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UNCOVERING THE IMPACT OF SCIENCE LAB ACTIVITIES ON ELEMENTARY SCHOOL CHILDREN'S PERFORMANCE AND CLASSROOM BEHAVIOR IN NIGERIA

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Abstract

This study aims to investigate the impact of science lab activities on the academic performance and behavior of elementary school children in Nigerian primary schools: It adopts an experimental design with pre-test, post-test, and control group methodology to assess outcomes, alongside a cohort approach for examining temporal relationships: The research draws on theoretical perspectives of Vygostky socio cognitive learning theory and behavioral development, exploring cognitive, affective, and psychomotor domains of learning. Young children (aged 5 to 6 years) were recruited from diverse urban and rural schools, classified into experimental and control groups, and followed for 12 weeks with periodic assessments. The findings reveal that in the experimental group, science lab exposure significantly enhances students' academic performance and reduces behavioral problems by fostering social interactions and emotional regulation. The study identifies differences in male and female science literacy skills and highlights the importance of early intervention in addressing educational and behavioral challenges. It concludes that structured science lab activities can transform practical science education, inform evidence-based interventions, and contribute to Nigeria's socio-economic development through improved science literacy and equitable learning opportunities.

Keywords: Science lab, elementary children, performance, behavior.

INTRODUCTION

In recent years, global efforts to improve STEM education have brought increasing attention to the role of practical science activities in fostering academic achievement and essential skills among students (Grancharova, 2024; Pozo-Rico et al., 2024). In particular, science lab activities are seen as a critical component for advancing science literacy, problem-solving abilities, and collaborative skills, all of which are pivotal for academic success. In Nigeria, where educational systems are seeking to bridge gaps in science education, the integration of practical experiences is crucial for developing a scientifically literate workforce capable of contributing to national development. This has been echoed by Nigeria's Minister of Education, Tunji Alausa, who emphasized a shift towards an education system with 80% practical activities as a means to revolutionize learning in the country (Udegbunam, 2019; Agency Report, November 2024).

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Despite the recognized significance of science education in nurturing critical thinking and innovation, many developing countries, including Nigeria, face challenges in providing well-equipped science labs, particularly at the elementary school level (Kotsis, 2024). This lack of exposure to hands-on learning activities can hinder students' academic and behavioral development, especially in science-related subjects. Existing research has demonstrated the broad benefits of science lab activities, such as improving critical thinking, problem-solving, and teamwork (Shana & Abulibdeh, 2020). However, there is limited exploration of the specific impacts of science lab exposure on students' attitudes, motivation, and overall engagement with science. This study seeks to fill this gap by examining how science lab activities can influence academic performance and behavioral outcomes in elementary school children, particularly in Nigeria, where the need for interventions in science education is paramount.

An important aspect worthy of investigating is the gender differences in the impact of science lab exposure. Previous studies have highlighted that male and female students often experience different educational outcomes in STEM fields due to a variety of factors, including societal expectations, cultural norms, and differences in cognitive and emotional development (Blanchard et al., 2010; Uzezi & Zainab, 2017). Understanding the distinct ways in which male and female students respond to science lab activities is essential for developing more inclusive educational practices that cater to the needs of both genders. Gender-sensitive interventions can ensure that both male and female students are equally motivated, engaged, and empowered by science education, thereby promoting equitable access to opportunities in STEM fields. By exploring these gender differences, this study aims to contribute to a deeper understanding of how science lab activities can be optimized to benefit all students, regardless of gender.

The theoretical framework for this study is anchored in the Social Constructivist Theory of learning, which emphasizes the active role of students in constructing knowledge through engagement with their environment (Vygotsky, 1978). Science labs, as environments that promote inquiry and experimentation, offer an ideal setting for such constructivist learning, where students can develop skills like problem-solving and critical thinking. Additionally, the study draws from the Social Cognitive Theory (Bandura, 1986), particularly the idea that observational learning and social interaction in group activities are integral to behavioral change. The integration of these two frameworks provides a comprehensive lens to examine how science lab activities not only affect cognitive outcomes like academic performance but also influence behavioral dynamics such as student engagement, motivation, and emotional expression.

