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Effect of Practice-Based Learning in Chemistry on Students' Academic Performance in Rwanda

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Abstract: This study sought to establish the effect of practice-based learning in Chemistry on students' academic performance in Rwanda. The study used the quasi-experimental research design. The researchers used the pretest-posttest approach whereby prerequisite knowledge of students was tested prior to treatment. Thereafter, the control group was treated in a traditional approach of teaching using lecturing method while the experimental group was trained using the practice-based learning approach. After the teaching period, which took three weeks, students were given a week to prepare for a chemistry achievement test herein referred to as posttest. Results were analyzed and compared to measure the effect of practice-based learning among students in the experimental group. The study established that the experimental group which was taught through the problem-based approach performed better than the control group which was taught through the traditional learning approach. Therefore, practice-based learning significantly improved the performance of the learners. It is recommended that secondary school science teachers should take the advantage of practice-based learning to improve students' performance in science subjects.

Keywords: Practice-based learning; chemistry achievement test; quasi-experimental research design; constraints; practical activities; academic performance

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Introduction

Practice-based learning is one of promising student-centered methodologies that actively engage learners in the learning process. Practice-based learning activities have the potential to help educators to achieve high tier institutional and policy goals such as developing 21st century skills in STEM subjects at scale. However, 21st century skills including collaborative problem solving skills are complex and non-linear in nature. Previous researchers have investigated on practice-based learning as an essential learning approach in science education. Acquiring science process skills has been linked with teachers' ability to engage students into practical activities; however, secondary school science teachers encounter difficulties during its implementation (Estapa & Tank, 2017).

Previous studies (Matzembacher, Gonzales & do Nascimento, 2019; Saavedra & Opfer, 2012) have indicated that students' misconceptions in science education has been a challenge in the area of teaching and learning sciences. The teaching and learning of science has seen various alterations which give teachers and students opportunities to develop positive attitudes towards science as a subject and to make learning of science less stressful but more practicable and meaningful (Aidoo, Boateng, Kissi, & Ofori, 2016).

Understanding the importance of practice-based learning as an approach to science teaching and learning science subjects is imperative in education (Billett, Harteis & Gruber, 2014). Recent advances have also emphasized the rationale of reforms in education in order to have students learn in environments which allow them to grasp science skills. Students should interact with study materials in the so-called learning by doing to gain hands-on skills required in the labor market.

The process of knowledge, skills and attitudes acquisition should focus on doing something repeatedly rather than such kinds of approaches like story telling (Baartman & De Bruijn, 2011). Science courses especially chemistry, require more experience, tangible together with concrete examples throughout the learning endeavors. Teacher as one of the key components in the process of teaching and learning should facilitate leaning through different approaches that favor the effective learning processes. Proper Methodologies used by teachers during delivering science content have great impact on students' understanding and grasping of the body of knowledge and practical skills. Studies have indicated that proper teaching and learning methods can alleviate the complexity of the course segment. Literatures (Khalid & Anjum, 2019) showed that the methodology could affect the learning either positively or negatively, depending on how it is fitting into the learners' needs (Nkemakolam, Chinelo & Jane, 2018). A study conducted by Liu and Pásztor (2022) about a practice-based learning in which the methodology was believed to increase the critical thinking ability among students came out with the results indicating high level of influence of PBL.

Furthermore, chemistry is more practical than theoretical. This implies that different knowledge, skills and attitudes have to be developed among the learners through the repetition of experiences leading to the building of new knowledge (Colardyn & Bjornavold, 2004). Integrating theories and practices during the course of learning the chemistry subject is crucial to equip learners with abilities to solve real life problems after completing their studies. Learning by doing stimulates the learning process where learners actively participate in the academic activities involving creativity and innovation (Kpolovie, Joe, & Okoto, 2014). Teaching and learning chemistry without hands-on activities or practical works could lead to passive learning.

