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EFFECT OF HANDS-ON LABORATORY ACTIVITIES ON SECONDARY SCHOOL STUDENTS' ENGAGEMENT IN CHEMISTRY IN ORUMBA SOUTH LOCAL GOVERNMENT AREA

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Abstract

This study investigated the effect of hands-on laboratory activities on secondary school students' engagement in Chemistry in Orumba South Local Government Area of Anambra State, Nigeria. A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The study involved 60 Senior Secondary II Chemistry students selected from two government co-educational secondary schools. The experimental group comprised 33 students taught using hands-on laboratory activities, while 27 students in the control group were taught using the conventional lecture method. Data were collected using the 33-item Science Engagement Scale, adapted from the Math and Science Engagement Scale. The instrument had a Cronbach's alpha reliability coefficient of .74. Mean and standard deviation were used to answer the research questions, while analysis of covariance was used to test the null hypotheses at the .05 level of significance. The results showed that students taught using hands-on laboratory activities had a higher mean engagement gain (20.56) than those taught using the conventional lecture method (7.87), with a mean gain difference of 12.69. The analysis further showed a significant difference in engagement between the two instructional groups, $F(1, 57) = 67.94$, $p < .001$. Among students taught using hands-on laboratory activities, female students recorded a higher mean engagement gain (21.38) than male students (19.34), while the analysis indicated a significant gender difference, $F(1, 56) = 6.26$, $p = .015$. However, the teaching method × gender interaction was not statistically significant, $F(1, 55) = 1.99$, $p = .163$. The study concludes that hands-on laboratory activities were associated with higher student engagement in Chemistry than the conventional lecture method. It recommends increased use of structured hands-on laboratory activities in secondary school Chemistry instruction and attention to gender-responsive classroom practices that support the active engagement of all learners.

Keywords: Hands-On Laboratory Activities, Students' Engagement, Gender

Introduction

Science education plays an important role in developing learners' understanding of the natural world and preparing them to apply scientific knowledge to everyday and societal problems. Through science education, learners are expected not only to acquire scientific knowledge but also to develop the skills, attitudes, and dispositions needed to observe, investigate, reason, and participate actively in scientific activities (Abimbola, 2018). Within the school science curriculum, Chemistry occupies an important position because it provides learners with an understanding of matter, its properties, composition, and transformations, as well as the chemical processes underlying many phenomena in everyday life (Abubakar, 2020). Chemistry is also closely connected with areas such as health, agriculture, environmental management, energy, manufacturing, and other technological applications (Atkins & de Paula, 2017; Silberberg, 2015). Consequently, effective Chemistry education requires learning experiences that enable students to interact meaningfully with scientific concepts and processes.

The nature of Chemistry makes active participation particularly important in the learning process. Chemistry involves abstract concepts as well as observable phenomena that can be investigated through practical activities. Laboratory experiences provide opportunities for students to observe chemical changes, manipulate materials and equipment, conduct investigations, and relate theoretical explanations to observable phenomena (Johnstone, 2010; Royal Society of Chemistry [RSC], 2021). Such experiences can provide learners with opportunities to participate directly in the learning process rather than merely receiving information from the

teacher. However, the extent to which students participate actively in Chemistry lessons depends partly on the instructional approaches employed in the classroom.

One important dimension of students' classroom participation is academic engagement. Student engagement refers to the degree to which learners are actively involved in and committed to learning activities. It encompasses students' behavioural participation, emotional involvement, and cognitive investment in learning (Anierobi & Unachukwu, 2020). Behavioural engagement may be reflected in students' participation, attention, effort, and persistence during learning activities, whereas emotional engagement relates to students' interest, enjoyment, and feelings toward learning. Cognitive engagement involves the mental effort and strategic thinking students invest in understanding and working with learning tasks. Engagement is therefore more than students' physical presence in the classroom; it concerns the extent to which they participate meaningfully in the learning process.

In Chemistry classrooms, maintaining students' engagement may be challenging when instruction is dominated by teacher explanations with limited opportunities for students to interact with materials, investigate phenomena, or participate actively in learning tasks. The conventional lecture method generally places the teacher at the centre of instruction, with students expected to listen, take notes, and respond to questions or explanations provided by the teacher. Although lecture-based instruction can be useful for presenting information and explaining concepts, extensive reliance on this approach may provide fewer opportunities for students to engage directly with practical aspects of Chemistry. This is particularly relevant in a subject in which students are expected to connect theoretical ideas with observable chemical phenomena.