The effectiveness of laboratory-based learning in improving student performance, particularly at the secondary school level, has been widely explored, with substantial evidence highlighting the benefits of guided-inquiry and virtual laboratories. Guided-inquiry lab activities, as compared to traditional methods, are shown to significantly enhance test performance, knowledge retention, and reasoning skills. Uzezi and Zainab (2017) demonstrated that secondary school chemistry students performed better in volumetric analysis tests when taught using a guided-inquiry approach, as compared to traditional lab methods. Similarly, Blanchard et al. (2010) found that guided-inquiry labs improved students' performance across multiple science subjects, showing gains in knowledge and reasoning, as well as long-term retention. Inquiry-based teaching methods, including guided-inquiry, have been praised for fostering critical thinking, hypothesis development, and experimental design skills, which are key in science education (Wilson et al., 2009). Notably, these methods not only benefit cognitive skills but also contribute to addressing achievement gaps across diverse student demographics, including gender (Blanchard et al., 2010; Uzezi & Zainab, 2017). Additionally, the impact of guided-inquiry labs extends beyond immediate academic performance, promoting lasting learning outcomes. For example, Blanchard et al. (2010) found that guided inquiry significantly improved students' retention and ability to apply knowledge over time.

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Virtual laboratories, especially in resource-constrained settings, have also proven to be effective in enhancing student performance. Sabasales (2019) compared the effects of virtual and physical labs on students' performance in physics, revealing that virtual labs contributed to similar improvements in test scores. Virtual labs provide an alternative method of instruction that compensates for the lack of physical resources, offering students a platform to simulate experiments that may otherwise be inaccessible. Studies such as those by Tatlı and Ayas (2013) and Bazie et al. (2024) emphasize the effectiveness of virtual labs in improving students' comprehension and procedural skills in chemistry, with findings supporting their utility as both an alternative and complement to physical lab sessions.

Despite these successes, gaps in the literature remain, particularly in terms of how these pedagogical strategies influence classroom behavior and engagement at the lower levels of education. While much of the existing research focuses on the measurable impacts of guided-inquiry and virtual labs on academic performance (Uzezi & Zainab, 2017; Sabasales, 2019), there is less emphasis on the underlying classroom dynamics and student behavior during these activities. In particular, the interaction patterns between students and the broader classroom environment, such as collaborative behaviors in group lab settings, have not been sufficiently explored. For instance, Onukwu and Ikenna (2024) found that group-centered laboratory activities foster higher achievement than individualized labs, yet their study primarily focused on academic outcomes rather than on behaviors that may contribute to these results. Furthermore, there is a gap in understanding how laboratory instruction impacts students' classroom behavior in terms of engagement, motivation, and collaboration. While studies such as Dietz and Slaughter (2013) suggest that laboratory activities improve science content mastery, they largely overlook how different instructional designs influence classroom interactions or how they affect students' attitudes and behaviors toward science learning. This lack of attention to classroom behavior and the social dynamics during inquiry-based or virtual laboratory activities limits the potential for understanding the full spectrum of benefits these pedagogical strategies may offer.

This study aims to investigate the impact of science lab exposure on the academic performance and behavior of elementary school children in Nigeria. It explores how engaging in practical science activities might enhance academic outcomes, reduce behavioral problems, and foster more positive attitudes toward science. By comparing the performance and behavior of students exposed to science labs with those who are not, the research seeks to identify key benefits of practical science education that can inform policies and educational reforms. This study is significant because it not only addresses the cognitive aspects of science education but also the social and emotional dimensions, which are often overlooked in traditional classroom settings. By contributing new insights into the relationship between science lab exposure and student behavior, this research aims to inform educational strategies that will support the development of well-rounded, scientifically literate individuals who are equipped to contribute to Nigeria's socio-economic development.

In line with this aim, the following sub-aims were also addressed in this study:

For the purpose of the study, a number of research questions have been raised and they include:

1. What is the level of science literacy skills that exist in elementary school?
2. What is the level of behavioral problems in elementary school children?
3. What is the significant impact of science literacy skills on elementary school children behavioral problems?
4. Is there a significant difference in the male and female science literacy skills?

