Influence of Laboratory Learning Environment on Students' Academic Performance in Secondary School Chemistry

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The study investigated the influence of laboratory learning environment on students' academic performance in secondary school chemistry. Specifically, the study determined the influence of the five dimensions of laboratory learning environment on students' performance in chemistry. The population for the study comprised all the Senior Secondary School Three (SSS III) chemistry students in all the public secondary schools in Ondo State, Nigeria. Descriptive research design of survey type was used. The sample consisted of 690 students from the schools selected for the study. Two research instruments were used for data collection, namely, Questionnaire on Chemistry Laboratory Learning Environment (QCLLE) and Chemistry Practical Achievement Test (CPAT). Data collected were analysed using analysis of variance (ANOVA) and multiple regression. The result showed that there was a significant relationship between the five dimensions of laboratory learning environment and students' performance in chemistry ($F_{(4,684)}$ = 678.96; p = 0.000). Material environment had the highest contribution to students' performance in chemistry (β = 0.345; 34.5%). This is seconded by integration (β = 0.219; 21.9%), followed by student cohesiveness (β = 0.173; 17.3%) and rule clarity (β = 0.139; 13.9%), while open-endedness (β = 0.097; 9.7%) had the lowest contribution. It is recommended that to enhance chemistry teaching and learning, the government should provide secondary schools with resources, teaching materials, models, equipment, and adequate laboratories for the teaching and learning of chemistry.

Keywords: laboratory, learning environment, students' academic performance, chemistry

Introduction

Chemistry is a branch of science and the prerequisite subject for many fields of science. These fields include agriculture, pharmacy, medicine, nursing, biochemistry, and chemical engineering. It contributes immensely to the technological growth of the nation. Therefore, any nation that aspires to develop scientifically and technologically must pay attention to the quality of chemistry education that is being taught in schools. It is against this background that made the Federal Government of Nigeria to identify the specific objectives to be achieved in the teaching of chemistry at the senior secondary school level in the National Policy on Education (Federal Republic of Nigeria, 2004) as follows:

1. Facilitating a transition to the use of scientific concepts and techniques acquired in integrated science with chemistry;

2. Providing the students with basic knowledge in chemical concepts and principles through efficient

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selection of content and sequencing;

3. Showing chemistry in its inter-relationship with other subjects;

4. Showing chemistry and its link with industry, everyday life, benefits, and hazards;

5. Providing a course which is complete for students not proceeding to higher education, while at the same time, it is a reasonably adequate foundation for a post-secondary chemistry course.

The policy recommends that science teaching and learning should be activity-oriented and student-centered such that students acquire relevant laboratory experiences. The achievement of these objectives will depend on and be influenced by the teacher, the students, the materials, the laboratory, and how both students and teachers perceive them in relation to intended learning outcomes.

Chemistry is a core science subject, and as such, a credit pass in it is required before a student can be admitted in any tertiary institution for most scientific based discipline. The study of chemistry entails the learning of concepts, established principles, laws and theories, and also substantial activity-oriented laboratory work. These laboratory experiments are to demonstrate practically some of the principles taught in theory, test the validity of certain empirical chemical laws, and illustrate properties of substances taught theoretically in the classroom. Learning chemistry means not only learning facts and concepts that describe the physical world at the atomic level, but also learning how to examine the physical evidences of chemical principles in a laboratory learning environment. Since chemistry is a science based on experimentation, therefore, performing experiments within a laboratory setting becomes very important in its' teaching and learning. Effective teaching and learning of chemistry can only take place when theoretical explanations are complemented with actual practices in the laboratory. The teaching laboratory is the standard method of training students in the skills and values central to scientific investigation and important in the development of positive attitude to chemistry. At the chemistry laboratory, students work cooperatively in small groups to investigate phenomena. This mode of instruction has potentials to enhance constructive social interactions as well as positive attitudes and academic performance. Even, though the knowledge of chemistry to the society is very important, students' performance in the subject as measured by their scores in Senior Secondary Certificate Examination (SSCE) is very poor.

The poor performance in sciences, especially in chemistry in SSCE, attests to the fact that chemistry teaching and learning and the conditions under which they take place need to be re-examined. These should include the laboratory learning environment and the availability of learning resources that can enhance students' performance in the subject.