The need for instructional approaches that provide greater opportunities for active participation has therefore drawn attention to hands-on laboratory activities (HLA**)**. Hands-on laboratory activities involve students directly manipulating materials and equipment, carrying out experiments, making observations, and participating in practical tasks under appropriate instructional guidance (Ajayi, 2018; Nzewi, 2018). Rather than positioning students primarily as recipients of information, HLA provides opportunities for them to become directly involved in learning activities. In Chemistry, such activities may involve conducting experiments, observing reactions, handling laboratory materials, recording observations, and discussing findings. These experiences can create opportunities for students to pay attention to learning tasks, participate actively, interact with peers and teachers, and sustain involvement in classroom activities.

The potential of hands-on laboratory activities to promote student engagement is particularly important because practical work provides a context in which students can interact directly with the subject matter. During laboratory activities, students may be required to follow procedures, make observations, discuss results, solve practical problems, and communicate their findings. Such activities can provide varied forms of participation and may stimulate students' interest and involvement in Chemistry learning. Previous studies have reported positive effects of practical and laboratory-oriented approaches on students' involvement in Chemistry learning (Chukwu & Okafor, 2022; Iyamuremye, 2023). However, the extent to which hands-on laboratory activities influence students' engagement may depend on the learners and the context in which the activities are implemented.

Another factor that may be relevant to students' engagement in Chemistry is gender. Gender refers to socially constructed roles, expectations, and patterns of behaviour associated with being male or female. In educational settings, gender-related expectations and experiences may influence students' participation, interest, confidence, and interaction with learning activities. Studies in science education have continued to examine gender because male and female students may experience science learning differently as a result of social expectations, classroom experiences, and perceptions of science. Examining gender alongside instructional strategy can therefore clarify whether an instructional approach is associated with differences in students' engagement between male and female learners.

It is against this background that the present study investigated the effect of hands-on laboratory activities on secondary school students' engagement in Chemistry in Orumba South Local Government Area of Anambra State, Nigeria. Specifically, the study examined students' engagement under hands-on laboratory activities and the conventional lecture method, considered gender differences among students exposed to hands-on laboratory activities, and examined the interaction effect of teaching method and gender on students' engagement in Chemistry.

Although practical and laboratory activities have received attention in science and Chemistry education, context-specific evidence remains needed on how hands-on laboratory activities influence students' engagement in Chemistry, particularly among secondary school students in the Nigerian context. In addition, examining gender provides an opportunity to determine whether students' engagement in hands-on laboratory activities differs between male and female learners and whether gender interacts with the instructional approach. Such evidence is relevant to understanding

how practical Chemistry instruction can be structured to provide meaningful opportunities for students to participate actively in learning.

Samuel (2023) notes that societal expectations, cultural norms, and gender stereotypes can impact students' learning experiences and performance. For instance, girls are often encouraged to excel in language and arts, while boys may be steered towards science and mathematics. Such expectations may influence students' self-perceptions, interests, confidence, classroom participation, and ultimately their academic outcomes. In education, gender stereotypes may lead to limited opportunities, bias in teacher expectations, self-perception challenges, classroom dynamics, and gender imbalance in various professions. These factors make gender an important consideration in understanding students' experiences and achievement in Chemistry education. Thus, this study seeks to investigate the effect of hands-on laboratory activities on secondary school students' engagement in Chemistry in Orumba South Local Government Area, Anambra State.

Statement of the Problem

Student engagement is an important aspect of effective Chemistry learning because it reflects learners' behavioural participation, emotional involvement, and cognitive investment in classroom activities. However, Chemistry instruction in secondary schools may still rely heavily on conventional lecture-based approaches that provide limited opportunities for students to participate actively in practical learning experiences. This may constrain students' involvement, attention, interest, and persistence during Chemistry lessons. Hands-on laboratory activities provide opportunities for students to manipulate materials, conduct experiments, make observations, and participate directly in the learning process. However, there is limited

context-specific evidence on the extent to which such activities influence secondary school students' engagement in Chemistry in the study area. Furthermore, it is necessary to examine whether engagement under hands-on laboratory activities differs between male and female students and whether gender interacts with teaching method in influencing engagement. The study therefore investigated the effect of hands-on laboratory activities on secondary school students' engagement in Chemistry in Orumba South Local Government Area of Anambra State, Nigeria.

