



Effects of Inquiry-Based Teaching Method on Students' Academic Performance and Attitudes towards Chemistry in Two Selected Secondary Schools of Bugesera District, Rwanda

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Abstract: The main purpose of this study was to investigate the effects of inquiry-based teaching approach on students' performance and attitudes towards chemistry in senior four secondary school level. A sample of 78 senior four chemistry students from two different schools was enrolled in the study. A pre-test and post-test quasi-experimental research design was adopted where students from one school were taught using inquiry-based teaching method and those from the other school were traditionally instructed. The instruments of data collection were a self-designed Chemistry Achievement Test (CAT) and a Chemistry Attitudes Questionnaire (CAQ). Data were analysed using Descriptive statistics, independent sample t-test and ANCOVA using pretest scores as covariates. The results of the study showed that inquiry-based teaching method improved students' performance and attitudes towards Chemistry. Moreover, no gender interaction with inquiry-based learning was observed, male and female benefits equally from inquiry-based learning. The study recommend the use of inquiry-based teaching method to improve students' performance and attitudes towards chemistry. It was also recommended that inquiry-based teaching method is not gender sensitive therefore both male and female students should be involved in inquiry-based learning activities to enhance their performance in Chemistry.

Keywords: Effects, Inquiry, Gender, Students' performance, Students' attitudes

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1. Introduction

In today's rapidly evolving world, training people in science and technology is becoming very crucial as it is an important predictor of social and economic development of any country. Obviously, science and technological advancement are becoming an important part of our daily life; therefore, any society that will be left out of this risk

the total isolation from the global community (Tsvyk & Tsvyk, 2018). For this reason, science courses should be given special attention through quality and productive education. Quality science education will play a key role in dealing with challenges brought by the 21st century; it will also facilitate knowledge-based economies as a goal for different countries around the world. Rwanda, as a landlocked country, with not enough natural resources and high population density, has also opted to create a

knowledge-based economy, through quality education, with special attention to science and technology (REB, 2015). Science education in general, and chemistry education in particular, is believed to produce competent human capital that can win the battle in the regional and international job market.

Chemistry as one of the core subjects in the science fields, is taught in Rwandan secondary schools since it is critical to diverse vital fields to humankind such as medicine, agriculture and textiles among others, the chemistry knowledge and skills open the door to a wide range of careers options. Moreover, it is very crucial to be admitted in various education fields in the higher learning institutions; For example, a student cannot be admitted in medicine unless he/she has passed Chemistry with high marks. Thus, there are economic benefits to both the country, whose citizens include many people with chemistry knowledge and to the individual themselves. This justifies why, Rwanda as a developing country has acknowledged the role of chemistry since its relevant application in daily life have a significant contribution in the development of the country. For this to be achieved, competence-based chemistry education that develops knowledge, skills, attitudes and value required at the job market is required, the process of teaching and learning, especially teaching methods should be aligned with the goals of education at the workplace.

In recent years, the process of science teaching in Rwanda and across the world gained too much attention than it used to be since the idea about the nature of scientific knowledge were emerging rapidly (Osborne et.al, 2003). Consequently, educators worldwide have recognized that there are meaningful teaching approaches that can be used to teach science subjects rather than traditional lecture-based-teaching method (Wood & Gentile, 2003). This resulted in various reforms and different countries have modified their curricula and active teaching methods were incorporated to align science teaching methods with the nature of scientific knowledge (Oplatka & Izhar, 2018). Although, lecturing teaching method dominates other teaching methods in Rwandan secondary schools, it rarely promotes students understanding of the content especially in science subjects (Byusa et al., 2020). For this reason, it was stipulated in the curriculum that it should be used together with inquiry-based teaching approach depending on the learning context.

