Research article

Rwandan secondary school students’ attitudes in learning chemistry: explored with task-based instruction

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ABSTRACT

This study intended to explore the contribution of Task-Based Learning (TBL) to raising students’ attitudes toward learning chemistry. The study employed a quasi-experimental research design with 369 secondary school grade-2 students in Rwanda. The study randomly assigned students to two groups of differentiated instruction. Thus, the experimental group was exposed to the TBL method, while a control group was taught the teacher-centered method. An internationally standardized Chemistry attitude questionnaire of 0.831 Cronbach alpha reliability coefficient was used before and after teaching and learning activity. The Kruskal Wallis test was computed in SPSS 23.0 to measure the effect of TBL in raising positive attitudes among students in the experimental group compared to the control group. The attitude gain was measured from pre-test to post-test in attitude variables. This study showed a statistically significant difference between the control group and the experimental group ($\chi^2 = 4.118$, df $= 1$, $p < .05$). Furthermore, the students perceived chemistry’s importance more than the other three variables (difficulty, interest, and usefulness of chemistry). Results also showed that gender affected students’ perceptions of learning chemistry. Females students developed more positive attitudes than male students. However, school location statistically affecting students’ attitudes towards chemistry. The study result implies that TBL method helped to increase students’ attitudes toward chemistry. Recommendations were given to implement TBL methods in the chemistry classroom.

1. Introduction

1.1. Background

Developing secondary students’ interest in science subjects is important in developing countries like Rwanda. This helps students develop positive attitudes toward science-related subjects, and become competitive in the world market. For instance, the Rwandan government introduced a competence-based curriculum (CBC) to produce school graduates who can apply the new knowledge and become experts in solving the problem of daily life (REB, 2015a). However, Nsengimana (2021) reported that science subjects are still taught theoretically due to insufficient instructional materials that cannot even be improvised. Also, Ukobizaba et al. (2020) revealed the forfeiture of interest in learning Mathematics due to inadequate instructional teaching methods used by the teacher. A study conducted on Students’ attitudes towards physics in Nine Years Basic Education in Rwanda showed students’ negative attitudes toward the subject. Similarly, Mushinzimana and Sinaruguliye (2016) reported that university students possess negative attitudes towards learning physics.

The need for motivation in learning biology was explored by Mukagihana et al. (2021) and found that there was no statistically significant difference in the motivation of learning the biology of pre-service teachers before and after learning with traditional instruction at a public university while this difference was found statistically significant via animation instruction. The findings from the study of Sibomana et al. (2021) showed that the lack of insufficient instructional materials, science laboratories, and the predominant use of teacher-centered methods decrease students’ interest in learning and hence perform poorly. The same study investigated factors affecting secondary school student’s academic achievements in chemistry. Among the reported factors includes students’ attitudes toward chemistry (Sibomana et al., 2021). Therefore, educators should strive to use teaching methods that motivate students to learn, making an enjoyable and engaging learning environment.

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Teachers’ instructional methods were reported to affect students’ attitudes towards the subject (Cheung, 2009; Khan and Ali, 2012; Mbonnyiriyuze et al., 2021; Musengimana et al., 2021). Low achieving students argued that traditional instructional methods that involve reading and listening, among others, cause a decline in their attitudes towards chemistry. They suggested that even if such methods are used, teachers could adapt and develop them according to students’ needs. Student-centered methods like the use of computers and videos, making inquiries, and field trips, when designed properly, lead to long-term positive attitudes towards chemistry. To create a positive attitude (b et al., 2018). The students appreciated the student-centered methods connected to their daily lives. This was also supported by Bromann and Parchmann (2014) while investigating students’ application of chemical concepts when solving context-based chemistry problems. In addition, innovative teaching methods enhance students’ attitudes towards chemistry. For instance, Problem-Based-Solving Techniques (PBST) positively changed secondary-two students to gas laws (Festus and Ekpete, 2012). Similarly, Adesoji (2008) revealed that students developed a more positive attitude towards chemistry when treated with the problem-solving instructional strategy. The cooperative learning method was found to improve tenth-grade students’ learning achievement and attitude towards biology (Rabgay, 2018).

Furthermore, the integrative STEM approach to science fostered a favorable attitude toward science at the 4th-grade elementary school level (Rabgay, 2018). Therefore, when determining if a given instructional method is valuable, the evaluation of students’ attitudes after and before learning could be one of the best steps to confirm the effect of the method used. This study explored the potential of task-based learning methods as justifi ed below as the motivation to conduct this study section.

1.2. Task-based learning (TBL)

The Task-Based Learning (TBL) method is a learner-centered method in which learning outcomes are achieved in various tasks. It finds its origin in English language teaching, where it is regarded as a variant of communicative language teaching (Carlss, 2007; Zheng and Borg, 2014). In education, a task is regarded as a goal-oriented activity. Bhandari (2020) defined a task as a meaningful piece of a classroom activity that makes learners actively participate in the learning by interacting with manipulating materials that help them comprehend and produce something new in the target language. Tasks are subdivided into real-world tasks or target tasks and pedagogical tasks (Nunan, 2010).

