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Virtual Laboratory and Hands-on Activity Approaches on Students' Academic Performance in Soap Production in Akwa Ibom State, Nigeria

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Abstract
The study investigated the effects of virtual laboratory and hands-on activity approaches on students' academic performance in soap production in Akwa Ibom State, Nigeria. Three research questions and hypotheses guided the study. The design was a quasi-experimental design of pre-test, post-test non-randomized group. Population of study comprised all the senior secondary two (SS2) students. A sample of 129 students in three intact classes were selected by simple random sampling technique. Chemistry Performance Test (CPT) in soap production was used to collect data. Reliability of the instrument was found to be 0.82 using Kuder Richardson-20 formula. Descriptive statistics of mean and standard deviation was used to answer research questions, while hypotheses were tested using Analysis of Covariance (ANCOVA) at p≤0.05 level of significance. Findings of the study showed that students taught soap production using virtual laboratory approach gained better than those taught using hands-on activity approach, followed by those taught using expository approach. There was a significant difference in students' mean academic performance scores, but there was no significant difference in male and female students' academic performance scores. Also, there was no significant interaction effect of treatment and gender on students' academic performance scores in soap production. Based on the findings it was recommended among others that Professional bodies and other Education stakeholders should organize conferences, seminars and workshops for Chemistry teachers to acquaint them with the use of virtual laboratory approach to improve the students' performance in Chemistry.

Keywords: Virtual laboratory approach, Hands-on activity approach, performance, Secondary schools, Soap production.

Introduction

Science is commonly understood as the inquiry into the natural world that underlies contemporary technological advancements. According to Shaibu (2014), science constitutes a human endeavour that yields a corpus of generalizable propositions, consisting of laws, theories, or hypotheses, that account for the observable phenomena of the cosmos. Furthermore, science is deemed a systematic approach to obtaining foundational knowledge about the physical realm (Science council, 2023). For developing countries like Nigeria, the quality of science teaching and learning in schools especially in senior secondary schools need

to improve in order to bring accelerated development. Akpan (2022) maintained that science and technology education as defined in the National Policy on education is an aspect of the educational process, involving in addition to general education, the study of technologies and related sciences and acquisition of practical skills, attitudes, understanding and knowledge relating occupations in various sectors of the economy and social life. The aim of learning science in secondary schools is to promote the understanding of the observable behaviour of the environment, with a view to applying the knowledge of such understanding in the real-life situation.

According to the National Policy on Education (NPE, 2014), the objectives of science education at all levels of education in Nigeria encompass the following: the acquisition of knowledge, skills, inquiry, and a rational mind for the conduct of a good life; the production of scientists for national development; service studies in technology and the promotion of technological advancement; the comprehension of the physical world, its forms, and the conduct of life; the provision of knowledge and understanding of the intricacies of the physical world and the forms and conducts of life. These objectives seem a marriage due to the classroom situations in our schools. Akpan (2017a) observed that due to the overcrowded condition of the classes coupled with the absence of laboratory support staff in some schools, teachers in majority cases carryout practical only two or three weeks to external examinations like the SSCE because they are overburdened with the task of combining their teaching job with that of laboratory support staff in the face of the large classes.

The paramount importance attributed to the vital role of science education in national development necessitates the implementation of a well-structured and organized approach to the teaching of science. Akpan and Itighise (2021) noted that all students can learn if given the appropriate amount of time and the appropriate instructional opportunities. The authors addressed the use of mastery learning model which proposes that all children can learn when provided with appropriate learning conditions in the classroom.

Within the realm of science, there are three distinct branches: Chemistry, Physics, and Biology. Chemistry is a subject that is primarily experimental in nature, and various didactic approaches have been observed in the imparting of chemical knowledge. In instances where Chemistry teaching is predominantly teacher-centered and employs whole-class, textbook-based methods, it is common for students to passively receive knowledge without adequate cognitive engagement in the learning process. Consequently, it is necessary to employ innovative teaching approaches that actively engage students and enhance their performance. Akpan and Uko (2019) noted that the end product of entrepreneurship and life-long education is the production of enterprising workforce to drive the individuals participating in economic activities of the nation and reduction of government participation and intervention, thus, eradicating poverty and dependence.

