwanda. The experimental group of four schools was exposed to the TBL method, while a control group of the other four schools was exposed to the conventional teaching method (teacher-centered). A chemistry test of a Pearson product-moment reliability coefficient of .643 was developed and used in both groups. The results of repeated-measures ANOVA revealed a significant effect of treatment on students' understanding of chemical reactions (p < .001) with a medium effect size (d = 0.357) in favor of the experimental group. Gender and school location variables were also analyzed. It was found that the interaction effect of experimental and gender was not significant (p > .05, d = 0.010). However, the effect was significant with the school location (p < .05, d = 0.026) in favor of students studying in rural schools. The results imply that TBL method improves students' understanding of chemical reactions. Recommendations were given to educational stakeholders to train teachers in this method and teachers to use it in chemistry teaching.*

Keywords: *chemistry education, chemical reactions, Rwandan lower secondary schools, students' understanding, task-based learning*

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Introduction

Creating a suitable learning environment for students and teachers is a major challenge facing education stakeholders, especially teachers. Learners centered techniques that promote active learning are the main practice for any country implementing a competency-based curriculum (CBC). These teaching techniques equip and prepare learners for their future careers in science and chemistry in particular. When properly used, active learning methods prepare citizens that are competitive for the world economy (Nsengimana et al., 2020). In chemistry education, more engaging methods are also emphasized. This is because chemistry is the most popular subject (Cardellini, 2012) due to its advantage of preparing students to pursue a career applied in many fields of life. It constitutes the center of global sustainable economic development through industrial applications. Despite the worldwide known application of chemistry, studies have revealed the learning difficulties of some basic chemistry concepts at the school level (Gongden et al., 2011; Lati et al., 2012; Supasorn & Waengchin, 2014). Among the reasons given includes poor teaching methodologies used by secondary school teachers (Sibomana et al., 2021).

Similarly, in a recent review of literature conducted on factors affecting secondary school students' attitudes toward learning chemistry, teachers' instructional methods are among the most factors positively affecting students' attitudes toward chemistry (Musengimana et al., 2021a). Consequently, the choice of the best teaching methods to meet the demands of the 21st century is still a burden to the education system. To this end, many studies have been conducted on different educational methods' effects on learning outcomes (Maxwell et al., 2015). Nevertheless, the existing literature indicates the persistence of students' low academic achievement in chemistry (Sibomana et al., 2021). Therefore, today's teaching and learning strategies that empower students with developed mental abilities, creativity, and innovation needed to boost the essential competencies must be emphasized. This builds the

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basis of developing effective, efficient, and innovative teaching and learning strategies to overcome barriers of poor understanding in chemistry. In this regard, the researchers opined that Task-Based Learning (TBL) would be a suitable teaching approach to improve students' understanding if used in teaching chemistry.

Task-based learning helps apply learned materials and knowledge transfer to realistic contexts. It helps to promote efficient and effective teaching of a particular subject. Task itself is a piece of classroom work provided to students during the classroom teaching process. It is regarded as the driving force that involves learners comprehending, producing, or interacting with the physical and social world to achieve a realistic outcome. In TBL, the task is central to the learning activity. Students are fully engaged in the learning process and construct their knowledge (Zhou et al., 2013). The teacher acts as a facilitator, guides students in doing the task by drawing attention to the discussions and makes corrections and adjustments to empower them with relevant skills. TBL favors collaboration among students. It helps students foster team spirit and allow reflection among students. Creativity, innovation, and problem-solving skills are developed among students while performing tasks in series from the easiest to the difficult (Tian et al., 2017).

Task-based teaching (TBT), also known as task-based approach (TBA), originated from language teaching, where learning assessment is based on task outcome instead of the accuracy of prescribed language forms. In Nunan's (2004) book, the definition of task generated two types of tasks. Pedagogical tasks performed by students in the classroom and target tasks referred to doing something outside the classroom and in the real world. Generally, there are three main categories of the task, as pointed out by Prabhu (1987), a guru of TBL. *Information-gap task* involves a transfer of given information from one person to another, a *reasoning-gap task that* involves deriving some new information from given information through processes of inference, deduction, practical reasoning; and *opinion-gap task* identifies and articulates a personal preference, feeling, or attitude in response to a given situation. Specifically, TBL involves three stages in the classroom: pre-task, while-task, and post-task; teachers were obliged to pass through all the said stages. In the pre-task stage, the teacher presents what is expected from the students and the lesson's objective, such as instructions and key competences to be developed. The task is conducted in a learner-centered environment since, during the while-task phase, the students perform given tasks in small groups guided by the teacher. In the final post-task, learners review each other's work and offer constructive feedback with the teacher's harmonization.

TBL was effective in gear learners' involvement (Carless, 2002), promoting problem-solving ability (Tian et al., 2017), and developing critical thinking (Zhou et al., 2013). It seems to be an appropriate active learning technique to put the learner in the center of learning. Comparing to other active teaching and learning approaches such as problem-based learning, inquiry-based learning, context-based learning, and project-based learning. Problem-based learning takes students through the experience of solving-problem, while TBL makes a task the central focus of a lesson. TBL is short-term, while project-based learning is for the long-term period. Inquiry-based learning is about discovering an answer (Lamanauskas, 2010), while project-based learning is about exploring an answer. Context-based learning uses real-life and fictitious examples in the teaching environment (Cigdemoglu & Geban, 2015), while phenomenon-based learning presents real-life problems and asks learners to actively discover the knowledge and skills required to solve them.