In learning English, real-world tasks describe the learners’ use of language in and outside the classroom. They refer to tasks given to students to perform certain real-life scenarios like skits, conducting an academic presentation, applying for a job, simulation, role plays, to mention a few. On the other hand, pedagogical tasks are based on text to activate and develop learners’ language skills. The students inside the classroom perform these, and they involve activities like writing a letter, problem sets, and worksheets, among others (Hismanoglu and Hismanoglu, 2011; Sanchez, 2004). Although there are designed for the classroom and others outside the classroom, students are encouraged to connect between the work being done in the classroom and the one being done in the world outside the classroom. This helps to relate the learned materials with their everyday lives. A task, therefore, involves processing information and interacting with the content. Briefly, in the TBL method, learners learn by doing activities alone, in pairs, or in groups (Sholeh, 2020).

The TBL method has special characteristics of improving students’ communicative skills through students’ and teachers’ discussion while performing the tasks (Bhandari, 2020), fostering the understanding of the concepts (Qing et al., 2013), encouraging students’ social interaction, promoting active participation, and helping the student perform better in the exams. In medical science, TBL has also played a significant role. For instance, it provides students with basic knowledge and engages them in applying the gained knowledge to solve the real-world problem faced in both medical and clinical work (Tian et al., 2017). When TBL was used, motivation and satisfaction were highly improved among students of clinical years of medical education (Ozkan et al., 2006). Few studies highlighted the importance of TBL in chemistry; it was therefore found to be effective in developing students’ critical thinking skills and critical thinking disposition (Qing et al., 2010, 2013).

Sholeh (2020), in the review of the related literature conducted on the implementation of Task-Based learning in teaching English in Indonesia, revealed the main roles played by teachers and students in TBL. The teacher plays three main roles: selecting and planning the sequencing of the tasks, making students ready for tasks by providing them the necessary materials needed while doing tasks, and raising the students’ awareness to effectively perform the task. On the other hand, students in TBL also perform three main roles: actively participating in the learning process, monitoring how the tasks are being conducted, and becoming risk-takers and innovators by using the gained knowledge to bring new meaningful ideas do something new. Hence, the learners’ central role is appropriately completing the assigned task. A collaborative and interactive environment between the teacher and students in the TBL classroom is very important (Bhandari, 2020). This creates a conducive learning environment in which the lesson delivered depends on a specific task being performed. Note that better learning outcomes are achieved through the completion of the task.

The students’ task accomplishment passes through three stages (Bhandari, 2020; Sholeh, 2020). The pre-task consists mainly of scaffolding activities to provide students with detailed guidance on how the task will be done. In the stage task, students learn by doing the task through the teacher’s guidance. They become risk-takers at this stage. The existing knowledge is used to perform the provided tasks. As they are not experts in performing the task, they work collaboratively for the successful performance of a task; if not they are also aware that they can learn from their mistakes. If anyone in the group commits a mistake, it is now a good time for the other member in the group to provide support, and correct explanation, or the teacher may also intervene in adjusting. This stage includes further planning, reporting, and analysing steps. The planning involves activities like the preparation of an oral or written report to explain what occurred in their group while performing the assigned task. The reporting phase deals with presenting the prepared report to the whole class to share how the task was conducted in the respective group. This provides a holistic environment where consistent task results and reflection on how the task was done are discussed. Finally, the analysis phase helps review the work done in each group. In this phase, the teacher harmonizes the discussion points out the main component of the learned materials and assists students in addressing the challenges faced while doing the tasks. The post-task is characterized by making a summary and conducting a short evaluation to determine student understanding of the learned materials.

1.3. Students’ attitudes in chemistry

Students’ attitudes can influence learning outcomes (Kurniawan et al., 2018). Students with positive attitudes improve their learning achievement. Learners’ positive attitude towards the subject stimulates their interest and potential to study that subject in the future. Academic achievement considerably depends on attitude towards chemistry (Cukrowska et al., 1999). Students with positive attitudes perform better than negative ones (Xu et al., 2013). Attitudes refer to feelings of likes or dislikes of a subject (Kurniawan et al., 2018). Referred the importance of attitude to social psychology and educational sciences, some researchers have framed it to these veins. According to Lu et al. (2016) study, results of correlation and structural equation modeling show some of the associations and potential relationships between the motivational and emotional factors studied and students’ attitudes and intentions towards studying science, which would increase their likelihood of future involvement in a scientific career. In addition, on the affinity dimension,
positive attitudinal changes were achieved about perceived self-efficacy and appreciation of science and science classes (Araújo et al., 2021). Attitudes toward chemistry are a set of beliefs students develop about chemistry or chemistry course (Saltá and Tzougkári, 2004). Hofstein and Mamlok-Naaman (2011) postulated a substantial relationship between students’ interest, attitudes, and the subject’s relevance. If students find the subject relevant to them in the society in which they live, they develop a positive attitude towards it, and hence they are interested in learning the subject. Students with negative attitudes are not interested in studying the subject and do not spend more time concentrating on the content of the same subject. Xu et al. (2013) categorized attitudes into three attitudinal dimensions: Affective, behavioral, and cognitive. The affective dimension relates to an emotional response that expresses students’ level of preference toward chemistry lessons. The behavioral dimensions refer to students’ behavioral tendency to act on chemistry. The cognitive dimensions reflect the evaluation that consists of individual beliefs and knowledge of chemistry.

