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# The Effect of Combined Virtual and Real Laboratories on Students' Achievement in Practical Chemistry

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**Abstract:** Educational technology has provided solution to several educational problems. One of such solution is the virtual laboratory; which aids teaching and learning of Chemistry practical. This study examined the effect of virtual laboratory when it is combined with real laboratory on students' achievement in practical Chemistry. The sample for this study is 120, senior secondary school three science students. The instrument used for data collection was Chemistry Practical Achievement Test (CPAT). The result showed that virtual laboratory combined with traditional laboratory had a significant main effect on students' achievement in Chemistry practicals.

**Keywords:** Virtual Laboratory, Students' Achievement, Practical Chemistry

## 1. Background of the study

### *1.1. Introduction*

It has been established that immersing students in virtual environment can make them understand science concepts and principles. Chemistry at the senior secondary school level as recommended by the curriculum should be taught as an experimental science irrespective of laboratory inadequacy and availability (Omilani, Ogunleye, Modupe and Okoduwa, 2006). Unfortunately, many teachers only teach practical chemistry only when the final examination is approaching and students receive a fire brigade instructions. This has caused poor performance in Chemistry. The teachers attribute their fire brigade instruction in practical chemistry to laboratory inadequacy and unavailability of material.

In cases where there is no constraint of laboratory inadequacy and unavailability of material, students also fail Chemistry at the Senior Secondary School Certificate Examination because practical Chemistry is poorly taught using only the traditional method in the conventional laboratory. Educational technology signifies an analytical procedure that is characterized by the identification of an instructional problem, setting of objectives, designing of learning experience and the evaluation of instruction (Ajelabi, 2000). Furthermore, educational technology is the application and organization of people methods, techniques, devices, material systematically and scientifically in order to solve teaching problems as well as improving educational system (Ajelabi, 2000). Virtual laboratory is one of the solution provided by educational technology that is very important in Chemistry education (Tatli and Ayas, 2010).

A virtual laboratory according to Hatherly (2007) is one where the students interact with an experiment or activity which is intrinsically remote from the student or which has no immediate reality. In some cases the virtual laboratory may be in form of interactive film experiments. In this case, the students interact with the virtual world by mere clicking on the computer screen using a mouse and the entire experiments runs itself and the data are collected (Hatherly, 2007). Through the images presented the students observe what would have happened in the real laboratory.

Tatli and Ayas (2010) identified the advantages of virtual laboratory as follows: it enables students' to see every detail of the experimental process and can play an active role; it makes abstract concepts of Chemistry lesson concrete and it overcomes problems faced in traditional laboratory applications.

Several studies in the past have shown that virtual laboratory effectively improve students achievement in Chemistry (Bakar & Zaman, 2007; Liminiou eta al, 2007 and Trindade eta al, 2002). On the contrary a few studies showed that virtual laboratory is not as much effective as real laboratory for example Darlgarno (2004) found out that virtual laboratory made no impact on students' achievement in Chemistry.

Given the disparity between the experience of students in the virtual laboratory and real laboratory, the students are likely not to understand the nature of science in a practical way when they are restricted to virtual laboratory alone.This is because the virtual laboratory provides an experience that misrepresents the real nature of science experiment to the learner. Virtual laboratory will provide the learner with an experience of science as an enterprise that is perfect and error free. This is a disconnect from the science of the scientist. Allen (2008) argues that when students are not provided with an opportunity to experience the controversy that accompanies science in the laboratory, they will receive a wrong message about the nature of science as an enterprise in which nothing goes wrong. This is what Allen (2008) refers to as the clash of epistemology.

In addition to this, the final Chemistry examination at the secondary school level in Nigeria requires student to carry out real experiments in the laboratory. Therefore restricting students to the virtual laboratory will deny them the opportunity to carry out real experiments during the final examination. Above all, the students in the virtual laboratory may not develop scientific attitude like: humility skepticism, logical reasoning, intellectual honesty, open-mindedness, suspending judgment, positive approach to failure, empiricism, determinism, patrimony, precision, respect for paradigms, empathy for human conditions, understanding that all knowledge has tolerance limits, appreciation of probability and statistics and respect for power of theoretical structureto mention a few (Omilani, Ayo-Vaughan and Abimbade, 2014).

However, the students born between 1990 to year 2000 and above are referred to as Millennials (International Education Advisory Board, 2010). According IEAB (2010) Millennials does not marvel at technology but they accept it adopts it and uses it. IEAB further recommends that to effectively engage and teach millennials students, schools systems must be outfitted with a pre requisite of ICT resources and curricular must be designed to promote a collaborative learner centred environment to which students can relate and respond. In addition to this Edmund and Narong (2012) found out that the 21st learner recommended the blending of face to face instruction with their preferred online learning tools; to facilitate effective the delivery of learning outcomes.