METHOD

The study adopted an experimental design using a pre-test, post-test, control group format. This approach enabled a rigorous assessment of the impact of science lab exposure on academic performance and behavior. Additionally, a prospective cohort design was utilized to evaluate the association between science lab activities and performance and attitude/behavior among elementary school children in Nigeria. The cohort was classified into experimental and control groups at baseline, ensuring all eligible participants were at the same entry point of performance and attitude/behavior issues at the study's start. Participants were followed for a period of 12 months, with assessments conducted at three-month intervals to investigate temporal relationships between exposure to science activities and outcomes while minimizing recall bias.

Sample and Sampling Technique

The study was conducted in Ijebu-Ode Local Government Area (LGA) in Ogun State, located in the southwestern region of Nigeria. Ogun State is composed of three senatorial districts, and the study encompassed two local government areas (LGAs) from each of these districts. Specifically, Ijebu-Ode LGA was selected as the study area to represent the local educational landscape. For a comprehensive analysis, two primary schools and two junior secondary schools were chosen from each of the two selected LGAs within Ijebu-Ode.

The focus of the study was on two educational categories: primary schools and junior secondary schools. In the primary school category, two classes—Basic 5 and Basic 6—were included, while in the junior secondary category, Basic 7 and Basic 8 students were selected as participants. The research utilized intact classes, meaning the study sample was comprised of pre-existing classroom groups that were not altered for the purposes of the study. Participants were purposively recruited from both urban and rural elementary schools to ensure that the sample was representative of the wider population within Ijebu-Ode LGA. The recruitment process involved multistage sampling technique to maximize participation and ensure diversity. These strategies included posting advertisements and flyers on school bulletin boards, distributing communication letters through local community partners, and leveraging online forums to reach potential participants.

To meet the study's inclusion criteria, only children aged 5 to 6 years old were selected. Additionally, participants were required to be free of any significant performance or behavioral issues at the time of recruitment. This was done to ensure that the sample represented children who were capable of consistent participation throughout the study. Children who exhibited early signs of performance or behavioral challenges were excluded from the study to maintain the integrity of the sample. Participants who met the inclusion criteria and provided consent for longitudinal participation were considered eligible to take part.

The demographic characteristics of the study sample are presented in Table 1, which shows the distribution of participants by gender and age.

Table 1. Demographic Data of the participants.

	Frequency	Percentage	Cumulative Percentage
Male	19	47.5	47.5
Female	21	52.5	100.0
Total	40	100.0	
Age			
5 years	11	27.5	27.5
6 years	16	40.0	67.5
7 years	13	32.5	100.0
Total	100	100.0	

Table 1 shows that out of the 40 participants, 19 (47.5%) were male, while 21 (52.5%) were female. This distribution indicates that slightly more female participants were included in the study compared to male participants, reflecting a gender balance that is close to parity, but with a slight majority of females. The age distribution of participants is also presented in Table 1. The study population consisted of 11 (27.5%) children aged 5 years, 16 (40.0%) children aged 6 years, and 13 (32.5%) children aged 7 years. The largest proportion of participants were 6 years old, followed by 7-year-olds and 5-year-olds. This suggests that the study primarily captured the experiences of children in the middle of the age range, with a more balanced representation of the younger and older children.

Data Collection Procedure

The researcher visited the school to obtain permission to carry out the study from the heads of the schools. During this visit, children were evaluated to confirm eligibility and ensure freedom from performance and attitude/behavior issues. Eligible participants were given written consent to their parents before they were enrolled in the study. The study was carried out in three stages: Firsly, the experimental and control groups completed a pre-test to establish baseline academic performance and behavioral measures. Exposure to science lab activities was assessed using a detailed questionnaire that collected information on duration, frequency, and intensity of prior science lab involvement. Thereafter, the experimental group participated in structured science lab activities for 12 weeks, while the control group continued with traditional teaching methods. Laslty, at the end of the intervention, both groups completed a post-test assessing academic performance and behavioral outcomes.

Intervention

The intervention designed involves hands-on science activities aimed at enhancing young learners' understanding of heat and material properties through experiential learning. The structured activities, “What Melts in the Sun?” and “Sun’s Heat in Different Locations,” serve as instructional interventions designed to:

Research Instruments

Three research instruments were used to collect data for the study. The instruments were the Science Performance Test (SPT) which is a Standardized science tests measuring elementary students’ cognitive skills; Behavioral Assessment Tools**:** Observational checklists and teacher-reported questionnaires evaluating student engagement, teamwork, and interest in science and Psychomotor Skills Assessment**:** Tasks designed to evaluate hands-on abilities and practical application of science concepts.