A virtual laboratory approach provides an interactive practical environment where students can conduct simulated scientific experiments (Redel-Macías *et al.,* 2016). This approach not only enhances students' abilities, skills, and understanding of scientific ideas but also offers several benefits in science education. Akpan (2016a) observed that the teacher centered instructional strategies that have dominated instructional processes since the advent of formal education are no longer adequate for inculcating in the learner for effective life in a knowledge driven society. Billah and Widiyatmoko (2018) found that the virtual laboratory approach, which incorporates theoretical material with graphics, animation, and videos, enables independent learning, particularly for students interested in computer-related topics (Eden *et al.,* 2023).

Zhao *et al.* (2019) reported that the virtual laboratory approach complements physical laboratory experiences and enhances conceptual understanding. It has also been shown to improve problem-solving skills (Gunawan *et al.,* 2017), foster creativity (Gunawan *et al.,* 2018), offer new learning perspectives not possible in a traditional laboratory (Jiménez *et al.,* 2021) and yield learning outcomes equivalent to hands-on laboratories (Wästberg *et al.,* 2019). In recognition of the importance of the inclusion of ICT in science learning, Akpan (2017b) advocated that traditional methods of instruction should give way to activity-based, minds-on, hands-on, students-centered strategy that enhances entire learning. By so doing, students from basic education level to senior secondary level in science will develop a more in-depth conceptual understanding of science and technology relationships as well as procedures.

The utilization of a virtual laboratory approach in educational institutions is purported to expand access to a greater number of students compared to traditional brick-and-mortar schools. This approach not only facilitates the transformation of object properties but also revolutionizes the practical and theoretical aspects of science education. Additionally, it is learner-centered and renews students' interest in the subject (Nwagbo & Ugwuanyi, 2015). Dyrberg *et al.* (2017) observed that students engage in higher-level discussions following the completion of lessons taught using the virtual laboratory approach, thereby potentially improving their preparedness for laboratory work. Tatli and Ayas (2013) conducted a study examining the impact of a virtual Chemistry laboratory (VCL) on students' performance, involving 90 students from three different ninth-grade classrooms (one experimental group and two control groups). The findings revealed no significant differences in the performance of students across the three classrooms.

On the other hand, the hands-on activity approach involves physical manipulation of materials to facilitate learning. According to Omosewo (2020), the hands-on activity approach is a process of presenting facts and performing tasks in the presence of others, either to demonstrate how to perform the tasks or to illustrate a principle. This approach is particularly effective in teaching problem-solving skills, providing real-world context, and fostering connections that enhance creativity and critical thinking, ultimately leading to long-term

success. The hands-on activity approach is primarily employed in the classroom setting as a practical method, involving active engagement with natural phenomena and manipulation of objects to acquire knowledge and understanding (Kibga *et al.*, 2021).

. Hands-on activity approach has been proposed as a means to enhance learners' comprehension of scientific concepts by providing tangible experiences and making abstract knowledge more tangible and comprehensible (Obeka, 2019). Through the hands-on activity approach, students not only acquire knowledge but also apply the concepts taught and develop feasible solutions to problems (Pirttimaa *et al.*, 2015). Furthermore, it has been recognized that this approach encompasses a variety of pedagogical methods in which learning is centered on hands-on and minds-on activities (Lui, 2014). Akpan (2018) maintained that the science laboratory experience should have a great influence on the learner on transfer of laboratory work experience for entrepreneurship. The education of the secondary school level should build in the learner permanent scientific skills that can be transferred and should be systemically organized with a plan in order to build in the learners the spirit of entrepreneurship. For these goals to be achieved, Akpan & Akpan (2017) maintained that Nigeria needs innovation in science and technology that can be achieved through effective teaching of basic science and technology which is the foundation of the sciences. Hands-on activities prioritize comprehension over memorization, and discourage mere copying, as students develop confidence in their ability to independently complete the work.