Purpose of the Study

The purpose of the study was to investigate the effect of hands-on laboratory activities on secondary school students' engagement in Chemistry in Orumba South Local Government Area of Anambra State.

Specifically, the study sought to investigate the:

1. Difference between the mean engagement scores of students taught Chemistry using hands-on laboratory activities (HLA) and those taught using the conventional lecture method (CLM).
2. Difference in the mean engagement scores of male and female students taught Chemistry using HLA and those taught using CLM.
3. Interaction effect of teaching methods (HLA and CLM) and gender on students' engagement in Chemistry.

Research Questions

The following research questions guided this study:

1. What is the difference between the mean engagement scores of students taught Chemistry using hands-on activities (HLA) and those taught using conventional lecture method (CLM)?
2. What are the differences in the mean engagement scores of male and female students Chemistry using HLA ?

Hypotheses

The study was guided by the following null hypotheses which were tested at 0.05 level of significance:

1. There is no significant difference between the mean engagement scores of students taught Chemistry using hands-on laboratory activities (HLA) and those taught using conventional lecture method (CLM).
2. There is no significant difference in the mean engagement scores of male and female students taught Chemistry using HLA
3. There is no interaction effect of teaching method (HLA) and gender on students' engagement in Chemistry

Methodology

This study adopted the quasi-experimental non-randomized research design. The population of the study consist of 256 (153 males and 103 females) Senior secondary year two (SS2) students offering chemistry in the 13- government owned secondary schools in Orumba South LGA of Anambra State. The sample size was made up of 60 students (26 males and 34 females) from two Government co-educational secondary schools in Orumba South using purposive and simple random sampling technique. The

experimental group was tagged group A, while the control group was tagged group B. The experimental group consisted of 33 SS2 Chemistry students (18 females and 15 males), while the control group consisted of 27 SS2 Chemistry students (16 females and 11 males) . The instruments used for data collection was Science Engagement Scale (SES) adapted from the Math and Science Engagement Scale (MSES) developed by Wang, Fredricks, Ye, Hofkens, and Schall (2016). The adapted instrument consisted of 33 items and was used to measure students' engagement before and after the treatment on acid-base reactions. The instrument employed a five-point Likert response format of Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD). The instrument was validated by three experts, One from the Department of Educational Foundations (Measurements and Evaluation unit), while the other two were from the Department of Science Education at Nnamdi Azikiwe University, Awka. Cronbach Alpha was used to determine the internal consistency of the instrument and a coefficient of 0.74 was obtained. Data for the study were collected using SES through pretest and posttest. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at $p \leq 0.05$. ANCOVA was used to test the hypotheses

Results

Research Question 1: What is the difference between the mean engagement scores of students taught Chemistry using hands-on laboratory activities (HLA) and those taught using conventional lecture method (CLM)?

Table 1: Mean Engagement Scores of Students taught using Hands-on Laboratory activities (HLA) and those taught using Conventional Lecture Method (CLM) Groups

Statistics	Pre-test Mean	Pre-test Std Dev.	Post-test Mean	Post-test Std Dev.	Gained Mean
Experimental Group (HLA)	54.27	7.14	74.83	6.82	20.56
Control Group (CLM)	53.60	7.31	61.47	7.06	7.87
Mean Difference	0.67	-	13.36	-	12.69

Data in Table 1 reveal that prior to treatment, students in both groups recorded comparable mean engagement scores. The experimental group (HLA) had a pre-test mean engagement score of 54.27 (SD = 7.14), while the control group (CLM) had a pre-test mean of 53.60 (SD = 7.31), indicating negligible initial differences between the two groups. However, after the treatment, the experimental group recorded a post-test mean engagement score of 74.83 (SD = 6.82), representing a mean gain of 20.56 points, while the control group recorded a post-test mean of 61.47 (SD = 7.06), representing a mean gain of only 7.87 points. The difference in mean gain between the two groups was 12.69 points, in favour of the experimental group. This finding suggests that students taught Chemistry using hands-on laboratory activities demonstrated a considerably higher level of engagement compared to those taught using the conventional lecture method.