The improvement in the learning of complex concepts depends on innovative teaching methods. These methods attract students’ attention, make them interested in the subject and boost their attitudes. Therefore, measuring students’ attitudes after learning with a new teaching method may be critical in predicting their feelings on the new method, whether it is effective in improving their academic achievement, and attitudes. To this end, several studies have shown that active learning methods facilitate students’ understanding of the taught science topics and contribute to an increase in their attitudes towards science after being supported by teaching methods like cooperative, PBL, 5 E’s inquiry Learning activities, computer-assisted materials among others (Çepni et al., 2006; Demirel, 2016; Mboneyi ryi yuvvze et al., 2021; Rabgay, 2018; Sen and Oskay, 2016).

Mixed results were obtained in the studies that examined gender effect on secondary school students’ attitudes towards chemistry (Cheung, 2009; Hofstein et al., 1977; Kubiakto et al., 2017; Menis, 1983; saltá and Tzougkári, 2004). For instance, some studies reported girls to develop more positive attitudes than boys (Bajaj and Devi, 2021; Heng and Karpudewan, 2015; Kenar et al., 2015; Liaghatdar et al., 2011), while others reported boys develop favorable attitudes toward chemistry learning (Anwer et al., 2012; Kousa et al., 2018; Saltá and Tzougkári, 2004). On the other hand, further studies indicated the equal attitudes of boys and girls towards chemistry (Ackay et al., 2010; Sakariyau et al., 2016). In addition, school location (urban versus rural areas) and academic achievement relationship in science has been widely studied (Adesoji and Olatunbosun, 2008). Students in urban schools performed better than their rural counterparts when PhET simulations were used (Ndihokubwayo et al., 2020). Anwer et al. (2012) found that rural students performed higher than urban students in a study conducted to examine students’ attitudes towards science. Given these conflicting reports, there is the need to carry out a study to determine the effect of TBL gender and school location variables.

1.4. Motivation to conduct this study

From the literature explored above, few studies reported the effectiveness of task-based learning on students’ attitudes (Alilomaidian, 2017; Hamouda, 2016; Oooyung Pyun, 2013). These studies show an overwhelmingly positive attitude when task-based language teaching is employed in speaking courses. Additionally, a review of literature conducted on factors affecting secondary schools’ attitudes towards chemistry learning (Musengimana et al., 2021) and teachers’ instructional methods was reported as a measure concern contributing to students’ attitudes. Unfortunately, the reviewed literature did not show any effect of TBL on students’ attitudes towards chemistry. Moreover, most of the studies conducted on TBL were based on English learning as a foreign language and in medical sciences. Few tackled chemistry experimental to measure students’ critical thinking and disposition (Qing et al., 2010, 2013). None of the studies dealt with the effect of TBL on students’ attitudes towards chemistry. Therefore, based on such a gap found in the literature, there was a need to conduct the present study determine the effect of task-based learning on students’ attitudes in chemistry, Rwanda. This work was needed as Rwanda started to implement a new competence-based curriculum (REB, 2015a) that envisages equipping learners with skills through hands-on activities (Ndihokubwayo, 2017). This work is from the largest doctoral research project of the first author. This article is a follow-up to a recently published paper (See Musengimana et al., 2022). The authors conducted a study to investigate the effect of TBL on students’ understanding of chemical reactions. The study results revealed an improved performance of students treated with TBL. Therefore, the observed improved attitude is expected to aid students’ learning of chemistry.

The present study is valuable to the literature as it provides information on students of lower secondary schools’ attitudes towards chemistry. It highlights the importance of TBL in improving students’ attitudes towards chemistry. Based on the present study’s findings, teachers will get insight into students’ attitudes towards chemistry. Besides, they may figure out how their attitudes may be improved using adequate instructional methods that attract their interest in the subject. Further information may be given to all educational stakeholders to plan for the instructional materials that boost students’ curiosity and enhance their motivation and interest, thereby improving their attitudes towards the subject. Therefore, students will find the applicability of the learned materials to daily life and find it relevant to society, while teachers will be aware of the role of task-based instruction in raising students’ attitudes toward learning chemistry lessons.

The study was guided by the functional theory of attitude changes (Katz, 1960). The theory considers the relationship between the attitudes and efforts of the individual with his/her motivational structure. It assumes the meaning of the influence situation in terms of the kind of motives that it arouses and the individual’s method of coping and achieving his/her goals. This theory helps understand the important conditions that influence the maintenance and stability of attitude change. It also serves as the basis for understanding the functions played by attitudes in students’ learning systems. For instance, a particular method may induce change in students whose attitudes serve one function.