Based on the foregoing, this study determined the effect of virtual laboratory when used as a supplement to real laboratory instruction and not a substitute. This is to achieve the delivery of desired learning outcomes in Chemistry practicals. Therefore this study examined how the students can combine the benefit of the real world and virtual world.

### *1.2. Hypothesis*

There is no significant main effect of the combination of real and virtual laboratory on students' achievement in practical Chemistry.

## 2. Materials and Methods

The virtual laboratory used was a software already prepared by British Council of education for K12 Chemistry curriculum.

### *2.1. Sample*

The sample for this study is 120 students selected randomly from two senior secondary schools in mainland local government of Lagos state. The two schools were randomly assigned to the control and experimental groups. Intact classes were used in each of the schools. However, based on the state policy then sixty students were in each of the control and experimental groups.

***Table 1.*** *Description of Treatment Groups.*

| Control group | Experimental group |
|---|---|
| Practical Chemistry | Practical Chemistry and Virtual Laboratory |

### *2.2. Instrument*

The instrument for data collection is Chemistry Practical Achievement Test (CPAT). This test was designed to assess the students' ability specifically in quantitative analysis. CPAT requires the student to first carry out volumetric analysis and later use the titre value obtained to compute the unknown values stated in the question. The reliability was established through test-retest method. The test was administered to 20 students who were not part of this study. After six weeks the same test was also administered to the same set of students. The data collected were subjected to Pearson product moment correlation and a reliability coefficient of 0.83 was obtained.

### *2.3. Procedure*

The study adopted a pretest, posttest control group quasi experimental research design.The study lasted for five weeks in both the treatment and control groups. During the first week, the pretest (Chemistry Practical Achievement Test CPAT) was administered to the students in both the control and experimental groups. The treatment lasted for three weeks and the post test was administered in the fifth week. During the three weeks of the treatment, the students spent two periods per week; a period is 40 minutes and Chemistry

usually have two double periods (A total of 3 double periods) learning practical Chemistry using the method of instruction assigned to the randomly. The students were taught procedures of volumetric analysis and how to use the titre value to calculate concentrations of the unknown. The researcher ensured that both groups used the same time for instruction and test.

***Table 2.*** *Illustration of procedure for the Study.*

| Treatment | Data Collection | Treatment | Data Collection |
|---|---|---|---|
| | Chemistry Practicals Achievement Test (CPAT) Pretest | | Chemistry Practicals Achievement Test (CPAT) Post test |
| Experimental Group | X | * | X |
| Control Group | X | ** | X |

* The experimental group was exposed to instruction in practical chemistry through virtual laboratory and conventional method of teaching through the real laboratory. The students in the experimental group takes the instruction the conventional way in the real laboratory from their teacher and the teacher is also present during the virtual laboratory instruction the teacher joins the researcher. During the virtual laboratory instruction, students were also exposed to the demonstration ofactivities done in the real laboratory as shown in the picture in figure 1-3.

***Figure 1.*** *The researcher explain what the students had seen in the virtual laboratory using the real laboratory apparatus.*

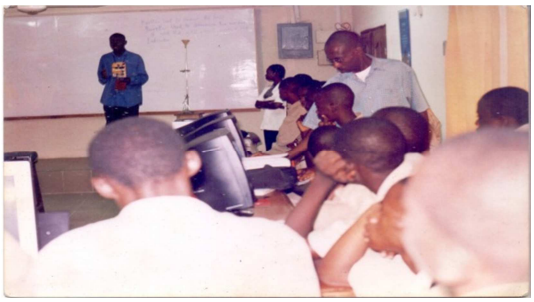

***Figure 2.*** *The students are being guided to use the virtual laboratory on their personal Computers.*

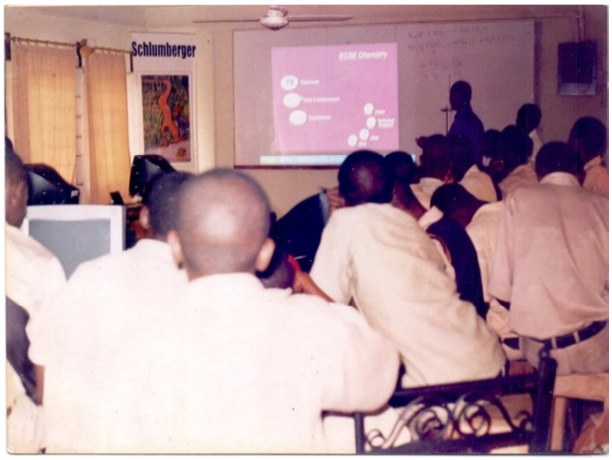


***Figure 3.*** *Students in the experimental group watching the virtual laboratory projections.*

** The students in the control group were exposed to conventional instruction inquantitative analysis in the traditional laboratory; without virtual laboratory instruction.