Inquiry-based teaching method is a teaching method that was undertaken to improve the process of teaching and learning science. It is a form of teaching that emphasizes the process of seeking knowledge by questioning and investigation rather than portraying a direct path to knowledge (Marcus, 2017). It is closely related to the ways scientists come to know what they know; Students develop understanding of the natural world through problem formulation, making hypotheses conducting investigations, and drawing conclusions based on evidence (National Research Council, 2000). The process of inquiry learning promotes students' understanding of the nature of science as well as the motivation for learning. It also develops students' inquiry skills which is a key aspects of lifelong learning. Considering the key role of inquiry in the 21st century education, Rwanda as a developing country has not been left behind in using inquiry-based teaching method as well as ensuring gender equality in all aspects of the teaching and learning process. Consequently, teaching approaches such as inquiry were incorporated in the ordinary level science curriculum in 2006 as well as in the recent competence-based curriculum (REB, 2015a).

The recent competence-based curriculum also witnessed a wakeup call for gender equality and gender education was incorporated as one of the crosscutting issue to be addressed throughout the curriculum implementation. Gender equality is crucial since sustainable economic development is likely to be achieved when both males and females are involved. Despite such dramatic change in curriculum policy over almost two decades, little is known whether this change is truly transforming learning experience in chemistry to the desired level; Literature review failed to identify any study which investigated the effects of inquiry-based teaching method on students' academic performance and attitudes toward Chemistry in Rwandan secondary schools. In other words, there is no clear evidence whether inquiry-based teaching method improve students' academic performance and attitudes compared with traditional teaching methods. The interaction effect of inquiry-based teaching method is also not known. According to National Institute of Statistics of Rwanda (2018) before the introduction of the competence-based curriculum, the performance of females was higher than that of male. However, after the introduction of the new curriculum the performance of females decreased while that of male increased (see table 1).

Table 1: Upper secondary school leaving examination results from 2015 to 2018

| Year | Percentage of students who Passed | | |
|------|-----------------------------------|--------|--------|
| | Female | Male | Total |
| 2015 | 92% | 85% | 89.00% |
| 2016 | 87.40% | 92.50% | 89.90% |
| 2017 | 87.50% | 92.40% | 89.40% |
| 2018 | 86.40% | 93.56 | 89.86% |

Source: National Institute of Statistics of Rwanda (NISR)

Statistics in Table 1 prompted the researchers to investigate whether there is gender interaction with one aspect of the curriculum such as teaching method particularly, inquiry-based teaching method. The researchers sought to investigate the interaction effect of gender with inquiry-based teaching method in teaching chemistry because it is highly advocated across curriculum implementation, especially in teaching science subjects, including Chemistry.

1.1 Objectives of the study

The main purpose of this study was to investigate the effects of inquiry-based teaching method on students' performance and attitudes towards chemistry lesson. Specifically, the study sought to find out whether male and female students benefited equally when inquiry-based teaching approach was used in teaching chemistry in senior four secondary school level. To achieve the objectives of this study, three research questions were raised:

1. What is the effect of inquiry-based teaching method on students' performance in chemistry?
2. What is the effect of inquiry-based teaching method on students' attitudes toward chemistry?
3. Will the inquiry-based teaching method have a different effect, if any, on students' academic performance of male and female students?

1.2 Hypotheses

The following null hypotheses were tested in the study at 0.05 significant level:

1. H01: There is no significant difference in performance of students taught chemistry using inquiry-based teaching method and those taught using traditional lecture method.
2. H02: There is no significant difference in attitudes of students taught chemistry using inquiry-based teaching method and those taught using traditional lecture method.
3. H03: There is no significant difference in the academic performance between male and female students taught chemistry using inquiry-based teaching method.