A quiet number of studies have adopted TBL in science education; however, few of them focused on chemistry, and almost none analyzed chemical reactions. For instance, Zhou et al. (2013) used California critical thinking disposition inventory to measure the effect of TBL in developing students' critical thinking during teaching and learning chemistry experiments, and Sanjaya (2018) developed physical-chemical teaching materials using a task-based learning model to avoid one-way learning delivery from lecturers to students. Chemical reactions have been reported to be difficult concepts by some studies. For instance, seventy chemistry teachers from forty different cities in Turkey were sampled for the study, and Kolomuç and Tekin (2011) found that even teachers possess misconceptions concerning the chemical reaction rate. Similarly, Özmen and Alipaşa (2003) analyzed students' difficulties understanding the conservation of matter in open and closed-system chemical reactions. Therefore, TBL was found effective to remediate such low understanding. We expect TBL to help improve chemistry learning in Rwanda because it meets the expectation of the current CBC implemented in 2016.

The usability of TBL follows social constructivism theory (Vygotsky, 1980). Constructivism is an approach to teaching and learning in which learning acquisition results from realistic tasks aiming to achieve specific objectives (Sarita, 2017). The theory explains the learning process considering four features: students' prior knowledge, active learning in place of passive learning, knowledge construction, and learning that depends on the social or physical environment in which the learner is living. Teachers should consider the prior knowledge of students that influences

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their new knowledge and allows them to practice the knowledge gained. They should be skilled in the subject content and flexible in their teaching methods, thereby creating learners with critical thinking skills to explain the taught content. Constructivism stresses students to determine how they will learn, allows them to evaluate alternative solutions to given tasks, and makes learning based on authentic tasks or realistic tasks (Amineh & Hanieh, 2015). The present study is built upon the social constructivism theory, in which the emphasis is placed mainly on the knowledge taught and how students learn it cooperatively. The theory relates to the teachers, the students, and the learning environment. The theory highlights that students' knowledge is well accumulated when they work together on a certain task. Therefore, the learning process gives learners a chance to respond to society's needs.

Conceptual understanding is defined as the learning outcome commonly measured by examinations or continuous assessment. In our context, understanding refers to the students' present performance levels measured in terms of scores in the assessment test. Then, if students perform a test well, it is likely that s/he understands the concept. Being optional to teachers, better instructional methods, properly used, lead to better understanding. Surprisingly, in most cases, teachers are still using inadequate teaching methods that invariably translate to students' low achievement (Byusa et al., 2020; Musengimana et al., 2021a; Sibomana et al., 2021). Research indicated that student achievement in science learning improves dramatically if students are active participants in constructing their knowledge (Freeman et al., 2014; Theobald et al., 2020). However, the consulted literature shows that the TBL method is also designed to make students active participants. This method has been extensively used in the learning of English, where it brought about positive results (Carless, 2007; Hismanoglu & Hismanoglu, 2011) and in medical education (Ozkan et al., 2006; Tian et al., 2017). Few studies revealed the effectiveness of TBL in Chemistry education (Zhou et al., 2013). In the light of the above discussions, the main purpose of the proposed study was to analyze the effect of task-based learning on students' understanding of chemical reactions in selected Rwandan lower secondary schools.

The following research questions guided this study:

1. To what extent does Task-Based Learning (TBL) improve students' understanding of chemical reactions in selected Rwandan lower secondary schools?
2. Is there any statistical effect of TBL on students' understanding of chemical reactions among male and female students?
3. Is there any statistical effect of TBL on students' understanding of chemical reactions based on the school location?

Research Methodology

Research Design

This study employed the quasi-experimental pre-test and post-test research design (Fraenkel et al., 2012) with eight intact classes. The experimental group was treated with TBL, while the control group was treated with the conventional methods. These are the normal teaching methods used by the teachers, mainly the ones highlighted in a study conducted by Musengimana et al. (2021b) to measure the most commonly used teaching methods in teaching chemistry in Rwandan lower secondary schools. Before the experiment, the pre-test was administered to both the control and experimental group. The teaching intervention lasted six weeks. Then, the same test was administered to the two groups as a post-test. The results were recorded and analyzed.

Research Sample

The target population of this study involved all S.2 (grade eight) students at lower secondary schools in the Gasabo and Rwamagana districts of Rwanda. The sample of this study consists of eight schools purposively selected in those two districts. The criteria of selection were based on the schools located in rural and urban areas. Thus, two schools in each district were rural, while the other two were from urban areas. Two schools (one urban and another rural) in each district were randomly assigned to the control group and the other two as the experimental group. The sample consisted of 163 students in the control group and 206 students in the experimental group giving a total of 369 students whom both did pre-and post-test.