## 3. Results

Table 3 shows the Analysis of Covariance using the students pretest scores as covariates.

***Table 3.*** *ANCOVA of post test achievement scores of students by treatment.*

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 25319.878[a] | 2 | 12659.939 | 54.968 | .000 | .484 |
| Intercept | 30254.334 | 1 | 30254.334 | 131.360 | .000 | .529 |
| Pretest | 2.803 | 1 | 2.803 | .012 | .912 | .000 |
| treatment | 23459.823 | 1 | 23459.823 | 101.859 | .000 | .465 |
| Error | 26947.047 | 117 | 230.317 | | | |
| Total | 386491.000 | 120 | | | | |
| Corrected Total | 52266.925 | 119 | | | | |

The table 3 showed that treatment has a significant main effect on students' achievement in chemistry practical {$F_{(1,117)}$ =101.85;$p<0.05$; $\eta 2=0.47$}. The null hypothesis is rejected therefore treatment has a significant effect students' achievement in practical Chemistry, the effect size of 47% means that the impact of the treatment is high on students achievement in practical Chemistry.

***Table 4.*** *Estimated Marginal Mean of Posttest achievement by Treatment.*

| Treatment | Mean | Std error | 95% confidence Interval | |
|---|---|---|---|---|
| | | | Lower bound | Upperbound |
| REAL LAB Practical | 38.291 | 1.95 | 34.341 | 42.24 |
| Real LAB + Virtual Lab | 67.259 | 1.95 | 63.308 | 71.209 |

The table 4 showed that students exposed to real laboratory practical had a lower posttest mean score (38.29) compared to those exposed to real practical and virtual laboratory (67.25). The wide mean difference (28.96) indicates that the mean scores of students exposed to the combination of real and virtual laboratories is the source of the significant difference.

# 4. Discussion

The result obtained in this study indicates that the treatment had a significant main effect on students' achievement in practical chemistry. This implies that using virtual laboratory as a supplement to hands on instruction in Chemistry practical for students is more effective than exposing the students to hands on alone. This may be attributed to the fact that students born in the information and technology age are conditioned to approach most aspect of their lives including their learning using information and technology.The researcher did not measure interest of thestudents but it was observed that the students were excited when they saw what they have seen earlier in real laboratory in the virtual laboratory; most especially when they arerepeating the experiments previously done in real laboratory in the virtual laboratory. The findings of this study is in agreement with that of TÜYSÜZ (2010) that teaching the chemistry topics in virtual laboratory by using virtual experiments affected students' achievement in and attitudes towards chemistry positively compared to the traditional teaching methods. The findings of this study also corroborates the findings of Tatli and Ayas (2010) that virtual laboratory is at least as effective as the real laboratories both in terms of students achievementand their ability to recognize laboratory apparatus.

Although the peculiarity of this study is that the treatment involved the use of virtual laboratory as a supplement to the real laboratory instruction in Chemistry practicals may be new but it has justified the claim of 21st century students that a blend of conventional teaching and ICT will go a long way to improve learning outcomes (Edmund and Namong, 2012). This study did not measure interest qualitatively and quantitatively but it is important to report the excitement observed among the students exposed to a blend of virtual laboratory and real laboratory Chemistry practicals. This observation is in line with the findings of Oloruntegbe and Alam (2010) that eight-five percent of the existing experimental study on the effect of 3D environments and virtual realities in science teaching and learning showed that the treatment improves learning outcomes in the affective domains such as satisfaction, interest, fun and enjoyment.

# 5. Conclusion

The students exposed to virtual and real laboratories had an advantage over those exposed to the real laboratory alone as measured by the posttest achievement scores. Therefore using virtual laboratory as a supplement to conventional instruction in chemistry practical is a veritable tool to enhance students' achievement.

# Recommendation

It is recommended that students should be exposed to virtual and real laboratories in practical chemistry; this will ensure that they acquire both cognitive skills and manipulative skills when it is used as a supplement.

Students in developing nation like Nigeria are yet to explore the impact of technology when it is integrated into instruction in the classroom. Therefore the integration of virtual laboratory into classroom will make students achieve well in practical Chemistry and other science.

More experimental study should be carried out on the effect of using virtual laboratory as a supplement to instruction in other science subjects.

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