1.3 Theoretical framework

Constructivism

The inquiry-based teaching method is underpinned within the constructivism learning theory. This theory was born as a result of the frustrations of the didactic teaching methods associated with behaviorism (Lister, 2015). Contrary to the didactic teaching methods, learners in constructivism learning environments are not considered passive recipients of knowledge from the teacher, rather, they construct and co-construct their knowledge through an interactive process discovery, investigation, debating, sharing and reflecting. This promotes deep understanding of the content as the students connect their prior knowledge to the learning experience. Piaget, one of the pioneers of constructivism wrote, "*To understand is to discover, or reconstruct by rediscovery, and such conditions must be compiled with if in future individuals are to be formed who are capable of production and creativity and not simply repetition*" (Piaget, 1973, p. 20). Constructivism learning allows students to take ownership and control of their learning rather than being passive receivers of knowledge in a spoon-feed way (McLeod, 2019). Although students play the central role in the teaching and learning process, Teacher's presence is critical as he/she plays the role of designer and facilitator of the teaching and learning process. All learning activities take place under close guidance of the teacher.

2. Literature Review

2.1 Inquiry-based teaching method

The teaching method is a way teachers use to present the content to the learners. It is an important component in the teaching and learning process. O'Connor (2000) observed that the type of teaching method may influence students' academic performance. Teaching method not only influences academic performance but also play a pivotal role in promoting students' motivation for learning and

participation in the teaching and learning process. Consequently, students' attitudes towards the subject are also affected (Sree, 2010). In the constructivist view of education, inquiry-based teaching method is one of the trending methods in science teaching. It has been associated with good science teaching for a long time (Rocard et al., 2007). According to Anderson (2002), the inquiry-based learning is one of the constructivist-based teaching method which reflect the goals and nature of science. In this method, students use the procedure which is like the ways scientists use in scientific research (NRC, 2000). The student or the teacher identifies the problem, proposes hypotheses, conducts scientific investigations, collects and analyses relevant data, interprets the findings based on evidence, and communicates the results (Colburn, 2000; Hofstein & Mamlok-Naaman, 2007; Pedaste et al., 2012). The teaching and learning process is question driven and based on students' inner curiosity. The student actively conducts investigations to explore and find more information about the natural world. Therefore, students play an active role in learning process while the teacher' role is to create a conducive and student-centered environment in which learning through inquiry is possible (Mascolo, 2009). Inquiry-based learning offers a range of opportunities to the students not only in chemistry but also in science subjects in general. Wenning (2005b) asserts that, through inquiry-based learning, the students learn chemistry as both process and as a product. Thus, the students will learn Chemistry content as well as appropriate ways of thinking that can promote independent learning. Chiappetta & Adams (2004) also describes inquiry-based teaching method as a teaching method that facilitates students' understanding of the basic principles, theories and concepts; instilling the ability to ask questions and to answer them as well as developing positive attitudes towards science.

2.2 Effectiveness of inquiry-based teaching method

Various studies have identified inquiry as a teaching method which facilitate students' understanding of the nature of science (Chiappetta & Adams, 2004), improves their performances and attitudes towards the learning of science courses (Gibson & Chase, 2002; Mao and Chang, 1998) and promotes students' engagement and motivation in a student-centered and active learning environment (Gómez & Suárez, 2020; Maxwell et al., 2015). Moreover, apart from the science contents knowledge, students exposed to the inquiry-based learning acquire such skills as asking questions (Alkan, 2018).

This process of knowledge construction is appropriate for the students to develop higher order thinking skills, inquiry skills, and lifelong learning skills (Ryan & St-Laurent, 2017; Ismail & Elias, 2006). Not surprisingly, various research findings have confirmed the inquiry-

based learning is more effective in terms of academic performance than traditional learning in learning science including Chemistry (Khan et al., 2011; Sen & Oskay, 2016; Tekin & Eryilmaz, 2021; Tshering & Yangden, 2021) and in promoting positive attitudes towards chemistry (Ni'Mah et al., 2018). Considering all the benefits brought by inquiry-based teaching, the word inquiry has been used to characterize good science teaching over the past decades (Anderson, 2002).