One of the factors that significantly influence students' academic performance in science subjects is gender. Gender refers to the distinct roles and responsibilities assigned to men and women within a specific society. It is a psychological term that describes the expected behaviour and attributes of individuals based on their male or female identity (Umanah, 2017). According to Eden & Mbuk (2019), gender is a critical factor that contributes to academic performance in Chemistry. It has been observed that males outperform females in the field of Chemistry (Goni *et al*., 2015). Umanah & Sunday (2022) in their study found no significant gender differences in students' academic performance, while Eden & Mbuk (2019) reported that female students performed better than their male counterparts. Akpan (2016b) found a significant gender difference in computer self-efficacy with male students having higher computer self-efficacy than their female counterparts.

Oser (2013) observed a significant difference in the academic performance of male and female students when exposed to virtual laboratories. Gongden (2022) revealed a significant difference in the mean achievement scores of male and female students taught using the computer animation strategy (CAS), with males performing better. Therefore, further investigation into gender differences in students' performance in Chemistry is necessary in order to develop potential intervention approaches. This study was to examine the effect of virtual laboratory, hands-on activity and expository approaches on the academic performance of senior secondary school students in soap production, with gender as a moderating variable.

Statement of the Problem

The significance of practical approaches, such as virtual laboratory and hands-on activities in the successful instruction and acquisition of Chemistry principles cannot be overstated. In many secondary schools, the predominant mode of teaching and learning relies on traditional lecturing, whereas the inclusion of appropriate practical methods, such as virtual laboratory and hands-on activities, could effectively facilitate the assimilation of conceptual knowledge in the concept of soap production in Chemistry.

It is against this backdrop that the present study is undertaken, with the aim of examining the impact of virtual laboratory, hands-on activity and expository approaches on the academic performance of senior secondary school students in the concept of soap production in Uyo Local Government Area of Akwa Ibom State, Nigeria.

Objective of the Study

The purpose of this study was to investigate the effect of virtual laboratory, hands-on activity and expository approaches on students' academic performance in soap production in Uyo Local Government Area of Akwa Ibom, Nigeria.

Research Questions

1. What is the difference in students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches?
2. What is the difference in male and female students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches?
3. What is the interaction effect of treatment (virtual laboratory, hands-on activity and expository approaches) and gender on student's academic performance in soap production?

Null Hypotheses

1. There is no significant difference in students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches
2. There is no significant difference in male and female students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches
3. There is no significant interaction effect of treatment (virtual laboratory, hands-on activity and expository approaches) and gender on student's academic performance in soap production?

Methodology

The study was designed as a pretest posttest, quasi-experimental non-randomized design. The use of a quasi-experimental design was considered appropriate in order to avoid disrupting normal class lessons, as intact classes were utilized. The study took place in Uyo Local Government Area of Akwa Ibom State, Nigeria. The target population consisted of all public co-educational Senior Secondary School two (SS2) students who were taking Chemistry in the thirteen (13) public coeducational secondary schools in Uyo Local Area. The total enrolment in these schools was two thousand eight hundred and ninety (2890) students. A sample of one hundred and twenty-nine (129) Senior Secondary two (SS2) Chemistry students were selected from three co-educational schools in the sample area using stratified random sampling technique. The study employed a researcher-made instrument called Chemistry Performance Test (CPT), which consisted of two sections: Section A included Students' Biodata on school name, gender and class, while Section B contained items on the CPT. Section B comprised of a 50 multiple choice item with four options A-D, with one correct answer and three distractors. The scoring system awarded 1 mark for a correct answer and 0 mark for a wrong answer, resulting in a total score of 50 marks. The instrument was validated by two experienced Chemistry lecturers and a specialist in Test, Measurement, and Evaluation in the Department of Science Education, who assessed the clarity, wording, appropriateness, and adequacy of the items. The recommendations provided by the validators were used to modify the instrument. In order to determine the reliability index of the instrument, trial tests were administered to a group of thirty (30) Chemistry students from a school not included in the main study but deemed equivalent to the study area. The results were subjected to the Kuder Richardson-20 formula and yielded a reliability index of 0.82.