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Intervention Delivered

Teachers in the experimental group were trained about TBL, and a sample of lesson plans was shared with them for effective implementation of TBL. Using the prepared lesson on categories of chemical reaction that was taught to differentiate a decomposition reaction from a combination reaction as an example, the teacher introduced the lesson by asking some questions relating to the chemical equation and explained what happened when a chemical reaction took place in the pre-task stage. In the while-task stage, the teacher explained some concepts of decomposition reaction and combination reactions. Then, s/he presented the task to students where s/he guided them to make a group of four members and asked them to write different elements and compounds on the pieces of paper. Each member was assigned the group's role, like the planner, the information collector, the data organizer, and the presenter. A fixed group leader was not set, and each member had to serve as the leader by turns to make each individual in the group actively involved in the task. In this stage, the teacher's role was to help learners set instructions to follow and facilitate (guide) them while doing the task by moving from one group to another to ensure guidelines are followed and give clarifications if needed about the decision taken by any group. Before harmonizing the work from different groups, two minutes were given to each group to present their work. Lastly, they were asked to combine elements or compounds in different ways to make a combination reaction or a decomposition reaction using their prior knowledge and the knowledge gained in the introduction part. Finally, the teacher helped learners in summing up what they had discussed in the post-task stage.

In the control group, teachers used the chalk and talk method, where most of the part was taken by the teacher explaining decomposition and combination reaction. While some students were following what was presented by the teachers, others remained inactive as they were not actively involved in the learning process. During group work activities, only talented students did the work while others copied it from their friends.

Instrument Preparation and Validation

The present study used the Chemistry Achievement Test (CAT). The researchers prepared the test referring to the available literature, Rwandan CBC textbooks, and daily experiences. The prepared questions were all in the unit of categories of chemical reactions taught at S2 school levels as listed in the Rwandan Chemistry syllabus (REB, 2015b). Section A consists of questions asking biodata and demographic characteristics of the respondents. Based on the above-listed criteria, 40 questions in section B and one question comprising ten sub-questions in section C were formulated at the validation stage.

The test was face validated by ten lower chemistry teachers. They were asked to check if each question was relevant and notify the difficult question by explaining why the question was difficult. Based on the reported difficulty index and wrong formulated questions, 15 questions were removed in section B. The remaining 25 questions of section B and one section C question represent the final CAT. The test was piloted before its implementation using the test-retest method to check its reliability. It was administered to 40 lower secondary school students who did not belong to the study sample. The same instrument was administered twice within a window of two weeks. Pearson product-moment coefficient was calculated using statistical package for social science (SPSS) version 23.0, and high reliability with r=.643 was found. The final 25 questions of section B are multiple-choice questions having one correct answer and three distractors. The one question of section C is a matching question with ten definitions in column A to be matched with the correct terms in column B (see Appendix A).

Ethical Consideration

The ethical permission was provided by the ethics board of the University of Rwanda College of Education (URCE). The authorization was taken from Gasabo and Rwamagana districts to collect data from schools. Also, each student and teacher signed a consent form of agreement to participate in the study.

Data Analysis

At a glance, the researchers had a sample of 430 students who at least sat for pre-test or post-test. Since researchers had to compare students pairwise, the students who only sat for pre-test or post-test were filtered out. School by school in both experimental and control groups was checked during the filtering process to find out

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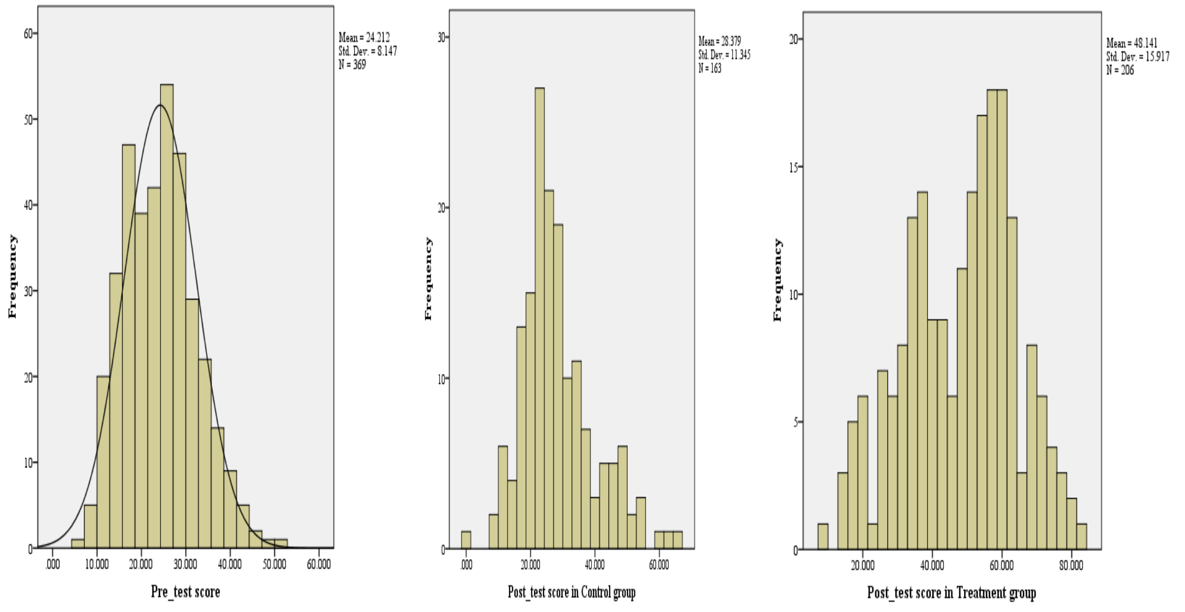
students who sat for pre-test but not for post-test, and these were filtered out. Again, students who sat for post-test but not for pre-test were also removed. After entering data and filtering them in MS Excel 2016, the analysis procedure of the kind of performance and conceptual understanding tests provided in the Ndihokubwayo et al. (2021) study was followed. The correct answers for each student across all 26 questions were computed. Scores were summed up, and percent scores were computed. These percentage scores with respective independent variables (control vs. experimental group, male vs. female, and urban vs. rural school) were exported into SPSS v.23.0. The histograms with the normal curves to test the normality of pre-test scores were plotted. The mixed analysis of variance (ANOVA) via analysis>>>general linear model (GLM)>>>repeated measures were computed.