On the other hand, the change is not observed in students whose attitudes serve a different function. Therefore, attitudes play different functions for different individuals, or they may affect the same individuals but in different settings based on the idea that attitudes are formed as a result for people to gain a greater understanding and structure of the world. This theory is suited to this study as students’ attitudes were changed after being treated with TBL, a new instructional method implemented in the classroom for chemistry learning.

The following three research objectives guided the study: (a) Exploring the effect of TBL on students’ attitudes towards chemistry among Rwandan lower secondary school students, (b) Correlating attitude to achievement scores, and (c) Measuring the difference made by TBL on students’ attitudes among difficulty, interest, usefulness, and importance of chemistry variables.

2. Methodology

2.1. Research design and teaching intervention

The study employed a quasi-experimental research design with pre- and post-assessment in experimental and control group models. The two groups were formed by random assignment, and one group was named the control group and the other the experimental group. The effect of TBL on students’ attitudes towards chemistry was determined by applying the attitudes towards the chemistry questionnaire to both groups as pre-assessment (before the intervention) and post-assessment (after the teaching intervention). During the teaching and learning activity (intervention), the control group was taught unit5 (categories of chemical reactions), one of the units found in the S2 chemistry syllabus.
The unit consists of three further sub-units, namely the types of reactions (combination reactions, decomposition reactions, single replacement reactions, double displacement reactions, and combustion reactions), classification of chemical reactions as endothermic and exothermic reactions (exothermic reactions and endothermic reactions, and explanation for the energy changes during chemical reactions), and ionic equations (rules for writing ionic equations).

Teachers in the control group used mostly chalk and talk methods usually considered the normal teaching or teacher-centered or conventional teaching method. Group work discussion was also used as a teaching method to solve some provided activities with no proper instructions, materials, or guidance on how the activities should be done. The experimental group taught the same unit by applying the TBL method. Each lesson delivery followed TBL principles. Teachers had to pass through the three phases of TBL described in the introduction.

In the pre-task phase, teachers introduced the lesson by relating it to students’ prior knowledge. They further introduced the task and provided the learning materials and the instructions on the task to be done in the next phase. Teachers also exposed the students to some complete sample tasks through demonstrations or observing videos. In the task phase, the teachers assigned tasks to students and guided them to complete them by advising, monitoring, and facilitating them to complete the task successfully. On the other hand, students discussed and negotiated while performing the tasks. In this phase, students worked individually, in pairs, or in a group depending on the complexity of the task, the availability of materials needed to complete the task, and the time allocated to the task. It is clear that students take part in the learning process but are not being abandoned by teachers to interact with the content or problem alone. Rather, the teacher provides specific support and guidance to learners. S/he may explain the method and provide supportive information on how the task will be conducted. For example, the teacher may ask to determine the net ionic equation for the reaction: $\text{Ba(NO}_3\text{)}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{BaSO}_4(\text{s})$. Before assigning the task to students, s/he may provide the stages involved in writing the net ionic equations, and then the students follow the stages provided to perform the assigned task. Each student was therefore assigned the role (the planner, the organizer, the information collector, and the presenter) to accomplish depending on the nature of the task. The role was not fixed rather, it circulated among the group members to make everybody in the group to be involved in the whole process of learning.

Teachers provided support where it was needed and facilitated students in performing tasks. This support faded as the students became knowledgeable and experts in the field through the successive performance of tasks from the simple to the complex. Therefore, students were encouraged to interact with each other, help one another, and enhance their creativity and critical thinking while reporting. They were further given time to present the outcome of their tasks to the entire class, where the teacher evaluated and provided constructive and informative feedback to reinforce the understanding of the concept studied. The final phase is the post-task. This phase was regarded as the harmonization phase in which the presented outcome of tasks from each group, pair, or individual was reviewed and analyzed. The teacher also explained the difficult concept that challenged students in the task phase. Moreover, students were given opportunities to reflect on their performance. Those who still have challenges repeated the task or performed another related task to develop in-depth understanding and confidence in the learned materials. The intervention lasted six weeks (from 13th January 2021 to 26th February) for the control and experimental groups. At the end of the intervention, both groups were given a post-assessment.

### 2.2. Research participants

The research participants consisted of 361 students consisting of 194 females and 167 males of lower secondary schools S2 (grade eight) with ages ranging from 13 to 17 years old located in Gasabo and Rwamagana districts. The participants were purposively selected in the two districts. One district was purposively selected from a rural areas, while another was from urban areas. The purposive sampling was used in this study as the researchers intended to determine the students’ attitudes in rural areas and those in urban areas. The intact classes were used. From each district, four schools were chosen; two schools were from urban areas and the other two from rural areas giving a total of eight schools with eight teachers, involving 176 students from an urban areas and 185 students from rural areas. Four classes were part of the experimental group, and the other four were part of the control group giving a total of 161 students in the experimental group and 200 students in the control group. Prior to data collection, the research, and innovation unit at the University of Rwanda College of Education (URCE) provided ethical permission. Educational officials at the district level provided school access permits based on ethical permission. Both teachers and students were briefed on the intent of the research and accepted to participate voluntarily by signing consent forms.