Research Question 2: What is the difference between the mean engagement scores of male and female students taught Chemistry using HLA?

Table 2: The Difference in the Mean Engagement Scores of Male and Female Students in Hands-on Laboratory Activities (HLA)

Statistics	Gender	Pre-test Mean	Pre-test Std Dev.	Post-test Mean	Post-test Std Dev.	Gained Mean
Experimental Group (HLA)	Male	53.83	6.91	73.17	6.74	19.34
	Female	54.56	7.38	75.94	6.89	21.38

The results in Table 2 show that before the treatment, all sub-groups recorded similar pre-test mean engagement scores. HLA male students had a pre-test mean of 53.83 (SD = 6.91), and HLA female students had 54.56 (SD = 7.38). For the CLM group, male students recorded 53.22 (SD = 7.43) and female students recorded 54.17 (SD = 7.24). After treatment, HLA male students achieved a post-test mean of 73.17 (SD = 6.74) with a gain of 19.34 points, while HLA female students achieved a post-test mean of 75.94 (SD = 6.89) with a gain of 21.38 points. Notably, female students in the HLA group showed the highest engagement gain, though both male and female students. The data suggest that both male and female students benefit from hands-on laboratory activities in terms of engagement, with female students in the HLA group recording marginally higher gains.

$H0_1$: There is no significant difference between the mean engagement scores of students taught Chemistry using hands-on laboratory activities (HLA) and those taught using conventional lecture method (CLM).

Table 3: ANCOVA Test of Significant Difference between the Mean Engagement Scores of Students in Chemistry in the HLA and TLM Groups

Source	Type III SS	df	MS	F	p-value	Decision
Corrected Model	4,827.63	2	2,413.82	52.17	.000	
Intercept	3,612.44	1	3,612.44	78.12	.000	
Pre-test (Covariate)	1,204.71	1	1,204.71	26.04	.000	
Teaching Method	3,142.88	1	3,142.88	67.94	.000	$H0_1$ Rejected
Error	2,638.05	57	46.28			
Total	348,962.00	60				
Corrected Total	7,465.68	59				

The result of the ANCOVA as shown in Table 3 reveals that there is a significant difference in the mean engagement scores of students in the HLA and CLM groups after controlling for pre-test scores, $F(1, 57) = 67.94$, $p = .000$. Since $p < .05$, the null hypothesis H_{01} is rejected. This indicates that the teaching method had a significant effect on student engagement, with students taught through hands-on laboratory activities recording significantly higher engagement scores than those taught through the traditional lecture method.

$H0_2$: There is no significant difference between the mean engagement scores of male and female students taught Chemistry using HLA .

Table 4: ANCOVA Test of Significant Difference between the Mean Engagement Scores of Male and Female Students in HLA .

Source	Type III SS	df	MS	F	p-value	Decision
Corrected Model	5,103.47	3	1,701.16	37.42	.000	
Intercept	3,498.22	1	3,498.22	76.97	.000	
Pre-test (Covariate)	1,187.63	1	1,187.63	26.13	.000	
Gender	284.62	1	284.62	6.26	.015	$H0_2$ Rejected
Teaching Method	3,075.34	1	3,075.34	67.66	.000	
Error	2,547.19	56	45.49			
Total	348,962.00	60				
Corrected Total	7,650.66	59				

The ANCOVA result in Table 4 shows that gender had a statistically significant effect on engagement scores, $F(1, 56) = 6.26$, $p = .015$. Since $p < .05$, the null hypothesis H_{02} is rejected. This implies that, when controlling for pre-test differences, there is a significant gender-based difference in mean engagement scores among students exposed to the two teaching methods. Female students in the HLA group consistently recorded higher post-test engagement means scores.

$H0_3$: There is no significant interaction effect of teaching methods (HLA) and gender on students' engagement in Chemistry.