Since 2015, Rwanda adopted the competence-based curriculum (CBC) that favors learners to be actively engaged in the learning process (Ndihokubwayo & Habiyaremye, 2018). Generally, practice-based learning helps learners to link the content learnt with the real world situations and to increase their curiosity that in turn leads to the acquisition of higher-order thinking and problem solving skills. Practice-based learning is a way to be used to improve learners' academic performance in chemistry by empowering their positive attitudes, innovation and creativity through teaching and learning activities (Högström, Ottander & Benckert, 2010).

The Ministry of Education report in 2015 indicates that the repetition rate in Rwanda particularly in ordinary level was 6.20 % in 2012 and remained at 11.60 % for three consecutive years. However, in Nyanza District where the current study was conducted the repetition rate was 16.4 %, which was higher than the national repetition rate. The report of the Ministry of education in the year 2019 further indicates a decrease in National examination pass rate from 86.3 % in 2017 to 81.6 % in ordinary level. Moreover, there was a decrease of candidates who passed the ordinary level national examinations, from 89.9 % in 2017 to 86.4% in 2021. In the context of the schools where the study was conducted, the national examination results from Rwanda Education Board (REB) in ordinary level, especially in senior three at GS Gatagara, GS Nyarutovu and GS Kaganza indicates significant failure in chemistry where 78.37 % of learners in GS Nyarutovu got the lowest grade (ninth grade. Additionally, 135/148 (91.21%) of learners in GS Nyarutovu were located in two last grades. Similarly at GS Gatagara, 38/64 (59.37%) are in red line with ninth grade and 45/64 (70.31%) learners were classified in two last grade in academic year 2019. Severely failure also was observed in academic year

of 2018 at GS Gatagara where 48/60 (80%) of learners obtained the last grade (ninth grade) and 56/60 (93%) learners obtained two last grades in chemistry as shown by the national examination results. Moreover, the failure of students in chemistry was observed at GS Kaganza based on the national examination in academic year 2017. Therefore, performance among senior three students could be positively affected by practice-based learning approach (Rwanda Basic Education Board, 2020/ 2021).

Literature Review

The Concept of Practical-Based Learning

Practice-based learning (PBL) has been shown to be an effective approach in improving student academic performance, self-efficacy beliefs and overall satisfaction with the learning experience (Horak & Galluzzo, 2017). Teachers as the designers of practical work have to be aware of the learning through practices. Sciences could be difficult to understand not only for their complexity but also due to the technical terms that seem to be challenging in terms of pronunciation, writing and memorization. According to Oyoo (2006), teachers should devise proper teaching/facilitation method such as using simple language in order to facilitate learners' understanding of presented instruction.

Learning resources such as well-equipped laboratories play an important role in practical skills transfer in an efficient and effective manner thereby eliminating barriers to classroom practices (Ituma, Twoli & Khatete, 2015). Students are expected to engage actively in constructing their own understanding under the guidance of teachers in the practice-based learning environment.

Teachers acting as facilitators throughout the experiments have to be aware of the required procedure to design practical work and to be knowledgeable and skilled about practices (Verloop, Van Driel & Meijer, 2001).

Teachers should have the capability of bringing learners' mindsets to the ongoing experiments. Learners' engagement and well implemented practice-based learning approach boosts the use of practice- based learning (Al-Azri & Ratnapalan, 2014). Teachers' ability to use this approach should therefore be supported by the school administration by providing equipment and materials necessary for implementation. According to Cicek and Tok (2014), lesson preparation is a very important part to be considered before teaching, for selecting suitable teaching approaches, to motivate learners, making the lesson meaningful to learners and addressing learners' needs in order to make the lesson attractive.

For effective use of practice-based learning approach, teachers need to be concentrated on the lesson preparation for increasing confidence, classroom management and avoiding time wasting (Alter & Coggshall, 2009). Another study by Grossman et al. (2009) highlighted the procedures for delivering practical lesson such making it simple by dividing experiment into different steps, to organize practical activities depending learner's cognitive ability and ensuring their active participation, providing learning resources and appropriate equipment and making instructions more simple and clear (Freedman, 1997). The well-designed practical work can positively affect the learners' academic achievement that implies the role of the teacher as the designer to know how to set practical work and to monitor the progress until the end of the experiment.