### 2.3. Research instrument

The students’ Attitudes Toward Chemistry (ATC) questionnaire developed by Salta and Tzougraki (2004) was adopted in this study. The instrument consists of 30 statements distributed into four variables: the difficulty, interest, usefulness, and importance of chemistry. The difficulty of the chemistry course consists of six items related to how they feel the chemistry lesson is easy or difficult for them. The interest of the chemistry course involves nine items that show how and in which way they like learning chemistry. The usefulness of a chemistry course for students’ future careers involves three items that show how chemistry affects students’ future careers, and the importance of chemistry for students’ life contains five items that show how chemistry knowledge is useful in human life. The overall questionnaire contains a five-point scale ranging from point 1 = strongly disagree (SD), 2 = disagree (D), 3 = Undecided (U), 4 = agree (A) to 5 = strongly agree (SA). Prior to its use, it was piloted to find out how this standardized instrument is reliable in the Rwandan context. The pilot study was conducted using a target group of 71 lower secondary students selected from a school that was not part of the sample schools. Among 71 students, responses from 47 students were valid, while 24 were excluded as students did not answer all questions. Computing Cronbach alpha, the reliability coefficient of internal consistency was 0.831. This shows that the scale has acceptable reliability. We must note that 23 items were reselected for the analysis stage with four attitudes dimensions. Table 1 shows the corresponding reliability coefficients found.

### 2.4. Data analysis and data presentation

We checked the normality of data while seeking appropriate statistics to be used. Kolmogorov-Smirnov test of normality showed that both control and experimental groups’ mean scores were not normally distributed. Thus, the p-value was statistically significant ($p < .05$). Therefore, a non-parametric test (Kruskal Wallis H tests) was used to reveal the significance of differences in teaching intervention and other variables (gender and school location). Descriptive statistics were initially computed, and mean, and standard deviations were presented

| Dimension | N of items | Cronbach’s alpha |
|-----------|------------|------------------|
| All items (pilot stage) | 30 | .831 |
| Re-selected items (analysis stage) | 23 | .791 |
| Difficulty of chemistry | 6 | .406 |
| Interest of chemistry | 9 | .531 |
| The usefulness of chemistry for future career | 3 | .727 |
| Importance of chemistry for students’ life | 5 | .533 |

Table 1. Dimensions of attitude test items and their corresponding reliability coefficients.
among experimental and control groups at both pre-and post-test stages. For each of the 30 attitude statements, the responses of all respondents were averaged (see Table 2).

Then, the Kruskal Wallis test was computed in SPSS 23.0 via analysis ribbon through non-parametric tests to legacy dialogs and select k-independent samples. This test measured the effect of TBL in raising positive attitudes among students in the experimental group compared to students who learned in the teacher-centered method (control group). It also measured the effect of gender and school location. Lastly, the attitude gain was measured from pre-test to post-test in attitude variables (difficulty of Chemistry, interest in Chemistry, the usefulness of Chemistry for a future career, and the importance of Chemistry for students’ life). Attitude gain in these variables was also measured in gender and location of the school. Thus, the difference from post-test to pre-test was divided by the difference from the highest score (5) to pre-test \[
(5 - \text{pre}) / \text{pre}
\] Then, percent average attitude gain \[
\frac{(\text{post}-\text{pre})}{(5-\text{pre})}\times 100
\] was computed.

3. Results

There was a statistically significant difference between the control and experimental groups in the post-test \((\chi^2 = 4.118, \text{df} = 1, p < .05)\) in favor of the experimental group. Such difference did not occur in pre-test results (see Table 3).

While the control group did not display any statistically significant gender difference, the difference was statistically significant \((\chi^2 = 8.759, \text{df} = 1, p < .05)\) in favor of female students in the experimental group. Although TBL showed the effect of gender, the school location did not show it. Thus, there was no statistically significant difference between rural and urban schools (see Table 4).

A correlation analysis was computed to check if there is a positive correlation between attitude and performance scores. We used SPSS via Kendall’s tau-b since we had continuous (performance) and ordinal (attitude) data. Kendall rank correlation (non-parametric) is an alternative to Pearson’s correlation (parametric) when the data one is working with has failed one or more test assumptions. This is also the best alternative to Spearman correlation (non-parametric) in case the sample size is small and has many tied ranks. We also drew graphs via graphs ribbon >> legacy dialog >> scatter/dot plots and used simple scatter to present the X-axis’s attitude scale alongside the Y-axis’s performance scale. Note that attitude scores were computed over five scores while performance scores were computed over percent scores. The correlation analysis revealed a high positive correlation between attitude and achievement tests before teaching interventions \((r = .715)\). Figure 1 shows the correlation between attitude and students' performance scores in the pre-test.