The cognitive component of learning measured by academic performance is likely to be developed when the affective component measured by attitudes is also taken into consideration. Therefore, attitudes are essential components in science teaching and learning, there is a strong positive correlation between attitudes and performance, students with positive attitudes toward science tend to perform better than students with negative attitudes (Tan, 2007). The study by Ni'Mah et al. (2018) to determine how attitudes towards chemistry change with the implementation of inquiry-based learning among 11th grade students concluded that students' attitude toward Chemistry increases with the implementation of inquiry-based teaching method. Sen and Oskay (2016) also examined the effects of 5E inquiry-based learning on students' performance and attitudes in learning factors affecting equilibrium. The inquiry activities followed five steps of engagement, exploration, explanation, elaboration and evaluation. The study found that inquiry-based teaching method improved student performance but that it had no influence on students' attitudes. Similarly, the study of Mao and Chang (1998) to investigate the impacts of an Inquiry-based teaching method on ninth grade earth science students' achievement and attitude toward earth science in secondary schools found the supremacy of inquiry-based teaching in terms of academic performance and attitudes over the traditional lecture-based teaching method. The authors argued that inquiry teaching method provides students with opportunities of learning actively through investigation, discussions, and student reflection. This stimulates students' motivation and develops higher mental skills which improve their achievement and attitudes towards science subjects.

Despite the benefits of inquiry-based teaching in science education, the actual implementation of inquiry-based learning remains difficult for both teachers and learners (Anderson, 2002); Even after many years of reforms this approach is not widely implemented in the classrooms and traditional learning still dominate the teaching and learning activities (NRC, 2000); This is due to challenges associated with inquiry implementation as compared to the traditional way of learning. The main challenges include: (i) Teachers' deficiency of inquiry experiences which causes low self-confidence in conducting the inquiry, (ii) Students' resistance to inquiry, (iii) Lack of inquiry skills on the side of the students that make it difficult for them to formulate good research questions,(iv) Inability of

students to manage and organize complex tasks,(v) The practical constraints of the learning contexts such as fixed schedules, and (vi) Unavailability of necessary resources (Kazempour,2009; Davis, 2003).

The implementation of inquiry-based learning is challenging; however, it is crucial for science teaching. Thus, the teacher needs to consider its benefits and develop strategies to overcome the challenges encountered during implementation. Although the teacher must try his best to solve these challenges, gender interaction with inquiry-based learning may prevail and affect the teaching and learning process. One of main goals of education across the world is to improve students’ academic performance and achievement, irrespective of any kind of any biological of environmental based discrimination practices. All children should have equal opportunities with regards to the teaching and learning process. Despite the willingness of providing education free of any kind of discrimination and providing equal opportunities to learners, the teaching and learning process is likely to be influenced by a myriad number of factors such as student factors, teacher factors, environmental factors, and economic factors among others.

Gender is one the factors believed to influence students’ performance; some people believe that it is a strong determinant of academic performance. Gender is an aspect concerning the responsibilities, roles, opportunities, constraints, and needs of males and females in all aspects of social context (Filgona & Sababa, 2017). Gender difference in achievement can be explained by many factors which include biological factors, the socialization

process which take place at home (Kangethe et al., 2014), gender biases in teaching (Frawley, 2005), and gender-related biases in assessment (Woodfield, 2005). A significant number of research studies that explored gender interactions with inquiry-based teaching method found that it is gender friendly in teaching chemistry and other subjects (Ajayi & Ogbeba, 2017; Ghumdia, 2016; Ibe, 2004; Yeboah et al., 2020). However few studies indicate that males perform better (Veloo et al., 2015) or females outperform males (Cooper et al., 2015)

3. Methodology

3.1 Research design

The study involved quasi-experimental pretest posttest design. This is mainly because there was no random assignment of participants in control and experimental groups. Secondary school’s classes exist as intact groups and school authorities do not accept that classes be dismantled and the reconstructed for research purposes (Gopalan et al., 2020; Njoroge et al., 2014); This is because it is too disruptive to curriculum and too time consuming to assign randomly students to either control group or experimental group. The schools chosen for the study were apart from one another to control students’ interaction. The students were taught by their normal teachers. However, the teacher for experimental group received a two-week training on effective implementation of inquiry-based teaching method to make sure that he prepares lesson in such way that inquiry-based learning is possible. The summary of research design and procedures of this study is shown in Table 2.

