Journal of Mathematics and Science Teacher
2022, 2(2), em019
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

Research Article

OPEN ACCESS

The effect of the chemistry practicals on the academic performance of Ward Secondary School students in Momba District in Tanzania

Alune Afyusisye [1*], Emmanuel Gakuba [1]

[1] University of Rwanda, College of Education, RWANDA
***Corresponding Author:** alunesi92@gmail.com

Citation: Afyusisye, A., & Gakuba, E. (2022). The effect of the chemistry practicals on the academic performance of Ward Secondary School students in Momba District in Tanzania. *Journal of Mathematics and Science Teacher, 2*(2), em019. https://doi.org/10.29333/mathsciteacher/12397

ARTICLE INFO

Received: 27 Apr. 2022

Accepted: 14 Aug. 2022

ABSTRACT

The knowledge of chemistry is fundamental in the development of industries of any country. Acquiring chemistry knowledge starts from lower schools to higher schools. In acquiring chemistry knowledge, practicals are very important in equipping students with the knowledge and skills of actual practices of the concepts they learn. Practicals are used as a catalyst in understanding chemistry concepts. The purpose of this study was to examine the effect of chemistry practicals on the academic performance of ward secondary students in the Momba District in Tanzania. The study examined the effects of chemistry practicals on the academic performance of students in ward secondary school. This study utilized a quantitative approach, with a quasi-experimental design. A quasi-experimental design was designed in form of pre- and post-test. The data were collected through students' chemistry achievement tests, and it involved 92 students, 46 from the experimental and other 46 from the control group. Descriptive statistics such as mean and standard deviation were used, and inferential statistics involved the independent samples t-tests. The findings show that there was a significant difference in performance between students who studied chemistry through practicals and those who studied chemistry without practicals. Therefore, the study recommends the consideration of practicals works in the teaching and learning of chemistry.

Keywords: academic performance, chemistry practicals, ward secondary schools

INTRODUCTION

Learning by doing in science subjects, particularly in chemistry is very important in enabling students to understand what they are learning. This has been emphasized by various researchers and academics mostly those who advocate for learning by doing (Köller et al., 2015; Muleta & Seid, 2016; & Shana & Abulibdeh, 2020). Learning by doing enhances students' motivation, interest, and understanding of chemistry concepts (Shana & Abulibdeh, 2020). It also enables students in developing different skills like observational skills, communication, questioning skills, and problem-solving (Tesfamariam et al., 2014). On the other hand, practical work allows students to use all the five senses during learning because while they are experimenting, they can see, hear, touch, taste, and also smell the products of experiments (Köller et al., 2015). This promotes active participation, and engagement in learning, and it draws students' attention to the lesson. It is exploration-based learning in which students build their levels of confidence and creativity, occasioning improved performance and sustained motivation to learn.

In addition, learning through chemistry practicals is regarded as learning by hands-on activities. Hands-on can be captured as learning by experience (Kagan, 1992). Students' experience in the chemistry laboratory when doing experiments gives them a more realistic experience of the content. This way of learning provides a conducive learning environment for students. Tesfamariam et al. (2014) highlighted that practical work leads to better learning of chemistry concepts. Practical work as hands-on activities allow students to engage in kinesthetic learning. Kinesthetic learning is the learning style in which information is processed through movement and touch (Navaneedhan, 2015). Learners absorb more information by doing rather than merely listening or seeing. As quoted from Shneiderman (1998):

> "'I hear, and I forget; I see, and I remember; I do and I understand'. Similarly, Sophocles's quote: 'One must learn by doing the thing; for though you think you know it; you have no certainty until you try'" (p. 3).

In this regard, practicals are core to the mastery of chemistry knowledge (Muleta & Seid, 2016) and therefore, teaching and learning chemistry at any level of education should involve practical work (Köller et al., 2015).

The effective use of chemistry laboratory resources remains a challenge in most Ward secondary schools in Tanzania. Ward secondary schools are secondary schools built by the efforts of the government and parents in each ward throughout the country