However, this correlation was found low after learning \((r = .075)\). This shows how teaching interventions were different in raising students learning outcomes. For instance, post-tests among achievement and attitude revealed .172 in the control group and 0.243 in an experimental group showing that the correlation between attitude and achievement

### Table 2. Descriptive Analysis of ATC questionnaire in the experimental and control group: pre-and post-test results.

| Variable                        | Experimental | Control |
|---------------------------------|--------------|---------|
|                                 | Post | Pre | Post | Pre | Post | Pre | Post | Pre |
|                                  | M    | SD  | M    | SD  | M    | SD  |
| Chemical symbols are like Chinese to me | 3.07 | 1.51 | 2.98 | 1.43 | 2.52 | 1.37 | 2.19 | 1.32 |
| I solve chemistry exercises very hardly | 3.07 | 1.39 | 3.26 | 1.37 | 3.15 | 1.33 | 2.80 | 1.18 |
| I make many efforts to understand chemistry | 4.20 | 1.10 | 4.02 | 1.23 | 4.31 | 1.07 | 4.16 | 1.10 |
| I find the use of chemical symbols difficult | 3.70 | 1.37 | 3.57 | 1.34 | 3.07 | 1.40 | 3.02 | 1.29 |
| I understand the chemistry concepts very hardly | 2.83 | 1.30 | 2.97 | 1.28 | 2.90 | 1.30 | 2.90 | 1.18 |
| When I try to solve chemistry exercises, my mind goes blank | 2.86 | 1.51 | 2.79 | 1.48 | 2.38 | 1.37 | 2.71 | 1.42 |
| I like chemistry course more than the others | 3.88 | 1.14 | 3.54 | 1.26 | 3.64 | 1.07 | 3.85 | 1.02 |
| I would like to have chemistry lessons more often | 3.76 | 1.34 | 3.37 | 1.17 | 3.73 | 1.27 | 3.62 | 1.23 |
| During chemistry lessons, I am never bored | 3.61 | 1.45 | 3.40 | 1.37 | 4.00 | 1.24 | 3.69 | 1.32 |
| Chemistry knowledge will be useful after my graduation | 3.75 | 1.43 | 3.71 | 1.40 | 3.14 | 1.67 | 3.58 | 1.57 |
| Chemistry is not a sophisticated subject for our compulsory education | 1.76 | 0.99 | 2.52 | 1.36 | 2.43 | 1.47 | 2.36 | 1.15 |
| The profession of a chemist is one of the highest attractive | 3.25 | 1.43 | 3.43 | 1.38 | 3.44 | 1.48 | 3.41 | 1.41 |
| I like chemistry courses | 3.69 | 1.45 | 3.68 | 1.35 | 3.95 | 1.27 | 4.01 | 1.25 |
| I would like to have many chemistry lessons | 3.07 | 1.48 | 2.99 | 1.47 | 3.44 | 1.54 | 3.26 | 1.40 |
| I find the chemistry course very interesting | 3.91 | 1.11 | 3.70 | 1.20 | 3.86 | 1.18 | 3.97 | 1.18 |
| My future career depends on chemistry knowledge | 2.99 | 1.55 | 3.04 | 1.45 | 3.48 | 1.63 | 3.28 | 1.49 |
| Chemistry knowledge is necessary for my future career | 4.01 | 1.29 | 3.85 | 1.25 | 4.22 | 1.11 | 3.92 | 1.28 |
| I would like to become a chemist when I finish school | 3.65 | 1.55 | 3.46 | 1.53 | 3.73 | 1.50 | 3.50 | 1.44 |
| Chemistry knowledge is useful to interpret many aspects of our everyday life | 4.35 | 1.00 | 4.12 | 1.05 | 4.37 | 0.99 | 4.26 | 1.00 |
| The progress of chemistry improves the quality of our lives | 4.11 | 0.99 | 3.96 | 1.20 | 4.22 | 1.04 | 4.10 | 1.00 |
| Chemistry is our hope for solving many environmental problems | 4.10 | 1.07 | 3.90 | 1.27 | 4.16 | 1.02 | 4.01 | 0.97 |
| The progress of chemistry contributes to the development of a country | 4.38 | 0.99 | 4.11 | 1.13 | 4.51 | 0.81 | 4.28 | 0.99 |
| Every citizen must have chemistry knowledge | 4.11 | 1.22 | 3.93 | 1.26 | 4.16 | 1.18 | 4.11 | 1.11 |
scores increased positively among students who learned via TBL than those who learned with the normal method, though it was a low correlation. Figure 2 displays a correlation between attitude and performance post-test scores.

After learning chemical equations, the group that learned with TBL raised their attitude towards learning chemistry more than the group that was taught with the teacher-centered method, except in terms of the usefulness of chemistry for a future career. More importantly, the attitude was gained in the importance of chemistry for students’ life. Thus, the experimental group gained 21% while the control group gained 16% of a positive attitude toward the importance of chemistry in students’ life.