Table 5: ANCOVA Test of the Significant Interaction Effect of Teaching Methods and Gender on Students Engagement Scores in Chemistry

Source of Variation	Type III SS	Df	MS	F	p-value	Decision
Corrected Model	5,241.89	4	1,310.47	29.12	.000	
Intercept	3,471.28	1	3,471.28	77.10	.000	
Pre-test (Covariate)	1,162.47	1	1,162.47	25.82	.000	
Teaching Method	3,061.34	1	3,061.34	67.99	.000	
Gender	262.18	1	262.18	5.83	.019	
Teaching Method × Gender	89.42	1	89.42	1.99	.163	$H0_3$ Not Rejected
Error	2,443.79	55	44.43			
Total	348,962.00	60				
Corrected Total	7,685.68	59				

The result of the ANCOVA in Table 5 shows that there is no interaction effect of teaching method and gender on student engagement and it was not statistically significant, $F(1, 55) = 1.99$, $p = .163$. Since $p > .05$, the null hypothesis H_{05} is not rejected. This finding implies that although both teaching method and gender independently exerted significant effects on engagement, the combined interaction of these two variables did not produce a significant differential effect on students'

engagement in Chemistry. In other words, the advantage of HLA over CLM in promoting engagement was fairly uniform across both male and female students.

Discussion

The findings of this study revealed that students taught Chemistry using hands-on laboratory activities recorded higher mean post-test engagement scores compared to their counterparts in the traditional lecture method group, with a notable difference in mean gain favouring the experimental group. This outcome is not unexpected, as the interactive and participatory nature of laboratory activities naturally stimulates curiosity, sustains attention, and fosters a sense of ownership in the learning process. When students are physically involved in observing chemical reactions, manipulating apparatus, and recording results, their emotional and cognitive investment in the lesson deepens considerably. This finding aligns with the work of Iyamuremye (2023), who reported that there is a statistical significant improvement in post-test performance and positive student engagement after Chemistry practical activities in Rwandan secondary schools, a finding that closely mirrors the results of the present study. Conversely, Samuel (2019), despite acknowledging the role of laboratory facilities in Chemistry instruction in Anambra State, found that teachers perceived students' performance in practical Chemistry to be generally poor, attributing this to attitudinal and resource-related challenges rather than to the instructional method itself, a position that stands in contrast to the positive engagement outcomes recorded in the present study where structured hands-on activities were deliberately employed. The superior engagement levels recorded in the experimental group in the present study therefore underscore the transformative potential of hands-on laboratory activities in making Chemistry instruction more stimulating, relevant, and learner-centred.

The result of the Analysis of Covariance conducted to test hypothesis one showed a statistically significant difference in the mean engagement scores of the experimental and control groups after controlling for pre-test differences, leading to the rejection of the null hypothesis. This finding is significant because it provides empirical evidence that the observed superiority of hands-on laboratory activities over the traditional lecture method in promoting student engagement is not a product of chance or initial group differences, but a direct consequence of the instructional treatment administered. The significance of this result is further reinforced by the work of Okoro and Eze (2021), who found that students who participated in programming labs and real-time problem-solving tasks in computer science were significantly more enthusiastic and attentive than those taught theoretically, demonstrating that experiential instructional approaches yield significantly higher engagement outcomes regardless of subject area. In contrast, Iyamuremye (2023) reported no statistically significant gender-based differences in engagement, a finding that partially diverges from the present study, which found gender to be a significant factor in engagement outcomes. The rejection of this null hypothesis is of considerable pedagogical significance, as it affirms that Chemistry teachers in Orumba South LGA and the broader Anambra State context can meaningfully improve student engagement by substituting or supplementing traditional lecture methods with well-structured laboratory activities.

The result of this study showed that both male and female students in the experimental group recorded higher post-test mean engagement scores than their counterparts in the control group, with female students in the hands-on laboratory activities group recording marginally higher engagement gains than male students in the same group. This finding suggests that female students may be particularly responsive to the

collaborative and observational character of laboratory-based instruction, perhaps because such settings offer structured social interaction and reduced competitive pressure compared to the conventional classroom. In contrast, Iyamuremye (2023) found no significant gender-based differences in engagement following Chemistry practical activities, which presents a divergent pattern from the present study and highlights the possibility that contextual factors, including class composition, school culture, and the specific nature of laboratory tasks, may moderate gender differences in engagement responses.