The researcher obtained permission from the principals of the selected schools to conduct the research. The experimental procedure was carried out with the assistance of the Chemistry teachers, who acted as research assistants. These teachers underwent a one-week training on the use of lesson packages and effective lesson delivery using virtual laboratories, hands-on activities and expository approaches. To ensure consistency, the Chemistry teachers were instructed on how to use the lesson packages developed by the researcher specifically for use in the selected schools. A training module containing sample lesson packages for teaching the chosen Senior Secondary Two (SS2) Chemistry students was utilized. The researcher designed, prepared, and discussed these sample lesson packages with the Chemistry teachers. Prior to the experimental activities, the pretest CPT was used to assess the students' baseline knowledge in the three groups. Thereafter, students in the Experimental group 1, 2 and control groups were taught the concept of soap production using virtual laboratory, hands-on activity and expository approaches respectively. After the teaching, the Posttest on Soap production was administered.

The data collected was analyzed using descriptive statistics of mean and standard deviation to answer the research questions, while the hypotheses were tested using Analysis of Covariance (ANCOVA) at $p \leq 0.05$ level of significance. Statistical Package for Social Sciences (SPSS) was used for analysis of collected data.

Presentation of Results

The results were presented based on the research questions and hypotheses.

Research Question 1: What is the difference in students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches?

Table 1: Mean and standard deviation of students' pre-test and post-test mean academic performance scores in soap production using virtual laboratory, hands-on activity and expository approaches

		Pre-test		Post-test		
Groups	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Virtual Laboratory	37	8.16	1.83	36.22	6.39	28.04
Hands-on Activity	44	5.61	3.57	23.14	6.90	17.53
Expository	48	6.23	2.43	16.40	7.30	10.17

Result in Table 1 shows the mean difference (post-test and pre-test) of students' Academic performance when taught using virtual laboratory, hands-on activities and expository approaches be 28.04, 17.53 and 10.17 respectively. This result indicates that students taught soap production using virtual laboratory approach gained better than those taught using the hands-on approach, followed by those taught using expository approach.

Research Question 2: What is the difference in male and female students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches?

Table 2: Mean and standard deviation of male and female students' pre-test and post-test academic performance scores in soap production using virtual laboratory, hands-on activity and expository approaches

		Pre-test		Post-test		
Groups	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Loss**
Male	55	4.56	2.14	24.38	7.52	19.82
Female	74	8.07	9.50	24.38	12.09	16.31

Result in Table 2 shows the mean difference (post-test and pre-test scores) for male and female students' academic performance in soap production to be 19.82 and 16.31, respectively. This result indicates that male students gained better than female students in soap production.

Research Question 3: What is the interaction effect oftreatment (virtual laboratory, hands-on activity and expository approaches) and gender on student's academic performance in soap production?

Table 3: Interaction effect of treatment (virtual laboratory, hands-on activity and expository approaches) and gender on student's academic performance in soap production

		Pre-test		Post-test		
Groups	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Virtual Laboratory						
Male	18	6.61	1.14	37.00	6.73	30.39
Female	19	9.63	1.90	35.47	6.14	25.84
Hands-on Activity						
Male	16	2.75	1.61	20.06	3.09	17.31
Female	28	7.25	3.65	24.89	7.86	17.64
Expository						
Male	21	4.19	1.66	16.88	2.85	12.69
Female	27	7.82	1.62	16.04	3.13	8.22

Result on Table 3 shows the pre-test and post-test mean score of the interaction effect of gender and practical approaches (virtual laboratory, hands-on activity and expository approaches) on the mean performance scores of students in soap production. The result showed that the male students exposed to virtual laboratory had a higher mean gain of 30.39 as compared to the female students who had 25.84 which indicates that virtual laboratory strategy proved to be more effective in increasing the mean performance score of female students in soap production more than their male counterparts. On the other hand, female students exposed to hands-on activity approach had a higher mean gain of 17.64 as against 17.31 for the male students. This means that hands-on activity approach proved to be more effective in improving the mean performance score of female students in soap production more than the male students. Furthermore, the result shows that male students under expository approach had a higher mean difference of 12.69 when compared to their female counterparts with a mean gain of 8.22.