Table 2: Quasi-experimental design processes

| Group | Pre-test | Experimental Process | Post-test |
|--------------------|-------------|----------------------|-------------|
| Experimental group | CAT and CAQ | IBTA | CAT and CAQ |
| Control group | CAT and CAQ | CTA | CAT and CAQ |

Key

CAT: Chemistry Achievement Test
 CAQ: Chemistry Attitudes Questionnaire
 IBTA: Inquiry- Based Teaching Approach
 CTA: Traditional Teaching Approach

3.2 Population, sample and data collection tools

Prior to data collection the introductory letter was presented to the mayor of Bugesera district asking research authorization in Bugesera district; once permission was granted, Simple random sampling was used to select two schools from a total of ten schools with

chemistry containing combinations in the district. The two schools were distributed to experimental and control groups. Finally, the researcher purposively sampled senior four students to participate in the study. This is because senior four students were in a good position to fully engage in the intervention activities since they were not preparing for national examination; Additionally, they had been exposed to the greater extent of the chemistry curriculum which could have developed and stabilized

their attitudes towards the chemistry subject. The sampling processes ended with a sample 78 senior four students to participate in the study. After sampling process, data collection process started. The instruments of data collection were Chemistry achievement test (CAT) and a Chemistry attitude questionnaire (CAQ). Chemistry achievement test (CAQ) was based on the unit five of senior four chemistry syllabus, trends in variation of the physical properties of elements while Chemistry attitudes questionnaire was a 5 points Likert scale developed by Salta and Tzougraki (2004) and adapted by the researcher. All instruments were validated by experts prior to the actual data collection.

3.3 Research procedure

In this study, there were two groups: experimental and the control groups. At the beginning of the study, groups were given Chemistry Achievement Test (CAT) and a Chemistry Attitude Questionnaire (CAQ) as a pre-test to establish baseline comparison. After the pretest, the two teachers were trained by the researchers on effective implementation of inquiry-based method. After the training of the teachers training, the experimental group, which consisted of 43 students was exposed to four weeks teaching, using inquiry-based teaching approach to teach the variation in trends of the physical properties of elements unit in Chemistry, while the control group was taught using a traditional teaching method for four weeks as well. A guided inquiry model was adopted in which the students were given questions to inquire and then asked to design their method of investigation so that they could get the answer. During the lessons, the students carried out different activities and investigations under close supervision and guidance of the teacher. The researchers also closely monitored the implementation of the inquiry-based teaching approach intervention to the treatment groups to ensure that the teacher is properly implementing this teaching method. The learning environment in the experimental group was characterized by being active, question driven, collaborative and student centered. The control group, which consisted of 35 students was also subjected to four weeks teaching using the traditional method. Finally, a post-test chemistry achievement test and Chemistry attitude questionnaire were administered to both experimental and control groups.

3.4 Method of data analysis

The data collected, students pretest and posttest scores and students' attitudes scores on Likert scale were analysed by using the statistical package for social sciences (SPSS) version-26. Prior to the analysis the independent t-test

assumptions were verified. It was found that the skewness and kurtosis values remained in the +2 and -2 interval, therefore the data can be regarded as normally distributed (George & Mallery, 2003). The Levene's test of homogeneity of variance also revealed that the equal variances assumption was met. After finding that all the t-test assumptions were satisfied, the independent samples t-test for equality of means was conducted to find the results. ANCOVA using pretest scores as covariate also was used in order to detect the interaction effect between gender and the inquiry-based teaching method. Finally, data analysis and presentations and analysis of results were carried out in line with the research questions and the hypotheses.