Research Results

First, the histogram to check the normality of students' scores before and after the intervention was plotted. This helped us confirm one of the assumptions of using parametric tests such as t-tests and ANOVA. Before teaching and learning chemistry, students normally distributed scores with a 24.21% mean score and 8.14% standard deviation. Thus, many students are concentrated in the center of the histogram (see Figure 1).

Figure 1

Histogram Showing Students Score Distribution at Pre-test (The First Figure on the Left) and Post-Test (The Middle and First on the Right Side)



While students got low average scores at pre-test, the situation was changed after learning chemistry. The right side of the figure shows students' distribution of post-test scores (after learning). Although the average score increased (Mean of 39.41), students' scores were found scattered, tending to form two distinct normal curves. This is shown by the standard deviation, which increased to 17.15.

Figure 1 provides an insight into students' performance descriptively. One can see that post-test students performed better than pre-tests as some students upgraded to 80% in post-test while none reached 60% in the pre-test. However, this was not conclusive. Further, inferential statistics were computed to measure the statistical significance between students' groups (control and experimental) depending on the teaching intervention provided. Table 1 provides repeated measures and univariate ANOVA results.

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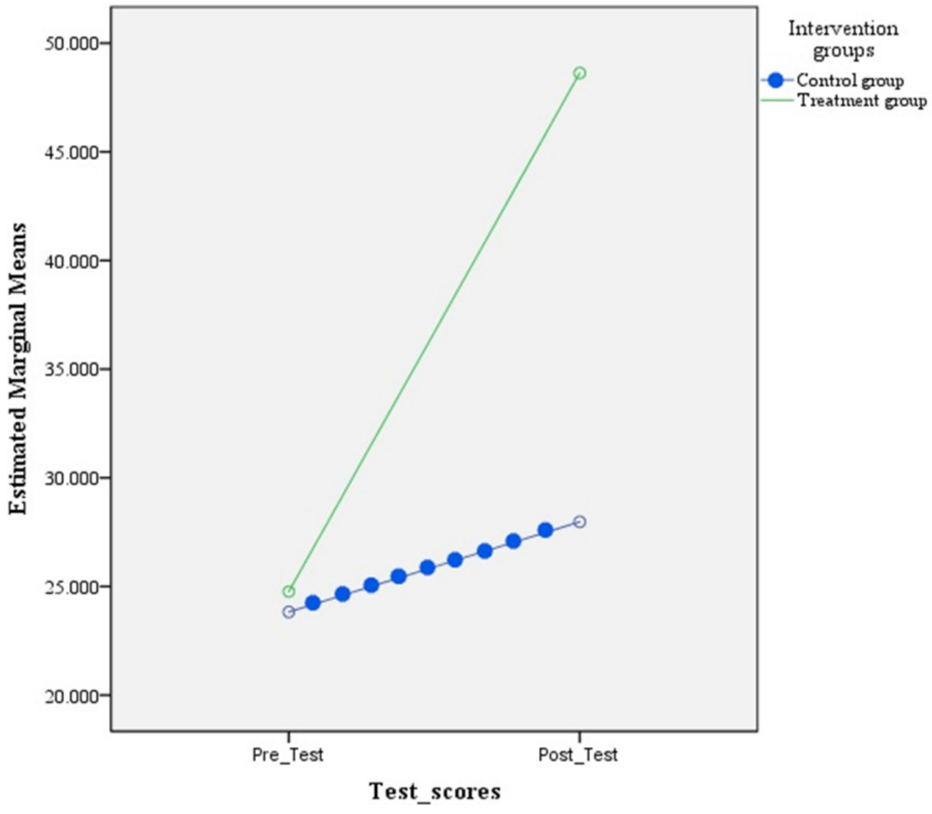
Table 1
Multivariate Tests