Null Hypothesis 1: There is no significant difference between students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches

Table 4: Analysis of Covariance (ANCOVA) of students' post-test academic performance scores classified by virtual laboratory, hands-on activities and expository with pre-test as covariate

Source of Variance	Sum of squares	Df	Mean	F	Sig
Corrected model	8783.747[a]	6	1463.96	51.46	.000
Pre-test (Covariate)	205.25	1	205.25	7.22	.008
Main effect: Practical Approaches	5981.26	2	299.63	105.13	.000
Error	3470.64	122	28.45		
Corrected total	12254.39	128			

*significant at p<.05

The result on Table 4 shows the analysis of Variance (ANCOVA) of the difference between students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches. The results show that there is a significant difference between students' mean academic performance scores (F=105.13; 0= 0.00). Hence the null hypothesis that there is no significant difference in students' mean academic performance scores in soap production when taught using virtual laboratory, hands-on activity and expository approaches is rejected at the 0.05 level of significance.

To show which of the treatment group was better in producing students' mean academic performance scores in soap production, a Post Hoc using LCD was performed as reported in Table 5.

Table 5: Summary of LCD Post hoc pair wise comparison of students' post- test performance classified by practical approaches

Treatment groups (I)	(J)	Mean Diff (I-J)	Std. Error	Level of sig.
Virtual Laboratory	Hands-activity	11.764*	1.421	.000
	Expository	18.435*	1.275	.000
Hands-activity	Virtual Laboratory	-11.764*	1.421	.000
Expository		6.672*	1.17	.000
Expository	Virtual Laboratory	-18.44*	1.28	.000
Hands-activity		-6.67*	1.17	.000

*R Squared = .717 (Adjusted R Squared = .703) *significant at p<0.05*

Table 5 shows the Post-Hoc result of the significant effect of treatment on academic performance scores in soap production. Results show that virtual laboratory and hands-on activity differ significantly, virtual laboratory and expository approach also differ significantly, hands-on activity and expository also differs significantly with virtual laboratory showing more promise in enhancing academic performance scores in soap production.

Null Hypothesis 2: There is no significant difference in male and female students' mean academic performance scores in soap production

Table 6: Analysis of Covariance (ANCOVA) of male and female students' post-test academic performance with pre-test as covariate

Source of Variance	Sum of squares	Df	Mean	F	Sig
Corrected model	8783.747[a]	6	1463.96	51.46	.000
Pre-test (Covariate)	205.25	1	205.25	7.22	.008
Main effect:					
Practical Approaches	5981.26	2	299.63	105.13	.000
Gender	39.99	1	39.99	1.41	.238
Error	3470.64	122	28.45		
Corrected total	12254.39	128			

**significant at p<.05*

The result on Table 6 shows the Analysis of Variance (ANCOVA) of the difference in male and female students' academic performance. The result showed that there is no significant difference in male and female students' academic performance (F= 1.406; P = 0.24). Since the associated probability value of 0.24 obtained is greater than 0.05 level of significance set for decision making, the null hypothesis which states that there is no significant difference in male and female students' academic performance score in soap production was retained.

Null Hypothesis 3: There is no significant interaction effect of practical approaches and gender on students' academic performance in soap production

Table 7: Analysis of Covariance (ANCOVA) of the interaction effect of practical approaches and gender on student's academic performance in soap production with pre-test as covariate

Source of Variance	Sum of squares	Df	Mean	F	Sig
Corrected model	8783.747[a]	6	1463.96	51.46	.000
Pre-test (Covariate)	205.25	1	205.25	7.22	.008
Main effect:					
Practical Approaches	5981.26	2	299.63	105.13	.000
Gender	39.99	1	39.99	1.41	.238
Two-way Interaction					
Practical Approaches* Gender	184.92	2	92.46	3.25	.042
Error	3470.64	122	28.45		
Corrected total	12254.39	128			

*significant at p<.05

The result on Table 7 shows the Analysis of Variance (ANCOVA) of the interaction effect of treatment (virtual laboratory, hands-on activity approaches) and gender on students' academic performance in soap production. The result showed that there is no significant interaction effect of treatment and gender on students' academic performance (F= 3.25; P = 0.42). Since the associated probability value of 0.42 obtained is greater than 0.05 level of significance set for decision making, the null hypothesis which states that there is no significant interaction effect of practical approaches and gender on student's academic performance in soap production was retained.