The control group felt 4% Chemistry difficulty alongside 1% in the experimental group. Likewise, the experimental group gained 2% of interest in learning chemistry while the control group lost 1% (see Figure 3).

A robust extended non-parametric test was computed to find out if these descriptive differences are statistically significant via analysis ribbon >> non-parametric tests >> legacy dialogues >> two or k-independent samples. K-independent samples (Kruskal-Wallis H test) were used for both four attitude dimensions, while 2-independent (Mann-Whitney U test) was used for each of the four dimensions. Kruskall-Wallis test revealed no significance between control and experimental groups both in pre-test ($\chi^2 = .267, df = 1, p > .05$) and post-test ($\chi^2 = .053, df = 1, p > .05$). Among four attitude dimensions, there was no significance between control ($\chi^2 = 5.077, df = 3, p > .05$) and experimental ($\chi^2 = 4.753, df = 3, p > .05$) groups. However, a detailed Mann-Whitney test revealed a significant difference between the difficulty of chemistry and the importance of chemistry for students’ life after learning (post-test) in the experimental group ($U = 1.000, Z = -2.556, p < .01$) in favor of ‘importance of chemistry for students’ life.’

Regarding gender, attitude dimensions showed no significance between male and female students in the control and experimental groups. However, a detailed Mann-Whitney test revealed a significant difference between the difficulty of chemistry and the importance of chemistry for students’ life after learning (post-test) in the experimental group ($U = .000, Z = -2.751, p < .01$) in favor of female students. Figure 4 displays the attitude gains according to gender.

Female students perceived the easiness (4%) and importance of chemistry (24% of gains) more than male students in the experimental group (see blue color in Figure 2), while male counterparts felt interested in chemistry (8% of gains) and perceived usefulness of chemistry (8%) more than female students (see orange color in Figure 4). However, both female and male students in the control group showed high gain usefulness.

### Table 4. Gender and location of the school at post-test.

| Variables          | Group   | Gender | N   | Mean rank | Chi-Square | df  | Asymp. Sig. |
|--------------------|---------|--------|-----|-----------|------------|-----|-------------|
| Gender             | Experimental | Male   | 76  | 69.51     | 8.759      | 1   | .003*       |
|                    |         | Female | 85  | 91.28     |            |     |             |
|                    | Control | Male   | 91  | 92.64     | 3.082      | 1   | .079        |
|                    |         | Female | 109 | 107.06    |            |     |             |
| School location    | Experimental | Rural  | 91  | 75.84     | 2.572      | 1   | .109        |
|                    |         | Urban  | 70  | 87.71     |            |     |             |
|                    | Control | Rural  | 94  | 100.42    | .000       | 1   | .985        |
|                    |         | Urban  | 106 | 100.57    |            |     |             |

* significance as p-value < .05.
of chemistry (20% versus 14% of gains) more than students in the experimental perceived (see grey and yellow color in Figure 4).

Regarding school location, attitude dimensions showed no significance between rural and urban schools both in the control and experimental groups. A detailed Mann-Whitney test revealed no significant difference between different dimensions too. Figure 5 displays the attitude gains according to school location. Among the students in the control group, those in urban areas felt the difficulty of chemistry, while those in the rural lost interest in chemistry. Urban students in the control group gained 26% on the usefulness of chemistry for future careers, while urban students of both experimental and control groups gained 25% on the importance of chemistry in their life.

4. Discussion

The present study intended to measure the effect of TBL on lower secondary school students’ attitudes towards chemistry. The Attitudes Toward Chemistry (ATC) questionnaire was used as a standardized scale to measure the students’ attitudes toward Chemistry. Table 1 presents the response means and standard deviation of all the 30 attitude statements. The results from Table 2 reveal an increase in students’ attitudes toward chemistry after being treated with TBL, as indicated by the p-value found ($\chi^2 = 4.118, df = 1, p < .05$). The pre-test results comparing experimental and control group responses showed no statistical significance. In the post-test, the statistical significance between the control group and the
experimental group may be attributed to the effectiveness of TBL in enhancing students’ interaction, cooperation, critical thinking as well as active participation fosters effective learning (Munira and Ferdousi, 2019; Qing et al., 2013; Tian et al., 2017). Another reason could be related to the fact that TBL principles follow social constructivism theory in which students prior conceptual knowledge is the most significant predictor of students achievement and hence related to students attitudes as pointed out by Xu et al. (2013). Moreover, a study conducted on the effect of TBL on students’ understanding of chemical reactions revealed an improved performance of students treated with TBL (Musengimana et al., 2022). Therefore, the observed improved attitude is expected to aid students’ learning of chemistry. Therefore, the intervention (TBL) induced changes in students’ attitudes toward chemistry according to the functional theory of attitude changes (Katz, 1960). As the reasons for attitude changes are individualized and related to personal functions of attitudes, the observed changes in attitude among students were different.