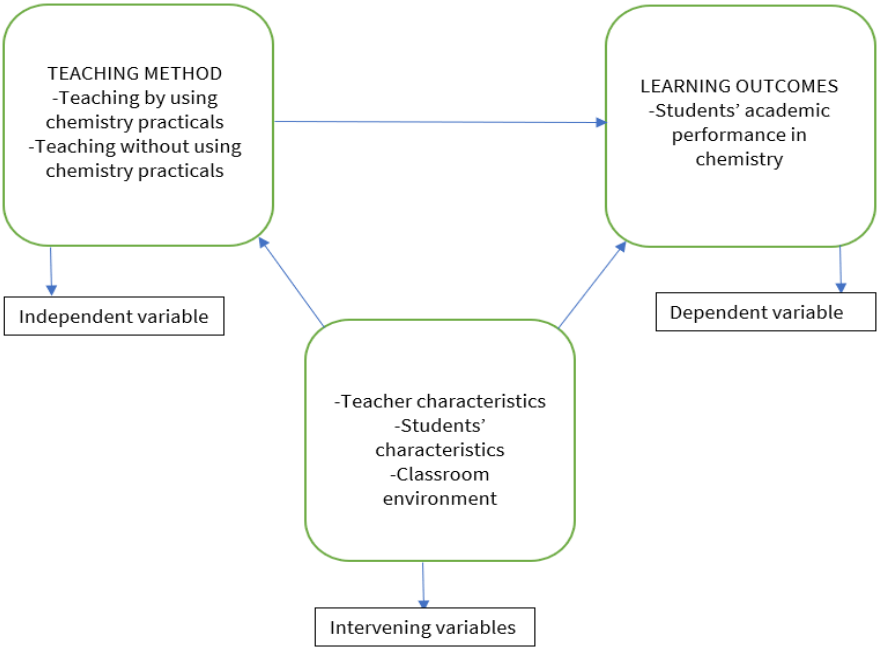

Figure 1. Relationship between the variables for determining the effects of chemistry practicals on the academic performance of ward secondary school students

(Buhatwa, 2014). "These schools are being threatened by a lack of chemistry teachers and equipped chemistry laboratories which lead to poor performance of students" (URT, 2010). Students were enrolled in ward secondary school before the construction of chemistry laboratories, so they were subjected to learning chemistry without practicals. Lack of practical work led to poor performance in chemistry in most ward secondary schools. In response to poor performance, the government effort through the secondary education development plan one (SEDP1) mandated that each secondary school must have a chemistry laboratory (URT, 2010). This plan helped to build chemistry laboratories in most ward secondary schools around the country.

Although most ward secondary schools have chemistry laboratories and students are expected to make use of them in learning, their performance in chemistry has remained low (Buhatwa, 2014). The appropriate use of the chemistry laboratories causes effective learning to take place. However, the effective use of chemistry practicals has not been given much attention in ward secondary schools in Tanzania including those in the Momba District. Therefore, the study examined the effective use of chemistry practicals on the academic performance of students in the Momba District.

Contribution of the paper to the literature

1. Learning chemistry concepts through practicals is more effective than learning chemistry concepts theoretically.
2. The effective use of chemistry practicals promotes the good performance of students.

The Objective of the Study

This study was designed to investigate the effects of practicals on the chemistry performance of ward secondary school students. The study examines whether practical activities in chemistry improve students' performance. The study tests the null hypothesis (H0), as follows:

H0: There is no significant difference in the mean scores on chemistry achievement tests between students taught through practicals and those taught without practicals.

Conceptual Framework

The conceptual framework of this study is represented diagrammatically (**Figure 1**). It shows the relationship between variables for determining the effects of chemistry practicals on the academic performance of ward secondary students. The performance of students is influenced by various factors, but the teaching method is the main factor considered in this study. Other factors include classroom environment, students' characteristics, and teacher characteristics (Wambugu & Changeiywo, 2008). The teaching method is treated in two ways in this study. The first way is teaching chemistry using practicals. Teachers in this way integrate constructivist learning theory, this theory builds on the active involvement of students during the learning process (Amineh & Asl, 2015).

Students can practice what they have learned when they are learning with practicals. Students can participate in group work, work together with their fellows, and generate knowledge and different skills (Tesfamariam et al., 2014). Also, students can be able to see, touch, smell, and taste the product of the experiment. This act can raise their interest in chemistry, and they become motivated in learning chemistry. The whole teaching process is kind of learner centered as it involved the active participation of students. On the other hand, the second way of treatment is teaching without chemistry practical in the classroom. Students were passive recipients of knowledge, mainly listened to the teacher and copied notes without knowing how to practically relate

concepts. This is a kind of teacher-centered learning. Finally, both teaching ways were measured through posttest to see their effects on the performance of students. Therefore, in this study, the chemistry teaching method is used to influence the academic performance of students.