3.5 Validity, reliability and ethical considerations

The instruments of data collection was verified by multiple experts to ensure the content validity and the pilot study was conducted to ensure face and construct validity. The pilot study also enabled the researchers to obtain the reliability of instruments by calculating Pearson correlation coefficient. The computed Pearson correlation coefficient of the achievement test was 0.853. This was a confirmation of test reliability which is according to Fraenkel and Wallen (2008), an instrument is considered reliable if its reliability coefficient is 0.7 or greater. In carrying out the study, ethical principles were adhered to by seeking authorization from concerned authorities. Participants were informed about the purpose and the importance of the study, and they agreed freely to participate in the study. Moreover, anonymity, and confidentiality were observed during and after data collection.

4. Results and Discussion

4.1 Effect of inquiry-based teaching method on students' performance in Chemistry

The effect of inquiry-based teaching method on students' performance in chemistry was determined through answering research question one, what is the effect of inquiry-based teaching method on students' academic performance in chemistry? Pretest and posttest chemistry achievement test scores were analysed using an independent t-test. The results are presented in table 3.

Table 3: Independent sample t-test comparing means of students' pretest and posttest Chemistry achievement scores between experimental and control groups

| Test | Group | N | X | SD | t | df | P |
|-----------|--------------------|----|-------|------|-------|----|---------|
| Pre-test | Experimental group | 43 | 13.93 | 7.76 | 1.37 | 76 | 0.176 |
| | Control group | 35 | 15.06 | 3.40 | | | |
| Post-test | Experimental group | 43 | 20.79 | 4.28 | -3.82 | 76 | 0.0002* |
| | Control group | 35 | 17.14 | 4.11 | | | |

*: Significant

From Table 3, the results of pretest show that there was no significant difference in terms of performance between the control and the experimental group at the beginning of the study since $t(76) = 1.37$, $p > 0.005$. However, the independent t-test statistics results showed a significant difference in the academic performance between students taught using inquiry-based teaching method and those taught using traditional teaching lecture method since $t(76) = -0.3.93$, $p < 0.05$, two-tailed. The calculated p value of 0.0002 is lower than the 0.05 alpha level of significance while the t-calculated value of -3.82 is lower r than the t-critical. Though the mean achievement scores of both control and experimental group were increased on the post test, it was clearly seen that the experimental group students performed better than their counterparts in the control group and that the difference was significantly different. Consequently, null hypothesis 1 is rejected. 0.0002 is lower than the 0.05 alpha level of significance while the t-calculated value of -3.82 is lower r than the t-critical. Though the mean achievement scores of both control and experimental group were increased on the post test, it was clearly seen that the experimental group students performed better than their counterparts in the

control group and that the difference was significantly different. Consequently, null hypothesis 1 is rejected.

4.2 Effect of inquiry-based teaching method on students' attitudes towards Chemistry

The effect of inquiry-based teaching method on students' attitudes towards chemistry was determined by answering research question two, what is the effect of inquiry-based teaching method on students' attitudes towards chemistry? Pretest and posttest data related to students' attitudes were analyzed using descriptive and inferential statistics. The results are presented in table 4.

Table 4: Independent sample t-test comparing means of students' pre-test and post-test Chemistry attitudes scores between experimental and control groups

| Test | Group | N | X | SD | t | df | P |
|-----------|--------------------|----|-------|-------|-------|----|---------|
| Pre-test | Experimental group | 43 | 91.34 | 9.59 | 0.31 | 76 | 0.75 |
| | Control group | 35 | 92.09 | 11.36 | | | |
| Post-test | Experimental group | 43 | 98.14 | 6.51 | -3.64 | 76 | 0.0004* |
| | Control group | 35 | 92.11 | 7.81 | | | |