RESULTS

Research on the level of science literacy skills that exist in elementary school

Table 2. Level statistics of science literacy skills.

		Frequency	Percentage	Mean	Std.Dev.
Low	1-8	20	50.0	8.51	3.33
Moderate	9-16	11	27.5	12.45	2.43
High	17-24	9	22.5	19.78	1.87

Table 2 showed the level of elementary pupils science literacy skill. 50% of the participants possessed a low level of science literacy skill, 27.5% of the participants possessed a moderate level of science literacy skill while 22.5% possessed a high level of science literacy skill. The result indicated that the participants possessed a low level of science literacy skill.

Research Question 2: What is the level of behavioral problems in elementary school children?

Table 3. Level statistics of elementary children behavioral problems.

		Frequency	Percentage	Mean	Std.Dev.
Low	1-60	12	30.0	16.32	4.22
Moderate	61-120	12	30.0	92.72	19.95
High	121-160	16	40.0	139.46	12.70

Table 3 showed the level of elementary pupils’ behavioral problems. 30% of the participants possessed a low level of behavioral problems, 30% of the participants possessed a moderate level of behavioral problems while 40% possessed a high level of behavioral problems. The result indicated that the participants possessed a high level of behavioral problems.

Result on the significant impact of science literacy skills on elementary school children behavioral problems.

The analysis results regarding "Science literacy skills on elementary school children's behavioral problems" are presented in Table 4.

Table 4. ANOVA showing the significant impact of science literacy skills on elementary school children behavioral problems.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	448.907	22	32.065	3.431	.000
Within Groups	794.403	17	9.346		
Total	1243.310	39			

Table 4 shows the F-value 3.431 which indicates a significant impact of science literacy skills on elementary school children behavioral problems. The significant level .000 is shown which is lesser than .05 which indicates that there is a significant impact of science literacy skills on elementary school children behavioral problems.

Result on the significant difference in the male and female science literacy skills

The analysis results regarding "male and female science literacy skills" are presented in Table 5.

Table 5. T-test analysis showing the significant difference in the male and female science literacy skills.

	N	Mean	Std.Dev.	Df	T	Sig
Male	50	11.50	3.21	38	.365	.015
Female	50	11.24	3.88			

Table 5 shows the t-score value of .365, and the mean scores of the male and female teachers are 11.50 and 11.24 respectively and a standard deviation of 3.2 1 and 3.88 respectively which indicates that there is a significant difference between the male and female science literacy skills. The table also shows .015 significant level which also indicates that there is a significant difference.

DISCUSSION, CONCLUSIONS, and SUGGESTIONS

According to the study, the level of science literacy skills that exist in elementary school was shown. The results suggest that science literacy skills in the studied elementary school children are generally low, with 50% of the participants demonstrating low levels of science literacy, 27.5% at a moderate level, and only 22.5% exhibiting high levels of science literacy. This indicates that a significant portion of the children lacks proficiency in fundamental scientific concepts, which can hinder their overall academic success and development in science-related subjects. The result is not in accordance with the result of Kartimi (2021) which revealed that students' learning activities in the application of scientific learning experienced an increase in science literacy skills with very strong criteria.

The low levels of science literacy observed in the majority of the participants are consistent with trends observed in various educational settings globally, where elementary school children often lack foundational science knowledge due to gaps in curricula or inadequate teaching methods. As identified in the literature review, science literacy is essential for children to engage critically with scientific ideas and participate meaningfully in discussions about science, technology, and the environment. According to research by Aikenhead (2006), early exposure to science education and fostering science literacy from a young age significantly influences students' long-term interest and success in the subject.