METHODOLOGY

Study Design and Participants

This study used a quasi-experimental design with a pre-test and post-test. According to Kothari (2004), this approach is used when the study needs some manipulation of one variable to see its effect on the other variable. This study involved the manipulation of an independent variable (chemistry teaching method) to see its effect on the dependent variable (student performance). In this matter, it used a quasi-experimental design with participants divided into experimental and control groups. The participants involved in this study were all Form Four students who were studying chemistry subjects from ward secondary schools in the Momba District. Momba District consists of 15 government and two private secondary schools, but the study involved ward secondary schools, which are government schools. Therefore, six schools in total were purposively selected for this study (Kothari, 2004) explains that purposive sampling is used when the researcher deliberately selects the participants of the sample that will provide the needed information. Also in Tanzania, one classroom in secondary schools is supposed to have 40 students. In this case, the researcher used the available students in each of the six schools and found a total of 92 students who are doing chemistry, and all participated in the study. Therefore, in obtaining 92 students a researcher used convenience sampling. According to Fraenkel et al. (2019), convenience sampling is used when a researcher cannot use either random sampling or non-random sampling and use the available for the study. Finally, the six schools were randomly divided into experimental and control groups.

Data Collection Instrument

Students' achievement tests (SAT) were used to collect data from tests performed by students before and after treatment for both experimental and control groups. SAT was designed for pre- and post-test, both comprised 10 multiple choices items, which were drawn from the selected topic "volumetric analysis". A pre-test was administered in the first week before the treatment and it is attached in **Appendix A** while the post-test was done in the last week after the treatment and is attached in **Appendix B**.

Reliability, Validity, and Data Analysis

The face and content validity of the test was checked by submitting the questions to the chemistry experts and then they were piloted. After piloting the reliability was calculated for both pre-test and post-test. Internal consistency reliability was measured for both pre-test and post-test and the Cronbach's alpha values obtained were 0.989 and 0.999, respectively. According to Fraenkel et al. (2019), the Cronbach's alpha value of 0.7 and above is enough to make the inference, therefore, the obtained values of SAT revealed that SAT was a reliable tool. The data obtained was quantitatively in nature and were analyzed through statistical package for social science (SPSS) version 12. Descriptive statistics mean and standard deviation (SD) were computed, and an inferential statistic independent t-test was also computed.

Context of the Study

The study was conducted in the Momba District found in Southwest Tanzania. Momba District suffers from poor social services including education. Momba District has secondary schools that are very scattered and located in an area that cannot easily be reached due to poor roads and communication. Most students from Momba District escape from science subjects including chemistry claiming that is difficult. Therefore, the researcher chose this research area to check whether there is an effective use of chemistry practicals on the performance of students.

Intervention

The intervention in this study was done within eight weeks and it started immediately after a pre-test. The material learned in this study was volumetric analysis. Students were taken through the meaning of volumetric analysis, terms used in volumetric analysis, types of apparatus used, titration process, and calculations involved in volumetric analysis. The same contents were taught to both groups experimental group and the control group but differently.

Control Group

Students in this group were taught without practicals in the classroom using a teacher-centered approach. This approach focused on knowledge transmission from the teacher to students. The teaching method was based on lecturing relies on textbooks, materials were presented from parts to the whole and it was focused on basic ideas.

Experimental Group

Students in this group were taught practically in the chemistry laboratory using a student-centered approach. This approach emphasizes inquiry, meaning-making, and authentic activities. The teaching method was based on hands-on activities, materials were presented from whole to parts, and it focused on big ideas. Before the experiment, students were introduced to the meaning, terms used, and apparatus used in volumetric analysis. Finally, students were involved in performing experiments, and activities were divided as shown in **Table 1**.

Table 1. Activities in the laboratory performed by the experimental group

Activities	Role of the teacher	Role of students
Before practical	Demonstrating to students how to handle apparatus and how to record data while experimenting.	Learning how to handle apparatus and to do an experiment
During practical	Scaffolding students when doing experiments example monitoring better use of chemicals and giving help to students, where it is necessary.	In groups participating in doing titration experiment while recording the results in the form of the initial volume and final volume
After practical	Scaffolding students in doing calculations.	Doing calculations related to the experiment by using the data obtained from the experiment.