Effect	*M*	*SD*	*N*	*df*	*p*	*d*	Hypothesis
Test scores (both Pre-and Post-test) * Intervention groups (control vs experimental)	28.37 vs 48.14	11.34 vs 15.91	163 vs 206	367	< .001***	.357	Reject
Post-Test scores * Gender (male vs female) in Control group	28.51 vs 28.35	12.36 vs 10.45	78 vs 85	161	> .05	.000	Retain
Post-Test scores * Gender (male vs female) in Experimental group	46.49 vs 49.45	14.91 vs 16.66	94 vs 112	204	> .05	.015	Retain
Post-Test scores * Area of school (urban vs rural) in Control group	24.08 vs 31.61	9.33 vs 11.68	70 vs 93	161	< .001**	.419	Reject
Post-Test scores * Area of school (urban vs rural) in Experimental group	42.38 vs 55.15	16.48 vs 11.97	113 vs 93	204	< .001**	.424	Reject

*Statistical significance ($p < .05$), **high statistical significance ($p<.01$), ***very high statistical significance ($p<.001$), M: Mean or average, *SD*: standard deviation, *N*: sample, *df*: degrees of freedom, *p*: significance or *p*-value, *d*: effect size

By comparing both pre-and post-test scores of students in both control and experimental groups, a very high statistically significant difference was found ($p < .001$) in favor of experimental group (those who learned with task-based learning method). Therefore, the null hypothesis was rejected as there is a significant difference in the mean scores of students taught chemistry using TBL and those taught using CTM. Figure 2 shows that both students were at the same level before learning. However, the experimental (treatment) group gained higher scores (see green color in Figure 2) with a medium effect size (d = .357 or 35.7%) after learning, as Table 1 presents.

Figure 2
Visual Effect of TBL between Control and Experimental Group



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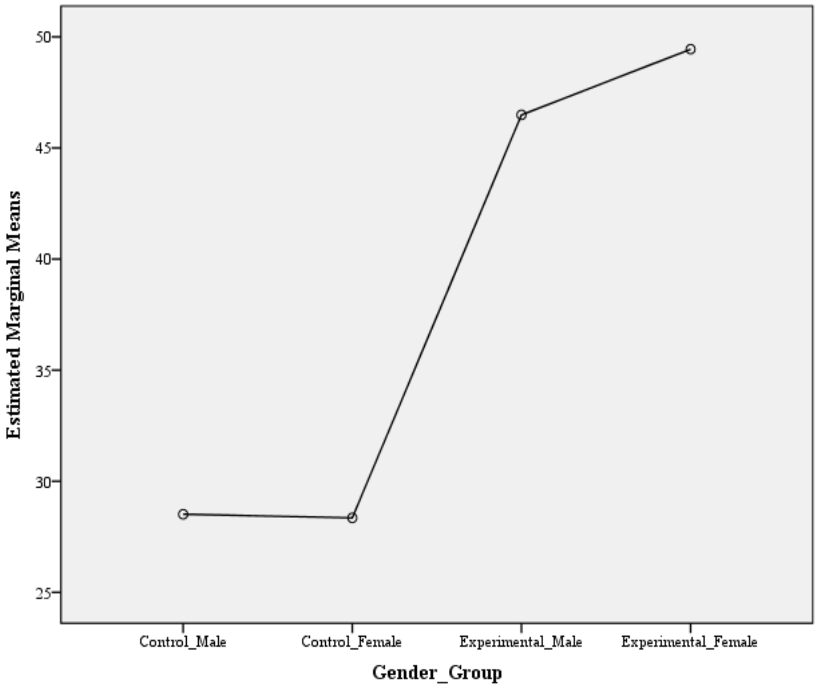
By comparing both post-test scores of students among males and females, the *p*-value was found to be 0.942 in the control group and .134 in the experimental group, greater than 0.05. Therefore, the null hypothesis was retained as there is no statistically significant difference in mean scores of male and female students taught chemistry using TBL. Figure 3 shows that both students were at the same level before and after learning. However, female students outperformed male students after learning (see Figure 3) with a low effect size (d=.015 or 1.5%) tough; the difference is not statistically significant, as Table 1 presents.

Figure 3
Effect of TBL on Gender



Comparing both control and experimental group post-test scores of students from urban and rural schools, a high statistically significant difference was found ($p < .001$) in favor of students from rural schools.

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Figure 4
Effect of TBL on School Location