The science laboratory, a unique learning environment, is a setting in which students can work cooperatively in small groups to investigate scientific phenomena. The environment in a laboratory is expected to be less formal, when compared to the conventional classroom setting and presents opportunities for more interactions between students and with the teacher, as well. Such greater interactions are likely to promote more positive social interactions that are ideal for creating a constructive and positive learning environment (Hofstein, Nahum, & Shore, 2001).

Although teachers and students share the same learning environment, it is likely that their perceptions on such a learning environment differ. The nature of the chemistry laboratory learning environment can make a difference on how students are motivated to achieve their set goals. The physical environment of the laboratory in terms of facilities, space, lightening, ventilation, workbenches, and stools in the laboratory influences the safety and comfort of students and also students' attitudes towards a particular subject and the learning of such

a subject. It can also influence the personal development of students. The laboratory learning environment in which chemistry teaching and learning occur is therefore likely to have a major influence on students' learning outcomes and impact positively on enhancement of chemistry teaching and learning. Students' perceptions of their learning environment influence how and to what extent they learn and retain knowledge (Aldridge, Fraser, & Wood, 2002; Luketic & Dolan, 2014). There are different scales which assess classroom environment. Each scale has been classified according to Moos's (1974) scheme for classifying human environments. The dimensions of human environments include relationships, personal development, and system maintenance/change (Moos, 1987). This theoretical model examines learning environments through relationships, personal development, and systems maintenance/change. Relationship dimensions are those relating to the nature and intensity of personal relationships. Personal development dimensions refer to the path through which knowledge development progresses. System maintenance and system change dimensions refer to the orderliness, clarity control, and responsiveness to change in the environment (Moos, 1987). This work was built on Walberg's (1981) research on psychosocial learning environments. This research explored the multidimensional nature of a psychological model of productivity.

Fraser (1998) later refined Moos's (1974) work to make it more appropriate, initially to describe classroom learning environments and then science learning environments. Fraser, McRobbie, and Giddings's (1993) work identified five dimensions, namely, student cohesiveness, open-endedness, integration, rule clarity, and material environment. Student cohesiveness describes how well students know each other's, work well together, and support one another. Open-endedness refers to students' opportunities to design their own research and pursue individual interests to enhance their personal constructions of scientific knowledge. The integration dimension characterizes how laboratory activities are connected to theoretical material taught in the lecture portion of the science classroom. Rule clarity refers to the extent of the formal rule structure and how it is followed within the classroom. Material environment describes the adequacy of their laboratory materials and equipment. The Science Laboratory Environment Inventory was developed as a measure of these aspects of science learning environments (Fraser et al., 1993).

From the foregoing, it can be argued that the report on poor performance of students in chemistry at the secondary school level might be due to both students' perception of the laboratory learning environment and the failure of teachers to conduct laboratory activities in a way that will make students more active participants in chemistry teaching and learning situation. The poor performance in chemistry and other related subjects is a reflection of the inadequacy inherent in the laboratory learning environments at the school level. It also appears from the review of available literatures that the influence of laboratory learning environment on students' learning outcomes in secondary school chemistry class has not been extensively looked into in Nigeria. This paucity of literature in this regard gives room for the need to conduct an empirical study on chemistry laboratory learning environment. The focus of the present study, therefore, was to investigate the influence of laboratory learning environments on students' academic performance in chemistry.

Statement of the Problem

In recent times, poor performance of students in chemistry in the SSCE has generated serious concern among science educators. Consequently, researchers have worked on several causative factors, such as inadequate laboratory equipment, teachers' qualification, and students' inability to acquire some basic science process skills. In an attempt to address the problem highlighted above, some studies have been carried out

through the use of carefully planned instructional strategies and models to improve the status of chemistry teaching and learning. Despite all these efforts, students' performance in chemistry has remained consistently poor at the SSCE. All these strategies gave a little improvement over the conventional teaching method, which is being used in our secondary schools. However, there seems to be a neglect of other important factors, such as laboratory learning environment. Hence, this study is to fill the existing gap.

Purpose of the Study

The purpose of this study was to investigate the influence of laboratory learning environment on students' learning outcomes in senior secondary school chemistry. Specifically, the objectives of the study were to investigate the relationship between the five dimensions of laboratory learning environment and students' performance in chemistry.