Discussion of Findings

The findings regarding the impact of practical approaches on students' mean academic performance scores in soap production indicate that students who were taught using the virtual laboratory approach demonstrated greater improvement compared to those taught using the hands-on approach, followed by those taught using the expository approach. This can be attributed to the student-centered activities for problem-solving, inquiry, and exploration of phenomena provided by the virtual laboratory approach. This finding is consistent with the study conducted by Sarabando *et al.* (2016), which revealed that learners who engaged in the virtual laboratory approach made more progress than those who solely relied on hands-on experiments. Furthermore, Dyrberg *et al.* (2017) observed that students who underwent a

lesson taught using the virtual laboratory approach engaged in discussions at a higher level and demonstrated potential for improved pre-laboratory preparation.

The findings indicate a significant impact of practical approaches on students' mean academic performance scores in the concept of soap production. This finding aligns with Gunawan *et al*. (2018), who conducted a study on the use of virtual laboratory to enhance students' conceptual understanding in Physics learning. The results revealed a positive effect of the virtual laboratory on students' conceptual understanding. However, these findings contrast with those of Tatli and Ayas (2013), who investigated the effect of a virtual Chemistry laboratory (VCL) on students' performance among 90 students from three different ninth-grade classrooms. The results showed no significant difference in the performance of students in the experimental group and the two control groups.

The findings regarding the difference in academic performance scores between male and female students in the concept of soap production indicate that male students out-performed female students. This can be attributed to the higher level of interest exhibited by male students during the lesson on soap production. Ukozor (2015) have noted that male students generally excel in subjects such as Chemistry, Physics, and Biology compared to their female counterparts. However, Nnamani and Oyibe (2016) examined the relationship between gender and academic achievement among secondary school students and found that female students achieved higher scores than male students. Nevertheless, this finding suggests that there is no significant difference in the academic performance scores of male and female students in the context of soap production.

The lack of significant disparity between male and female students' academic performance scores in the concept of soap production is in line with Umanah & Sunday (2022) who found no significant gender differences in students' academic performance. The findings of this study contradict the work of Gongden (2022) which revealed a significant difference in the mean achievement scores of male and female students taught using the computer animation strategy (CAS), with males performing better. Furthermore, these findings oppose those of Oser (2013), who identified a significant difference in the academic performance of male and female students when exposed to virtual laboratories.

Regarding the interaction effect of practical approaches and gender on students' academic performance in soap production, the findings indicated that male students exposed to virtual laboratories exhibited a higher mean gain compared to their female counterparts. Conversely, hands-on activity and expository approaches proved to be more effective in enhancing the mean performance scores of female students in soap production. This could be attributed to the fact that the virtual laboratories were captivating to the students, thereby stimulating their scholastic achievement. This finding aligns with the works of Ukozor (2015), who observed that male students generally outperform female students in Chemistry, Physics,

and Biology. However, the interaction effect of practical approaches and gender on students' academic performance in soap production was not deemed significant.

The absence of a significant interaction effect between practical approaches and gender on students' academic performance in soap production coincides with the findings of Umanah & Sunday (2022), who both found no discernible gender differences in student academic performance in their respective studies. Furthermore, this finding aligns with Jack & Zubairu (2022), who observed an insignificant interaction effect of gender and treatments on students' achievement in Chemistry. However, these results contrast with Gongden (2022), whose study revealed a significant difference in the mean achievement scores of male and female students when taught using the computer animation strategy (CAS).

Conclusion

The result of this study highlighted the effect of virtual laboratory, hands–on activities and expository approaches in enhancing academic performance of Chemistry students in soap production. The hands-on activity approach helped the students to overcome the difficulties inherent in learning the concept of soap production which is a practical based concept and is difficult to understand theoretically by both students and teachers. Based on the findings of this study, it was concluded that virtual laboratory strategy was most effective in enhancing students' performance. There was no significant interactive effect of gender by treatment groups.

Recommendations

Based on the findings, it was recommended that;

i. The use of virtual laboratory approach should be encouraged for teaching of Chemistry and other science concept
ii. Teachers of Chemistry in secondary schools should be trained on the use of virtual laboratory approach as it will re-emphasize the need for teachers to always enrich the teaching and learning process with good practical approaches
iii. Professional bodies and other education stakeholders should organize conferences, seminars and workshops for Chemistry teachers to acquaint them with the use of virtual laboratory approach to improve the process and product of learning.

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