Advantages of Practice-Based Learning Approach

Learning through practice creates a conducive learning environment (Hammond, 2011). Practice-based learning can take place not only in formal settings such as schools but also in informal settings which means that students can perform practical exercises even at home. The skills acquired through practice-based learning facilitate students to cope with skill demanding tasks after schooling period. According to (Kennedy, Billett, Gherardi, & Grealish, 2015), practical and theoretical works should be properly combined for the effective learning to take place. Practical work can enhance intellectual capability, which characterizes the higher-order thinking skills and understanding. Furthermore, learning through practice can empower students with creativity and innovation (Giannopoulou, Gryszkiewicz & Barlatier, 2014).

A study by Yakhlef (2010) highlighted the importance of practice-based learning through the linkage of the learned knowledge and its implication in the real daily lives. The hands-on activities in chemistry can stimulate learners' perception towards chemistry and can enhance their learning by involving them in solving social problems based on the acquired knowledge and skills (Matzembacher et al., 2019).

Practice-based learning further helps learners to develop knowledge and skills during delivery and its implementation in terms of carrying out the assigned task. Practice–based learning is considered as the learner-centered method where the learning style creates enough space for learners and positively affects their academic performance compared to the classic methods based on theoretical principles. It has been discovered that practical learning inspires learners to acquire complex concepts in entertainingly way where the curiosity and creativity increase leading to more effective learning (Scantlebury, 2008).

Furthermore, as highlighted by Khamali, Mondoh and Kwena (2017), practice-based learning mainly affects the learners' academic achievement positively. Practical work supports the learners to know their specific ability, to identify the opportunities around them, to be focused during the experiment as well as to develop the observation skills.

This study sought to establish the effect of practice-based learning on academic performance. The study was guided by the following research question: What is the effect of practice-based learning on classroom performance among chemistry students of senior three at Groupe Scolaire Kaganza in Nyanza district, Rwanda?

Methodology

This section provides a detailed description of the research design, population and sampling techniques, data collection procedures, data analysis and presentation, reliability and ethical consideration.

Research Design

The study used the quasi-experimental research design. The researchers used pretest-posttest approach whereby prerequisite knowledge of students was tested prior to treatment. Thereafter, the control group was treated in a traditional approach of teaching using lecturing method while the experimental group was trained using practice-based learning. After the teaching period, which took three weeks, students were given a week to prepare for a chemistry achievement test herein referred to as posttest. Results were analyzed and compared to measure the effect of practice-based learning among students in the experimental group.

Population and Sampling

The study included 180 students selected from a total population of 328 senior three students from two sampled schools in Nyanza District. Control and experimental groups were formed randomly.

Statistical Treatment of Data

Pre-test and post-test were administered to the control and experimental groups before and after the intervention to determine the effect of practice-based learning on students' classroom performance. Pre-test was disseminated to both control and experimental groups prior to the intervention. The results were kept for comparison with the post-test after the intervention using the t-test approach of data analysis.

Results and Discussion

In this section, results are presented with discussions in line with research questions that guided this study. It begins with presentation of respondents' demographics and then moves into data analysis and presentation.

Demographics of Respondents

As seen in Table 1, the sample of 180 students participated in the study. The study comprised of 105 boy students (58 %) and 75 girl students (42 %). Students' age range was as follows: 13-16 years were 126 (70 %), 17-20 years were 43 (24 %) and above 20 were 11 (6 %).

Table 1: Demographics of Respondents

SN	Variable	f	%
1	**Gender of Students**		
	Male	105	58
	Female	75	42
	Total	**180**	**100**
2	**Students' Age**		
	13-16	126	70
	17-20	43	24
	Above 20	11	6
	Total	**180**	**100**

Research Question: What is the effect of practice-based learning on classroom performance among chemistry students?