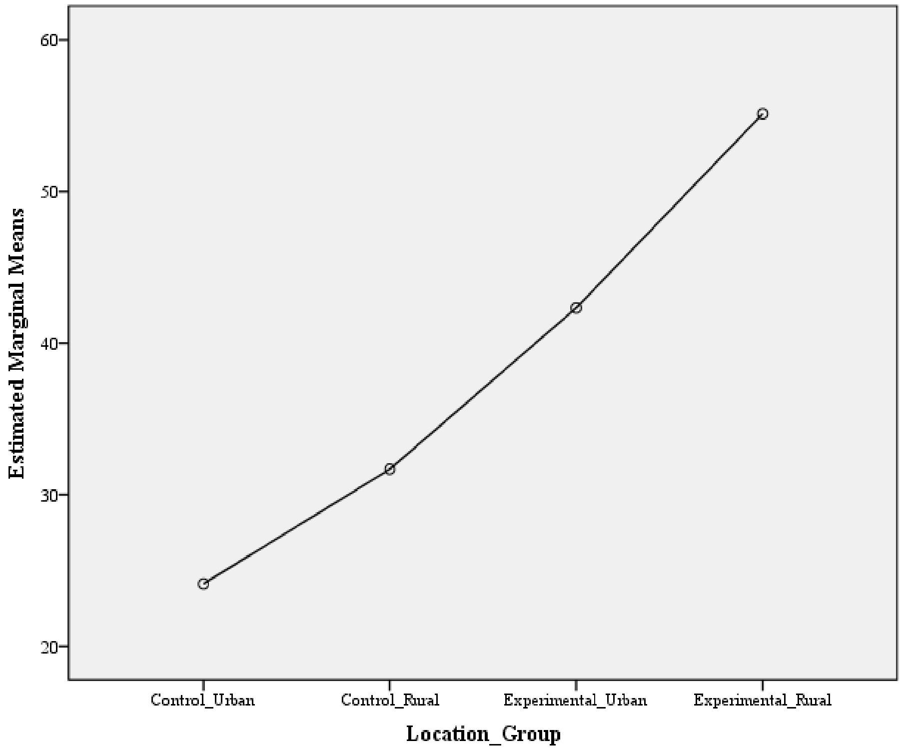

Figure 4 shows that both students were not even at the same level before learning. However, students from rural schools gained higher scores (see Figure 4) with a medium effect size (d = .424 or 42.4%) after learning, as Table 1 presents.

Discussion

The study intended to test the effect of task-based learning (TBL) of chemistry among Rwandan lower secondary school students in the topic of the chemical reaction. It was found that both students in control and experimental groups were at the same level before learning. The effect of learning through TBL was released by the increase in mean scores and the effect size of these scores after learning as elucidated by post-test results. The mean scores and the effect size were higher in the experimental than in the control group. Therefore, TBL was better than the conventional teaching method (CTM).

The effectiveness of TBL used in the present study may be attributed to the learning strategy used while implementing TBL. This study shows that students perform better when they can actively participate in the learning process. As students work towards task realization, their brain retains more. Through the interaction between student and student, and student and teacher, as in a social constructivism theory (Powell & Kalina, 2009) dedicate, more parts of the brain are activated through listening, writing, and moving around if necessary. These allow students to learn faster and deeper than listening passively.

Moreover, while grouping students in the group to perform a given task, the teacher considers the more inclusive activities, helping the all-group members actively participate without focusing on only the most talented students to lead the group. This will help all the students in the group develop a good understanding of the concepts being learned after completing the task. In addition, each student is assigned the role to perform in the group while performing the task. For instance, one student may first balance the equation while writing the ionic equations. The second may split dissolved ionic substances into separate ions. The third may look for the spectator ions and cancel them to make a net ionic equation. The fourth may write a report on that and present it to the rest of the class. The role assigned to the group members like a leader is not restricted to one student for an extended

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period; rather, it circulates among the students to make each participant responsible for the task being conducted. This favors the active participation of each individual in the group and leads to a better understanding of the concept taught. This idea is opposed to that of normal group work in which only talented students in the group are conducting the activities while others remain unresponsive and lose interest in the learning process. To them, the learned content becomes more complex as they have not been involved in the construction of knowledge (Byusa et al., 2020; Sibomana et al., 2021). TBL method was therefore found to improve the understanding level of students in chemical reactions in the present study. The findings of this study are in line with those of Qing et al. (2010, 2013), in which TBL was found to develop students' critical thinking disposition in chemistry experiments and students' critical thinking skills.

As it was found in this study, grouping students to perform a task does not increase their performance, but it stimulates students' curiosity, as Kibga et al. (2021) pointed out. High school students in the TBL group raised scores in performing experiments compared to traditional groups (Qing et al., 2010). Two main misconceptions arose while investigating the students' understanding of chemical reactions. The first that "the total mass increases in a precipitation reaction because the precipitate produced is solid and it is heavier than a liquid," and the second was that "when a chemical combustion happens in a closed system, the total mass decreases" (Özmen & Alipaşa, 2003, p.1). Cigdemoglu and Geban (2015) revealed that supporting conceptual understanding is challenging, and while integrating the 5E model, students improved their understanding of chemical reactions. Likewise, web-based discussion (Iyamuremye et al., 2021) and web-based simulation (Olakanmi, 2015) accelerated students' understanding of chemical reactions.

The effect of TBL was also analyzed on two variables: gender and school area. It was found that gender does not affect students' understanding. The plausible explanation for this observation is that the TBL method favors both males' and females' active participation as the distribution of tasks among the group is not gender-sensitive. Each individual performs a given task equally to understand the learned concept after completing work effectively. The equal performance observed among male and female students may also lie in the fact that the Rwandan CBC put much emphasis on cross-cutting issues in which gender is included. Gender issues need to be addressed across subjects. It enables girls and boys to acquire their knowledge, skills, and talents without discrimination and improves equality and quality of education (REB, 2015). This result corroborates the findings of Olatoye et al. (2011), who also found that the interaction effect of gender was not significant when co-operative and individualized teaching methods were used to teach organic chemistry on senior secondary school students.