Hypothesis

The following hypothesis was therefore generated:

There is no significant relationship between the five dimensions of laboratory learning environments and students' performance in chemistry.

Method

The study adopted the descriptive research design of survey type. The population for the study comprised the Senior Secondary School Three (SSS III) chemistry students in all the public secondary schools in Ondo State. The study focused on public schools located in the three geopolitical zones of the state. Two local government area councils were randomly selected in each zone for the study. Purposive sampling technique was also used to select four secondary schools from each local government area for a total of 24 secondary schools being involved in the study based on the following criteria: (a) standard and functional chemistry laboratory; and (b) qualified and experienced chemistry teachers.

In each school selected for the study, intact class of chemistry students was involved in the study. The sample for the study consisted of 690 students from the schools used for the study. Two instruments tagged "Questionnaire on Chemistry Laboratory Learning Environment" (QCLLE) and "Chemistry Practical Achievement Test" (CPAT) were used for data collection. The QCLLE was designed to assess students' perceptions of their chemistry laboratory learning environments. The QCLLE consisted of 30 items measuring five different dimensions of science laboratory environments (student cohesiveness, open-endedness, integration, rule-clarity, and material environment) containing six items in each scale. The five response alternatives for each item were "Strongly agree," "Agree," "Undecided," "Disagree," and "Strongly disagree." The QCLLE was scored using a score range of 1 for "Strongly disagree" to 4 for "Strongly agree" for positive items and the scoring was reversed for negative items. The CPAT was used to assess students' performance in chemistry laboratory activities. This consisted of a 5-option multiple choice of 25 items for which a table of specification was constructed to ensure content validity. The units of chemistry covered include separation techniques, qualitative analysis, and volumetric analysis. The scores of the students after the laboratory activities were taken as the performance in chemistry.

The instruments were given to experts in chemistry education and test and measurement. Based on their comments, the instruments were corrected, restructured, and hence refined in order to meet the face and content validity requirements. A trial test was carried out by administering the instruments on 50 non-participating

SSS III students from one of the schools outside the local government area used for the study. The data obtained from trial testing were analysed using Cronbach's alpha and a coefficient of internal consistency of 0.88, 0.91, and 0.69 were obtained for QCLLE and CPAT respectively.

Results

There is no significant relationship between the five dimensions of the chemistry laboratory learning environment (material environment, integration, student cohesiveness, open-endedness, and rule clarity) and students' performance in chemistry. The analysis is shown in Table 1.

Table 1

Analysis of Variance (ANOVA) Showing the Relationship Between the Five Dimensions of the Laboratory Learning Environment and Students' Performance in Chemistry

Model	Sum of squares	Df	Mean square	F	Sig.	Decision at $p < 0.05$
Regression	230980.8[a]	5	46196.16	678.96	0.000	*
Residual	46539.24	684	68.04			
Total	277520.00	689	-	-	-	-

Notes. * Significant at $p < 0.05$ alpha level; [a] Adjusted $R^2 = 0.831$.

The result in Table 1 shows that the relationship between the five dimensions of the laboratory learning environment and students' performance in chemistry was significant ($F_{(4,684)} = 678.96$; $p = 0.000$). Therefore, the null hypothesis was rejected. This implies that there is a significant relationship between the five dimensions of the laboratory learning environment and students' performance in chemistry. Table 1 also shows that the independent variable (five dimensions of the laboratory learning environment) accounted for 83.1% of the total variance in the performance of students in chemistry.

To find out the relative contribution of each of the variables of the independent variable to the performance of students in chemistry, multiple regression analysis was used and the result is shown in Table 2.

Table 2

Relative Contribution of Learning Environment Variables to Students' Performance in Chemistry

Learning environment variables	Unstandardized coefficients		Standardized coefficients	Rank	t	Sig.
	B	Std. error	Beta			
(Constant)	2.716	0.995	-	-	2.730	0.006*
Material environment	0.341	0.036	0.345	1st	9.378	0.000*
Integration	0.215	0.034	0.219	2nd	6.340	0.000*
Student cohesiveness	0.171	0.038	0.173	3rd	4.548	0.000*
Open-endedness	0.095	0.032	0.097	5th	2.918	0.004*
Rule clarity	0.037	0.037	0.139	4th	3.690	0.000*

Note. * Significant at $p < 0.05$ alpha level.