Pretest Results

This research question compared the control and experimental groups in order to establish the effect of practice-based learning on classroom performance among chemistry students. In the pretest, the control group had the mean score of

12.8278 while the experimental group had the mean score of 13.5000 as indicated in table 2.

The Sig of 0.67 in the Levene's Test for Equality of Variance (table 3) is greater than the critical value meaning that the difference between the control group and experimental group during the pretest was not significant, meaning both groups had similar performance in Chemistry.

Post test Results

After administering the pretest, the two groups were treated differently, the control group with the traditional teaching and learning approach and the experimental group with the practical based learning approach while the teachers played the role of facilitator in order to determine the effect of the practical-based teaching and learning approach. Furthermore, students in the experimental group were allowed to interact actively with the learning materials and between themselves towards the construction of their own understanding of the content. After the teaching session, students were given the time to review the learned materials and a subsequent chemistry achievement post-test was administered to measure their performance as reflected in table 4 and 5.

Table 2: Independent samples t-test from pre-test for control and experimental groups

Groups	N	Mean	Std. Deviation	Std. Error Mean
Control	90	12.8278	2.52088	.26572
Experimental	90	13.5000	2.36667	.24947

Table 3: Levene's Test for Equality of Variances

Levene's Test for Equality of Variances			t-test for Equality of Means			
	F	Sig. (2-tailed)	t	df	Sig. (2-tailed)	M.D
E.V.A	.001	.980	-1.844	178	.067	-.67222
E.V.NA			-1.844	177.295	.067	-.67222

Table 4: Independent samples t-test from post-test for control and experimental groups

Groups	N	Mean	Std. Deviation	Std. Error Mean
Control	90	11.6944	2.11694	.22314
Experimental	90	13.3333	2.41251	.25430

Table 5: Levene's Test for Equality of Variances

Levene's Test for Equality of Variances			t-test for Equality of Means			
	F	Sig. (2-tailed)	t	df	Sig. (2-tailed)	M.D
E.V.A	2.010	.158	-4.844	178	.000	-1.633
E.V.NA			-4.844	175.044	.000	-1.633

The Sig of 0.67 in the Levene's Test for Equality of Variance is greater than the critical value meaning that the difference between the control group and experimental group during the pretest was not significant, meaning both groups had similar performance in Chemistry.

Post test Results

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In the posttest, the control group had the mean score of 11.6944 while the experimental group had the mean score of 13.3333 as indicated in table 6. The Sig of 0.00 in table 7 is greater than the critical value suggesting that the difference between the control and the experimental groups is statistically significant. This implies that the experimental group which was taught through the problem-based approach performed better than the control group which was taught through the traditional learning approach. Therefore, practice-based learning

significantly improved the performance of the learners. The finding corroborates with that obtained in a previous study by Günter, Akkuzu and Alpat (2017) where quasi-experimental design was used to compare the performance of students in the control and the experimental groups using different teaching and learning approaches. The findings were that students treated with laboratory experiments reflecting their daily life performed better than those in the control group treated using closed ended laboratory experiments.

The findings are also in agreement with those by Abrahams (2009) which established that learning chemistry could be effective for both learners and teachers when practical works are included in the lessons. Thus, hands-on activities have been correlated with students' motivation, engagement and good performance in chemistry subject as these activities alleviate the abstract nature of science content (Pun and Cheung, 2021).

Conclusions and Recommendations

Conclusion

Since students in the experimental group taught through practical based approach exhibited better performance compared to those in the control group taught through traditional approach, it is concluded that practice based learning enhance students' performance in chemistry.

Recommendations

Secondary school science teachers are encouraged to take the advantage of practice-based learning to improve students' performance in science subjects. Additionally, continuing professional development programs should be enhanced to help teachers' develop skills about choosing the suitable teaching approaches. Pedagogical inspections should be conducted in order to provide technical advice on teaching and learning practices for better performance.

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