In terms of behavioral problems, the results reveal that a significant proportion (40%) of the children had high levels of behavioral issues, while 30% exhibited moderate levels, and another 30% displayed low levels. The high prevalence of behavioral problems highlights an area of concern that could potentially affect the educational outcomes of the children. Behavioral problems, such as inattentiveness, impulsiveness, and non-compliance, can interfere with the learning process, making it difficult for children to benefit from educational opportunities. This aligns with the findings of studies, such as those by Barkley (2015), which link behavioral issues to academic underachievement, especially in science and other cognitive domains. The result also agrees with the result of Amany Sobhy Sorour et al (2014) which shows that prevalence of total difficulties scores among primary school children with learning disabilities was 98.1% abnormal difficulties compared to 79.7% of normal children. Furthermore, the result shows the significant impact of science literacy skills on elementary school children behavioral problems. The result indicated that there is a significant impact of science literacy skills on elementary school children behavioral problems. The analysis of the relationship between science literacy skills and behavioral problems through an ANOVA revealed a significant impact, suggesting that children with higher levels of science literacy tend to exhibit fewer behavioral problems. This relationship is significant because it implies that enhancing science literacy could help mitigate some of the behavioral problems observed in elementary school children. According to research, cognitive engagement with subjects like science fosters a sense of achievement and curiosity, which can positively affect behavior and reduce disruptions in the classroom (Linnenbrink & Pintrich, 2002). Therefore, addressing science literacy may not only improve academic performance but also promote better behavioral outcomes.

The analysis also indicated a significant gender difference in science literacy skills, with males scoring slightly higher than females. This finding resonates with global educational research, which frequently highlights gender disparities in science achievement, often attributing them to social, cultural, and educational factors (Blickenstaff, 2005). While the difference in means was small, it is important to recognize and address gender disparities in science education, as early experiences with science can shape future interests and career choices in STEM fields. The result confirms the result of Murat Gençi (2015) which reveals that In terms of gender of the students, a significant difference emerged after the application, when compared to before the application.

Conclusion

This study's findings underline the significant challenges related to science literacy and behavioral problems among elementary school children. The low levels of science literacy observed, along with the high incidence of behavioral problems, point to the need for urgent interventions to improve both academic and behavioral outcomes for these children. The significant relationship between science literacy and behavioral problems suggests that interventions aimed at enhancing science education may also have the added benefit of reducing behavioral issues, thereby improving the overall learning environment.

Additionally, the gender differences observed in science literacy skills necessitate targeted efforts to promote gender equity in science education, ensuring that both boys and girls have equal opportunities to excel in this crucial area. Future educational reforms should focus on fostering a positive attitude toward science among all students, irrespective of gender, and providing teachers with the necessary tools and support to engage students effectively.

Given the low levels of science literacy among elementary pupils, it is crucial to design and implement more engaging, hands-on science programs that encourage curiosity and critical thinking from an early age. Teachers should be trained to adopt inquiry-based teaching strategies that foster problem-solving and scientific reasoning. Since the findings suggest a link between science literacy and behavioral problems, integrating behavioral management techniques into science teaching could help address disruptive behaviors in the classroom. For example, projects that require teamwork and collaborative problem-solving can help build positive social skills, while science-based activities may keep students engaged and focused. Moreover, to address the observed gender disparity in science literacy, schools should actively encourage female students to pursue science subjects. This could include mentoring programs, female role models in science, and gender-sensitive curricula that break down stereotypes and challenge gendered expectations about scientific ability.

Teachers should be provided with professional development opportunities to enhance their science teaching skills and better manage behavioral issues in the classroom. This may involve training on differentiated instruction, culturally relevant pedagogy, and the use of educational technology to make science more accessible and engaging. Schools should encourage greater parental involvement in supporting children's science education, whether through at-home learning activities or participation in school science fairs and projects. Engaging the broader community in educational activities can create a more supportive environment for science learning. Future studies may explore the specific causes of the low science literacy levels and the high behavioral problems, including an examination of environmental, socio-economic, and cultural factors that may be influencing the results. Longitudinal studies could also help track the impact of science literacy interventions on long-term academic and behavioral outcomes.

Ethics and Conflict of Interest
All ethical rules were observed at all stages of the research. Authors declare that they acted in accordance with ethical rules in all processes of the research. Authors declare that there is no conflict of interest between the authors of this work.

Author Contribution
All authors contributed equally to the research.

Data availability
The data that support the findings of this study are available on request from the corresponding author.

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