*: Significant

From table 4, the mean attitudes score for control and experimental group was 92.09 and 91.34 respectively with a P-value of 0.75, $p > 0.05$; This indicate that there was no significant difference in terms of attitudes toward chemistry between the control and experimental group at the start of the treatment. The post-test result indicates that the mean attitudes scores of control and experimental group has increases to 92.11 and 98.14 respectively;

However, the mean attitudes scores of experimental group was significantly higher than that of the control group, $t(76) = -3.64$, $p < 0.005$ indicating a significant difference in terms of attitudes scores between control and experimental groups in the favor of the experimental group. Consequently, the researchers reject hypothesis 2, because students taught Chemistry through inquiry-based teaching method had more positive attitudes towards

Chemistry than students taught through traditional lecture-based teaching method.

4.3 The interaction effect between gender and inquiry-based teaching method in Chemistry

Gender interaction with inquiry-based teaching method was assessed by answering research question three, will the inquiry-based teaching method have a different effect, if any, on students' academic performance of male and female? The experimental group which was exposed to inquiry-based teaching method was divided into two groups based on gender, their pretest and posttest scores were analysed using ANCOVA, and the results are contained in table 5.

Table 5: Results of ANCOVA comparing posttest scores by gender with pretest as covariate

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|-----------------|-------------------------|----|-------------|--------|------|
| Corrected Model | 49.176 ^a | 2 | 24.588 | 1.362 | .268 |
| Intercept | 1741.074 | 1 | 1741.074 | 96.466 | .000 |
| Pretest | 47.966 | 1 | 47.966 | 2.658 | .111 |
| Gender | 3.054 | 1 | 3.054 | .169 | .683 |
| Error | 721.941 | 40 | 18.049 | | |
| Total | 19358.000 | 43 | | | |
| Corrected Total | 771.116 | 42 | | | |

a. R Squared = .064 (Adjusted R Squared = .017)

The results in table 5 show that, there is no statistically significant difference between academic performance of males and females after being exposed to inquiry-based teaching method since the computed F value of 0.169 and probability value of 0.683 ($p > 0.05$), are not statistically significant at 0.05 significance level. This mean that both male and female students benefited almost equally from the inquiry teaching method. Based on the results, the researchers fail to reject hypothesis 3; because there is no significant difference in the academic performance of males and females taught chemistry using inquiry-based teaching method.

4.4 Discussion of findings

The study examined the effect of inquiry-based teaching method on students' performance and attitudes towards chemistry. The results indicated clearly a positive impact of inquiry-based teaching approach on students' performance and attitudes towards chemistry as the students in experimental group who were exposed to inquiry-based learning activities performed better and displayed a more positive attitude towards chemistry than students in control group. The possible explanation of such results is that students in experimental group had opportunities for critical thinking, problem solving, deductive thinking, involves probing, finding out, investigating, analyzing, synthesizing, discovering, evaluating, questioning and reasoning about the material

They were studying. Inquiry-based learning promote students' science process skills which are helpful to the experimental group to learn chemistry in a better way compared to the control group. This result is parallel with several studies that have supported the superiority of inquiry-based teaching approach over traditional lecture-based teaching method in teaching Chemistry.

Khan et al. (2011), concluded that the inquiry-based instruction improved students' achievement in the subject of chemistry at secondary school level. Sen & Oskay (2016) also found that guided inquiry-based teaching approach study increased students' academic achievement in the subject of factors affecting chemical equilibrium. They have also concluded that students in experimental group who were exposed to guided inquiry-based learning displayed fewer misconceptions than their control group counterparts. The study conducted in Tanzania by Ibrahim et al. (2018) also found that the experimental group on which the inquiry-based teaching method was implemented gained higher mean scores than the control group taught using traditional lecture method. Similarly, Apart from Chemistry, inquiry-based teaching method was found to be effective in teaching other science subjects (Crawford, 2000; Njoroge, et al., 2014.). Although the finding of this study shows that inquiry-based teaching method is more effective than traditional teaching method, Renninger and Hidi (2006) opines that inquiry-based teaching method has no priority over traditional teaching method. He assert that teaching methods that rely on minimum guidance from the teacher are time consuming and not effective.