Table 2. Descriptive statistics of the pre-test scores for the experimental and control groups

Group	N	Minimum	Maximum	Mean	Standard deviation
Experimental	46	11.00	65.00	34.96	14.02
Control	46	10.00	64.00	34.76	14.18

Table 3. Descriptive statistics of the post-test scores for the experimental and control groups

Group	N	Minimum	Maximum	Mean	Standard deviation
Experimental	46	19.00	92.00	55.33	22.38
Control	46	17.00	78.00	47.15	17.95

Table 4. Independent t-test results on the pre-test scores between experimental and control groups

Independent t-test	T	df	Sig. (2-tailed)	Mean difference	Standard error difference
Pre-test equal variances assumed	.067	90	.947	.196	2.939

Table 5. Independent t-test results on the post-test scores between experimental and control groups

Independent t-test	T	df	Sig. (2-tailed)	Mean difference	Standard error difference
Pre-test equal variances assumed	1.974	85	.052	8.348	4.229

RESULTS

The results obtained from this study were collected from students' achievement tests (SAT). Data analysis of the results collected from SAT was, as follows:

Students' Performance in Volumetric Analysis

The researcher conducted the descriptive statistics on the pre-test score for the experimental and control group. The test scores obtained from the pre-test for both groups were entered into SPSS and the descriptive statistics; mean and SD was computed. The results obtained for both the experimental and control groups are displayed in **Table 2**.

The mean for the experimental group is 34.96 and the mean for the control group is 34.76. There is a very small difference in the mean for the experimental group and control group, which is 0.2. The SD is 14.02 and 14.18 for the experimental and control group, respectively.

Also, the descriptive statistics data obtained from post-test scores for both experimental and control groups are shown in **Table 3**. The mean for the experimental group is 55.33 and the mean for the control group is 47.15. The SD for the experimental is 22.38 and 17.95 for the control group.

Effects of Practicals on Students' Performance in Volumetric Analysis

The researcher performed a statistic test to see the effects of practicals on students' performance using an independent t-test. The researcher entered the data into SPSS to conduct an independent t-test to compare the pre-test scores for the experimental and control groups, the results obtained are shown in **Table 4**.

The difference between the experimental group (M=34.96, SD=14.02) and the control group (M=34.76, SD=14.18) (both having a sample size of 46) was statistically non-significant t(90)=0.196. p=0.947 at an alpha value of 0.05 level of significance, so we do not reject but accept the **H0**. This implies that there is no significant difference between the pre-test mean scores in the chemistry achievement test of students from the experimental group and control group.

On the other hand, the results of the independent t-test on the post-test scores between experimental and control groups are shown in **Table 5**. The difference between the experimental group (M=55.33, SD=22.38) and the control group (M=47.15, SD=17.95) (both having a sample size of 46) was statistically significant t(85)=8.348. The value of p=0.05 at an alpha value of 0.05 level of significance. This implies that there is a statistically significant difference between the post-test mean score in the academic performance of students learning through chemistry practicals and those who do not.

DISCUSSION

The study investigated the effects of chemistry practicals on the academic performance of ward secondary students. The study was guided by one research null hypothesis stated that there is no significant difference in the mean scores of chemistry achievement test between students taught through practicals and those taught without practicals. The results obtained from this study rejected this null hypothesis. So, the study found a significant difference in the chemistry performance between students taught through practicals and those taught without practicals. The performance of the students who learned chemistry through practicals was higher than that of the students who learned chemistry without practicals. This difference in performance may be attributed to the intervention that was done.

The findings are supported by Mwangi (2016), who investigated the effect of chemistry practicals on students' performance in chemistry. He found that chemistry practicals have positive effects on the academic performance of students. The results were also correlated by Buhatwa (2014), who found the importance of laboratory practicals in science subjects. The study results also are in line with Olubu (2015) who found that chemistry practicals facilitate student understanding, which results in a good performance. The results are also in line with Pavešić (2008), who explains that the good achievement of students has been influenced by practical work. He adds that practical works promote positive attitudes of students towards learning chemistry. The results also agreed with the ones obtained by Shana and Abulibdeh (2020), which show the positive relationship between practical work and the academic achievement of students.

Chemistry practicals increase motivation, and students' engagement and promote communication skills (Köller et al., 2015). Increasing, motivation and interest in students help them to love and learn chemistry (Hodson, 1990) Chemistry practical also helps students to develop a positive attitude and curiosity towards chemistry. This helps students to learn chemistry voluntarily which increases engagement and affects attitude, hence raising their performance. Also, the results in the agreement with Etiubon and Udoh (2017), who explained that the use of practicals activities is an effective way of teaching chemistry.

CONCLUSION AND RECOMMENDATION

The study investigated the effects of chemistry practicals on the academic performance of students in ward secondary schools. From the findings, the use of chemistry practicals promotes the good performance of students. As the mean obtained from the post-test of the experimental group was higher than the mean obtained in the pre-test, this improvement may be attributed to the intervention (practical work) which was done. The study, therefore, concluded that teaching chemistry by using chemistry practicals is an effective way to improve students' academic performance.