However, the school's location significantly affected students' performance in favor of rural areas both in control and experimental groups. Thus, students in rural schools outperformed their counterparts at urban schools both before and after learning. Therefore, the hypothesis that schools in Rwanda perform similarly was rejected. This may be because schools in rural areas are located in good environments where students do not face more disturbance as it is in an urban area. Moreover, schools in urban areas are overpopulated, which hinders effective learning. It requires more effort and time for the teacher to facilitate more than 60 students in the classroom. Contrariwise, in the Ndihokubwayo et al. (2020a) study, students in urban schools performed better than those in rural schools during learning via PhET simulations and YouTube video instructions.

Conclusions and Implications

This study confirms that the TBL method has the most significant effect on students' understanding of chemical reactions. There is a significant difference between the understanding level of the students treated with TBL and those exposed to CTM. The results showed that this method is most engaging for males and females. In addition, this method showed the difference in students' understanding of chemistry located in rural and urban areas. Students in rural areas outperformed their counterparts in urban areas; however, a causal-comparative study should be done to support this outcome. It is evident to conclude that TBL as a student-centered approach is an efficient method in teaching and learning chemistry to improve students' understanding. This study is more important as it proves the existing body of knowledge that TBL contributes to better learning outcomes. Therefore, it provides insight to teachers and educators on the effectiveness of TBL in the context of Rwanda and how it can be applied in the learning of chemistry. Therefore, the study recommends that the chemistry teachers expose the students to TBL methods to improve their active engagement and understanding levels. In addition, more support should be provided to teachers through training, workshops, and seminars to acquaint them with the adequate skills necessary to implement TBL and other active learning methods.

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Declaration of Interest

The authors declare no competing interest.

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Appendix A

CHEMISTRY ACHIEVEMENT TEST (CAT)

Dear participant,

Thank you for your willingness to participate in this study. We are researching the effect of task-based learning on students' achievement and attitude in chemistry in lower secondary schools in Rwanda. This questionnaire is designed to collect information about students' achievement in chemistry, especially on chemical equations. You are kindly requested to answer all items in this questionnaire. Since the findings of this research will serve the academic purpose only, the provided information will be treated with confidentiality and anonymity as it is also agreed in the consent form.

***Section A*: Demographic information**

Time: 40 MIN

1. Student's Names: …………
2. Gender: Male ☐ Female ☐
3. Age: ………
4. Name of School: ………..
5. School location:……….

***Section B:* Multiple choice questions**

Tick (V) the appropriate option in the following:

1. What is a chemical reaction?
   d) A shorthand way to represent the components of a chemical reaction
   e) Process in which some substances change into different substances
   f) Process in which reactants change into products
   g) All the above

2. Which of the following is not evidence of chemical reaction?
   a) Change in color
   b) Evolution of gas
   c) Change in state
   d) Formation of precipitate

3. Which of the following represents a chemical equation?
   a) $4H_2O$
   b) $3C_2H_6$
   c) $CO_2 + 2NaCl$
   d) $2H_2O \longrightarrow 2H_2 + O_2$

4. The word equation of the following chemical equation:
   $Fe(s) + S(s) \longrightarrow FeS(s)$ is
   a) Iron filling react with Sulphur powder to produce a black compound of iron sulphide
   b) Iron powder is heated with Sulphur powder to form iron sulphide
   c) Iron fillings mix with Sulphur powder to give iron sulphide mixture
   d) (a) and (b) are correct.

5. Choose the correct statement(s).
   a) Magnesium is able to displace copper from copper sulphate
   b) Zinc cannot displace copper from copper sulphate
   c) Iron cannot displace copper from copper sulphate
   d) Silver is able to displace copper from copper sulphate

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6. Which one of the following reactions is a synthesis reaction?

a) $CaCO_3 \longrightarrow CaO + CO_2$
b) $Fe + O_2, H_20 \longrightarrow Fe(OH)_3$
c) $NaOH + HCl \longrightarrow NaCl + H_2O$
d) $Cl_2 + ZnI_2 \longrightarrow ZnCl_2 + I_2$

7. For the equation: $xPb(NO_3)_2 \longrightarrow yPbO + zNO_2 + w\,O_2$. The values of **x, y, z,** and **w** for a balanced equation are:

a)	a.	2	3	3	1
b)	b.	1	4	2	3
c)	c.	2	2	4	1
d)	d.	2	4	2	1

8. The net ionic equation for the equation:

a) $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \longrightarrow 2\,NaNO_3(aq) + BaSO_4(s)$ is
b) $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$
c) $Na^+ + NO_3^- \longrightarrow NaNO_3$
d) $Ba^{2+} + 2NO_3^- \longrightarrow Ba(NO_3)_2$
e) $2Na^+ + SO_4^{2-} \longrightarrow Na_2SO_4$

9. The double displacement reaction involves the reactions like:

a) Precipitation reaction
b) Reduction of CO_2 to CO
c) Neutralization reaction
d) a and c are correct

10. One of the following reactions is not a combustion reaction; which one?

a) $Ca(OH)_2 + CO_2(g) \longrightarrow CaCO_3 + H_2O$
b) $4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$
c) $CH_4(g) + O_{2(}g) \longrightarrow CO_2(g) + H_2O(g)$
d) a and b are correct