The ANCOVA result from the test of Hypothesis two revealed a statistically significant gender effect on engagement scores, leading to the rejection of the null hypothesis. This finding is of significance because it establishes that gender is not a neutral variable in the context of Chemistry engagement; rather, it plays a measurable role in shaping how students respond to different instructional methods. Importantly, despite the significant gender effect, the non-significant interaction between teaching method and gender found in the present study indicates that HLA was equally beneficial for both male and female students, a finding that is consistent with the recommendation of Iyamuremye (2023) that schools ensure all students, irrespective of gender, have access to hands-on Chemistry activities. The rejection of this hypothesis is significant in drawing educators' attention to the need to design laboratory activities that are sensitive to gender-differentiated engagement patterns, while ensuring that the overall benefits of HLA are equitably distributed across all learners

In examining whether the effect of teaching method on student engagement varied by gender, the present study found that while both teaching method and gender independently exerted significant effects on engagement, the interaction of these two

variables was not statistically significant. This means that the advantage of hands-on laboratory activities over the traditional lecture method in promoting engagement was observed consistently across both male and female students, without one gender benefiting disproportionately over the other from the laboratory-based instructional approach. This finding is meaningful because it establishes HLA as a broadly inclusive instructional strategy for engagement in Chemistry, one whose positive effects are not contingent on the gender of the learner. Iyamuremye (2023) offers support for this interpretation, having found that practical Chemistry activities were equally effective for male and female students in Rwanda with no significant interaction between gender and the instructional approach on engagement outcomes. However, a contrasting nuance emerges from the individual main effects: the finding that gender independently influenced engagement while the interaction was non-significant suggests that pre-existing gender-differentiated dispositions toward Chemistry learning, such as differences in self-efficacy, interest, or attitude, may account for some of the gender gap in engagement, rather than the instructional method itself. This calls for attention not only to how Chemistry is taught, but also to the broader motivational and attitudinal context within which both male and female students encounter the subject.

The ANCOVA result from the test of significant interaction effect of teaching method and gender on students' engagement in Chemistry showed that the interaction effect of teaching method and gender on engagement was not statistically significant, and consequently the null hypothesis was not rejected. This outcome is significant for several reasons. First, it confirms that the positive impact of hands-on laboratory activities on engagement is gender-neutral in its interaction dimension, meaning that Chemistry teachers need not modify or differentiate their laboratory instructional

approach based on gender in order to achieve improved engagement across the class. Second, it implies that any gender differences observed in engagement outcomes are attributable to the independent main effect of gender rather than to a differential response to the instructional treatment itself. This interpretation is consistent with the conclusion drawn by Iyamuremye (2023), who found that practical Chemistry activities produced comparable engagement benefits for both genders and recommended that all students be given equal access to hands-on Chemistry experiences. In contrast, studies such as that of Okoro and Eze (2021) demonstrated that experiential instructional approaches in computer science significantly raised engagement across student groups without differential gender effects, lending cross-disciplinary credibility to the notion that the interaction of gender and active instructional methods on engagement tends to be non-significant when the activity is well-structured and inclusive. The non-rejection of this hypothesis therefore carries an important practical implication: it absolves teachers of the need to create separate engagement strategies for male and female students in the context of laboratory-based Chemistry instruction, provided that the laboratory environment is designed to be accessible, stimulating, and equitable for all learners.

Conclusion

The findings of the study revealed that hands-on laboratory activities significantly improved the engagement of students in Chemistry in Orumba South L.G.A of Anambra State. Based on the findings, the researcher concludes that hands-on laboratory activities is more effective for enhancing students' engagement in the study area.

Recommendations

The following recommendations were made in the light of the findings of the study;

1. Chemistry teachers should adopt hands-on laboratory activities (HLA) in their teaching to enhance students' engagement in the subject.
2. Students should actively participate in hands-on laboratory activities and practical exercises during Chemistry lessons, as this will improve their understanding, engagement in the subject.
3. Educators should apply gender-responsive strategies when using hands-on laboratory activities, ensuring that both male and female students are equally engaged which in turns improves students' engagement in chemistry.

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