Among the four variables tested (difficulty of chemistry, interest in chemistry, usefulness of chemistry in future life, and the importance of chemistry to students’ lives), it showed that students in both control and experimental groups understand the importance of chemistry to their life compared to other variables (see Figure 3). Their attitudes towards the difficulty, interest, and usefulness of chemistry are slightly positive. The findings are lined with Arniezca and Ikhsan (2021) findings. Their study’s findings pointed out that students understand the importance of chemistry in their life, but their attitudes towards the difficulty, interest, and usefulness of chemistry tend to be neutral. Similarly, in a study by Salta and Tzougraki (2004), students’ attitudes toward the importance of chemistry in their lives were positive. Students also showed neutral attitudes toward the difficulties and the interest in chemistry, but they held negative attitudes toward its usefulness to their future careers. To them, a chemistry course is not related to their future career. The low gain observed in the control group is related to the fact that chemistry was taught theoretically in the control group. The teachers used lecturing method where most of the activities were teacher-centred. Main students’ activities were to follow explanations provided by teachers, copy notes from the board, and perform the exercises either individually or in groups. The group work activities engaged only talented students who normally play the role of group leaders. Other group members remained inactive and copied answers of activities from the talented students. This
influenced them to lose interest, in learning chemistry. They did not find any relevance of chemistry to their daily life and hence perceived chemistry as the most difficult subject.

The effect of TBL on gender is another variable tackled in this study. Female students developed more positive attitudes compared to their male counterparts due to the TBL learning environment. This may be attributed to the Rwandan Association for Women in Science Education (RAWISE)'s awareness, which empowers and motivates girls students to learn science. Hofstein and Mamlok-Naaman (2011) attributed this inequality of male or female students' attitudes towards chemistry to the nature of content and chemistry curriculum, the instructional methods being implemented during the lesson delivery and the type of research instruments used in the study. The more positive attitudes of girls toward chemistry were also found in the studies of various researchers (Anwer et al., 2012; Arniezca and Ikhsan, 2021; Heng and Karpudewan, 2015; Liaghatdar et al., 2011). On the other hand, some studies (Kousa et al., 2018; Menis, 1983; Seba et al., 2013) revealed the opposite results in which boys developed more attitudes toward chemistry than girls.

Females and male students' attitudes gain were also compared, considering the four variables in the control and experimental groups as Figure 2 presents. The female students perceived chemistry as the easiest subject in the experimental group, while their attitudes were negative in the control group. Girls from the experimental group showed less positive attitudes than males regarding the interest in chemistry variables in the control group. females' attitudes were slightly negative while males' attitudes were more negative. In addition, while male students in the experimental group perceived the usefulness of chemistry to their future careers more than their female counterparts did, the female attitude was higher than that of males in the control group. Moreover, female students showed more positive attitudes toward the importance of chemistry compared to male students in the experimental group though the female students also showed a positive attitude toward the importance of chemistry in the control group. Arniezca and Ikhsan (2021); Salta and Tzougraki (2004), who worked on the same variables, found dissimilar results. For instance, Salta and Tzougraki found no significant difference between the male and female students in the level of interest, usefulness, and importance of chemistry. Only female students possessed a less positive attitude regarding the difficulty of chemistry than male students in Greece. Arniezca and Ikhsan revealed a significant difference between males and female students regarding the difficulty, the interest, the usefulness, and the importance attributed to chemistry. Thus, females developed more positive attitudes than males.

However, the effect of TBL on students’ attitudes considering the school location was not statistically significant. Schools in urban areas perceived chemistry more interest and importance than schools in rural areas in the control group, as shown in Figure 5. Experimental group students from rural areas showed more interest in chemistry than experimental group students from urban areas. However, experimental group students from urban areas showed more importance in chemistry than experimental group students from rural areas.

5. Conclusion

The present study determined the effect of TBL on students' attitudes towards chemistry. A significant difference was not found between the control group and the experimental group both in the pre-test and post-test based on the presented results. However, it was among four attitude dimensions. A significant difference was revealed between the difficulty of chemistry and the importance of chemistry for students' life after learning in the experimental group in favor of the 'importance of chemistry for students' life.' Regarding gender, attitude dimensions showed no significance between male and female students in the control and experimental groups. However, a detailed significant difference was revealed between the difficulty of chemistry and the importance of chemistry for students' life after learning (post-test) in the experimental group in favor of female students. Likewise, school location had no statistical significance on the students' attitudes towards chemistry even between different dimensions tested. Therefore, the TBL method is still valuable and contributed to increasing students' attitudes towards learning chemistry. It provided information on how gender variables affect students' perception of chemistry. It also informs the variation of students' attitudes based on school location. Use interactive pedagogical approaches that are learner-centered and make them active participants in the learning process, such as TBL is recommended. Teachers should also use different techniques to motivate and develop an interest in attitudes towards chemistry among students. The consulted literature shows inconsistent attitudes towards chemistry among female and male students. Therefore, there is a need for future studies to identify the real cause of variations in attitudes towards chemistry learning.

Declarations

Author contribution statement

Jeannette MUSENGIMANA: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Edwige Kampire; Philothere Ntwaiha: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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