11. When writing the exothermic reactions, the energy change of the reaction is:

a) Sometimes negative
b) Always positive
c) Either positive or negative
d) Always negative

12. A high energy of the products for endothermic reaction shows that:

a) The energy is shared between the reacting species
b) The reactants have transferred energy to the products
c) The energy of products is increased due to the absorption of heat during the reaction
d) No energy change between reacting species and their surrounding

13. The difference between complete and incomplete combustion is:

a) The incomplete combustion involves the presence of oxygen and a fuel
b) The complete combustion takes place with no production of a big amount of energy
c) The complete combustion produces CO_2 and H_2Owhile the incomplete one produces a poisonous gas (CO).
d) No correct answer

14. Which one of the following is not considered when writing ionic equations?

a) All the state of matter of substances must be indicated
b) Insoluble substances remain unchanged

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c) If not necessary for the molecular equation to be balanced
d) The participating ions are only used

15. The spectator ions are:
a) Ions that are combined to form a soluble salt
b) Ions that remain unchanged and present on both sides
c) Ions remaining the same in their original state before and after a chemical reaction
d) (b) and (c) are correct

16. The stomach secretes gastric juice, which contains hydrochloric acid. The gastric juice helps with digestion. Sometimes there is an overproduction of acid, leading to indigestion. Antacids, such as milk of magnesia, can be taken to neutralize the excess acid. Milk of magnesia is only slightly soluble in water and has the chemical formula Mg $(OH)_2$. A balanced chemical equation that shows how the antacid reacts with the acid is:
a) $Mg(OH)_2 + HCl \longrightarrow MgCl_2 + H_2O$
b) $Mg(OH)_2 + HCl \longrightarrow 2MgCl + H_2O$
c) $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$
d) $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + H_2$

17. What coefficient would balance the equation: $AgBr(s)$ Sunlight $\longrightarrow Ag(s) + Br_2(g)$
a) 2 2 2
b) 2 1 2
c) 2 2 1
d) 1 2 2

18. What kind of reaction is this? $Fe_2O_3(s) + 2Al(s) \longrightarrow Al_2O_3(s) + 2Fe(l)$
a) Decomposition
b) Synthesis
c) Double displacement
d) Single displacement

19. Three beakers labeled as A, B, and C, each containing 25 ml of water, were taken. A small amount of NaOH, anhydrous CuSO4, and NaCl was added to the beakers A, B, and C, respectively. It was observed that there was an increase in the temperature of the solution contained in beakers A and B, whereas, in the case of beaker C, the temperature of the solution falls. Which one of the following statement(s) is (are) correct? Please also explain your choice.
(i) In beakers A and B, an exothermic process has occurred.
(ii) In beakers A and B, an endothermic process has occurred.
(iii) In beaker C exothermic process has occurred.
(iv) In beaker C endothermic process has occurred.
a) (i) only
b) (ii) and (iii)
c) (i) and (iv)
d) (iv), (ii) and (iii)

20. Which of the following is an endothermic process?
a) Dilution of sulphuric acid
b) Sublimation of dry ice
c) Condensation of water vapors
d) Respiration in human beings

21. What type of chemical reactions take place when electricity is passed through water?
a) Displacement

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b) Combination
c) Decomposition
d) Double displacement

22. One of the following processes is an example of decomposition reaction. Which one?
a) Respiration
b) Photosynthesis
c) Digestion
d) Transpiration

23. The order of reactivity of K, Na, Al, Mg, and Ca in the reactivity series is as follow:
a) K > Ca > Na > AL > Mg
b) K > Na > Ca > Mg > Al
c) K< Na < Ca < Mg < Al
d) Na > K >Ca > Al > Mg

24. Analyze each of the chemical equations below. Which equation is not balanced?
a) $H_2 + Cl_2 \longrightarrow 2HCl$
b) $KClO_3 \longrightarrow KCl + O_2$
c) $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$
d) $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

25. The net ionic equation for all reactions of strong acids with strong bases that form salt and water is:
a) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$
b) $H^+(l) + OH^-(l) \longrightarrow H_2O(l)$
c) $H^- (aq) + OH^+ (aq) \longrightarrow H_2O(l)$
d) All are correct

Section C: Matching question

26. Match each definition in column A with the correct term in column B.

Column A: Definitions	Column B: Terms
1. Two reactants combining to form a single product	A. synthesis reaction
2. One reactant breaking down into two or more products	B. combustion reaction
3. Ions changing places in two compounds	C. decomposition reaction
4. One of the reactants in a combustion reaction	D. single replacement reaction
5. Substance reacting quickly with oxygen	E. double replacement reaction
6. One ion takes the place of another in a compound	F. coefficient
7. Another term for a combustion reaction	G. Plus sign
8. A symbol used in a chemical equation that means "reacts with"	H. Exothermic process
9. The number that tells how many molecules of a particular substance take part in a chemical reaction	I. burning
10. A process that releases energy	J. fuel

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Column A	1	2	3	4	5	6	7	8	9	10
Column B										

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