Table 2 shows that all the learning environment variables contributed significantly to the students' performance in chemistry ($t_{(720)} = 2.73$; $p < 0.05$). That is, material environment was significant ($t_{(720)} = 9.38$; $p \leq 0.05$), integration was significant ($t_{(720)} = 6.34$; $p < 0.05$), student cohesiveness was significant ($t_{(720)} = 4.55$; $p < 0.05$), open-endedness was significant ($t_{(720)} = 2.92$; $p < 0.05$), and also rule-clarity was significant ($t_{(720)} = 3.69$; $p < 0.05$). Table 2 also shows that material environment had the highest contribution to students' performance in chemistry ($\beta = 0.345$; 34.5%). This is seconded by integration ($\beta = 0.219$; 21.9%), followed by

student cohesiveness (β = 0.173; 17.3%) and rule clarity (β = 0.139; 13.9%), while open-endedness (β = 0.097; 9.7%) had the lowest contribution.

Discussion of Findings

The results of hypothesis showed that there was a significant relationship between the five dimensions of laboratory learning environment (material environment, integration, student cohesiveness, open-endedness, and rule clarity) and students' performance in chemistry. The results also showed that the five dimensions of the chemistry laboratory learning environment were positively correlated with students' academic performance. These associations are positive for the scales of material environment, integration, student cohesiveness, open-endedness, and rule clarity scales. This implies that in classes where the students perceived satisfactory material environment and greater integration, student cohesiveness, open-endedness, and clear rules, there will be improvement in their performance. The findings of the study also revealed that student cohesiveness is the least favorably perceived dimensions of the chemistry laboratory environment, followed by rule clarity, with integration being the most favorably perceived. This is in line with the finding of Henderson, Fisher, and Fraser (1995) that integration of practical and theory components of course is an aspect of the learning environment likely to promote favorable learning outcomes.

The result further showed that students show relatively favorable perceptions of their chemistry laboratory lessons, with the lowest score occurring for the open-endedness scale. It seems that experiments in chemistry laboratory lessons are normally organized with clear procedures that the students must follow in carrying out laboratory activities. The lower score on open-endedness scale has also been reported in the previous studies (Gidding & Waldrip, 1996; Waldrip & Wong, 1996). The result was also in agreement with the findings of Aladejana and Aderibigbe (2007) that the five components of the science laboratory environment were positively correlated with students' academic performance.

The analysis further showed that chemistry students perceived greater integration between theory and practice. The integration of chemistry laboratory activities with the textual materials informed students that each investigation contains important chemical ideas that were directly related to the concepts being explained. The finding was supported by Akpan (2012) that learning environment could have potential influence on students' achievement. The findings of the study further revealed that students' perception of chemistry laboratory learning environment correlates positively with students' performance considering the regression summary for students' performance and chemistry laboratory learning environment. This means that students' perception is relevant towards the determination of their performance in chemistry.

Conclusion and Recommendations

The study concluded that there is significant relationship between the five dimensions of laboratory learning environment (material environment, integration, student cohesiveness, open-endedness, and rule clarity) and students' academic performance. All the five QCLLE factors are directly related to students' performance in chemistry. That is, the more favorable the laboratory environment is, the more positive are the performance and attitude towards chemistry, and vice-versa.

On the basis of the findings of this study, the following recommendations are made:

1. To enhance the teaching and learning of chemistry, teachers and administrators should pay particular attention to the low score in the open-endedness and material environment dimensions of the laboratory learning

environment. This indicates areas where improvement can be made in the teaching and learning of chemistry.

2. The findings of this study indicated that material environment was one of the least favorably perceived dimensions of laboratory learning environment. It is therefore recommended that the government should provide secondary schools with resources, teaching materials, models, equipment, and adequate laboratories for the teaching and learning of chemistry. The federal government could assist through the Education Trust Fund (ETF) in funding science laboratories in schools.

3. Seminars, workshops, and conferences should be organized occasionally for both the chemistry teachers and their students. This will help the teachers refresh their knowledge, especially on modern strategies of teaching and learning which could enhance the teaching and learning of science, particularly chemistry.

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