The result of the study also revealed a positive effect of inquiry-based teaching method on the students' attitudes towards chemistry. The mean attitudes scored of both control and experimental group has improved on posttest compared to the pretest. However, the mean attitude scores of experimental group was significantly higher than that of control group. This result can be explained by the fact that inquiry-based learning processes are centered on student' own curiosity and that the student is actively involved in the learning process. This result is in line with that of many studies in the literature which found a positive effects of inquiry-based learning on students' attitudes. The study by Arthur (2004) revealed that inquiry-based instruction facilitate students to work collaboratively, make connections to other experiences, and demonstrate confidence to ask and answer their own questions, therefore improving their performance. Gibson and Chase (2002); Koksai and Berberoğlu (2014 ;) also made similar conclusions.

When dividing the students by gender, we found that there was no significant difference in the pretest and posttest mean scores of male and female students in the experimental group. Therefore, no gender gap was observed in terms of academic achievement in chemistry while using inquiry-based teaching method. This may have resulted from the fact that the teacher gave the same opportunities for male and females student while teaching by avoiding any activity or behavior that could be regarded as gender-bias stereotype. This may have made all the students enthusiastic throughout the inquiry-based lesson and to participate in presentations and critical reflections about the learning content which could have promoted their understanding. These findings are consistent with that of Adejo (2015) who found that the post-test mean scores of males and females in the conceptual understanding of the selected topics of chemistry subject were not statistically significant with the use of inquiry-based teaching method. Alachi et al. (2021) concluded that inquiry-based teaching method has a positive impact on students' understanding of science concepts and achievement. However, from their findings, it was noted that gender has no effect on students understanding of science concepts and achievement.

Another study by Ibrahim et al. (2018) found that inquiry-based teaching is gender friendly in teaching chemistry. This implies that both male and female students performed equally well after exposure to Inquiry- based teaching method. Similarly, the study by Ajaja (2013) on the effects of 5E learning cycle on students' achievement in Chemistry found a non-significant interaction effect between the teaching method used and gender on achievement in chemistry. Yu and Liu (2003) also have found that gender does not have any significant impact on students' learning. Based on the findings of this study, the innate factors and the socialization process between males and females have no-significant contribution to their academic performance. Contrary to the above studies,

several studies have found a gender bias with respect to the use of inquiry-based method to teach chemistry. Some have found a significant gender-related difference in students' academic performance in favour of male (Eze, 2008; Ifeakor, 2005) while others concluded that it is more productive for female (Aniodoh & Egbo, 2013; Mwenda & Ndayambaje, 2021).

5. Conclusion and Recommendations

5.1. Conclusion

In conclusion, it was found that the inquiry-based teaching approach used in this study increased students' academic performance and attitudes towards chemistry. Consequently, it is an effective teaching approach in teaching chemistry. Moreover, males and females benefit equally in terms of academic performance when they are exposed to inquiry-based teaching approach. Therefore, there is no need of separation of teaching method for female and male students since inquiry-based teaching method should be used successfully to teach both gender. This might indicate that there are other factors hindering effective learning of females in chemistry. These factors might be explored in further research studies.

5.2. Recommendations

1. Chemistry teachers should use inquiry-based teaching approach to teach chemistry as an effective method to promote students' performance and attitudes in chemistry.
2. Teachers and students' perception that chemistry is all about only memorization of facts should be hindered and students and the role of questioning, exploration and investigation in learning chemistry must be acknowledged.
3. Chemistry teachers should use inquiry-based teaching method to teach chemistry irrespective of the gender of the student to enhance their performance in chemistry.

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