The study revealed some limiting factors to effective chemistry practicals in most ward secondary schools which are insufficient of chemistry laboratory facilities, absence of chemistry labolatory technicians and power supply. Therefore, the study recommends the authorieties to equip these schools with necessary requiremetns for chemistry laboratory. The government should purchase chemicals and equipment to make them available in the chemistry laboratory. This will give students opportunities to do chemistry practicals on time that will easily make them connect what they learned theoretically and how to perform them practically.

Also, the study recommends that any chemistry teacher should consider chemistry practicals as core in teaching and learning chemistry. So, any chemistry learning should embed practical works to make students actively engaged in the lesson.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgements: The authors would like to thank to the Inter-University Council for East Africa under the World Bank for their financial support, which contributed tremendously to the first author's master's studies at the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science at the University of Rwanda.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author

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APPENDIX A

Students' Achievement Test (Pre-Test)

This paper consists of 10 multiple-choice items. Choose the most correct answer and write its letter in the table provided below. Do not write your name anywhere on this paper.

1. _____is the process of determining the amount of substance in terms of volume and concentration of reacting solutions.
   a. Titration
   b. Volumetric analysis
   c. Acid-base titration
   d. Standardization
2. A_____is used for mixing, stirring, and heating chemicals.
   a. Volumetric flask
   b. Conical flask
   c. Beaker
   d. Reagent bottles
3. _____used to measure the volume of a base during volumetric analysis.
   a. Beaker
   b. Pipette
   c. Burette
   d. Test tube
4. During volumetric analysis is used_____to measure the volume of acid.
   a. Pipette
   b. Beaker
   c. Conical flask
   d. Burette
5. _____are used for precise dilutions and preparation of standard solutions.
   a. Volumetric flasks
   b. Measuring cylinder
   c. Reagent bottles
   d. Beakers
6. The most suitable indicator for titration of NaOH against benzoic acid, C_6H_5COOH is
   a. Bromophenol blue
   b. Methyl orange
   c. Thymol blue
   d. Phenol red
7. _____is the point which indicates the completion of the reaction by changing its color.
   a. Equivalent point
   b. Indicator point
   c. End point
   d. Neutralization point
8. _____is the theoretical point at which the equivalent amount of titrant and titrand is added together.
   a. End point
   b. Neutralization point
   c. Equivalent point
   d. Indicator point
9. _____is a chemical substance that changes the color of a solution at the end point.
   a. Methyl orange
   b. Indicator
   c. Litmus paper
   d. Molar solution
10. _____is the concentration of a substance in mole per liter/decimeter cubic of a solution.
    a. Molar solution
    b. Molarity
    c. Concentration
    d. Molality

Question	1	2	3	4	5	6	7	8	9	10
Answer										

APPENDIX B

Students' Achievement Test (Post-Test)

This paper consists of 10 multiple-choice items. Choose the most correct answer and write its letter in the table provided below. Do not write your name anywhere on this paper.

1. A suitable indicator for the titration of a strong acid and a weak base is
   a. Methyl orange
   b. Phenolphthalein
   c. Litmus solution
   d. Universal indicator
2. _____is the solution, which contains one mole of a substance dissolved in one liter or one dm^3.
   a. Concentration
   b. Molarity
   c. Molar solution
   d. Standard solution
3. _____is the process of adding one solution from the burette to another in the titration flask to complete the chemical reaction involved.
   a. Titration
   b. Volumetric analysis
   c. Quantitative analysis
   d. Volume mixing
4. A suitable indicator for the titration of a weak acid and a strong base is
   a. Methyl orange
   b. Phenolphthalein
   c. Litmus solution
   d. Universal indicator
5. To deliver a fixed accurate volume of a solution use a_____.
   a. Pipette
   b. Burette
   c. Beaker
   d. Conical flask
6. _____is the solution whose concentration is exactly known.
   a. Molarity
   b. Molarity
   c. Standard solution
   d. Molality
7. To deliver a fixed accurate volume of a solution use a
   a. Pipette
   b. Burette
   c. Dropper
   d. Beaker
8. _____is the amount of substance in a given volume of solution.
   a. Molarity
   b. Molar solution
   c. Concentration
   d. Molarity
9. _____used to measure the volume of a base during volumetric analysis.
   a. Beaker
   b. Pipette
   c. Burette
   d. Test tube
10. _____is the process of determining the amount of substance in terms of volume and concentration of reacting solutions.
    a. Titration
    b. Volumetric analysis
    c. Acid-base titration
    d. Standardization

Question	1	2	3	4	5	6	7	8	9	10
Answer										