SCIENCE PRACTICAL WORK AND ITS IMPACT ON UNDERGRADUATE STUDENTS' CRITICAL THINKING SKILLS IN FEDERAL UNIVERSITY OF KASHERE, GOMBE STATE, NIGERIA

OGUNDARE Samuel Akinola Ph.D[1]
samogundare91@gmail.com
akinola.ogundare@fukashere.edu.ng

IBRAHIM Ahmed Ph.D[2]
ahmadkt21@gmail.com

&

SAGIRUIsa Ph.D[3]
Department of Science Education[1, 2 & 3]
Federal University of Kashere, Gombe State
sagiru5604@gmail.com

Abstract

This quasi-experimental study aimed to assess how practical work impacts the critical thinking skills of undergraduate students in biology and chemistry courses at Federal University of Kashere, Gombe State. Participants were chosen from third-year integrated science education students and divided into control and experimental groups for the chemistry and biology courses. The control groups received traditional science teaching, while the experimental groups engaged in intensive practical activities covering the same content. Both groups underwent pre- and post-tests. The results showed that the experimental groups significantly outperformed the control groups in their scores. Thus, it's recommended that secondary schools provide ample opportunities for students to engage in practical lessons, ensuring that laboratories are well-equipped to support these activities.

Keywords: Integrated science education, Students' critical thinking skills, Practical work, Science instruction.

Introduction

For the past four centuries, educators and researchers have examined the value of practical work in scientific fields like chemistry, biology, and physics. Numerous studies have highlighted the benefits of practical work, including the development of laboratory skills, scientific knowledge, critical thinking, and understanding of scientific concepts and theories (Fadzil & Saat, 2013; Schwichow, Zimmerman, Croker & Härtig, 2016). Practical activities have been shown to foster positive attitudes and enhance motivation for effective learning in science, as noted by Okam and Zakari (2017). The integration of practical activities in science education has been a key research focus due to its potential impact on students' critical thinking skills. Shana and Abulibdeh (2020) conducted a study on the impact of practical work on students' science achievement, finding that practical activities significantly improve students' understanding and engagement in science subjects (Shana & Abulibdeh, 2020).

Laboratories play a crucial role in facilitating practical activities. Practical activities in laboratories aid in distinguishing between observation and data presentation (Hofstein& Kind, 2021). These activities enable students to learn through understanding while actively engaging in the process of constructing knowledge by doing science. However, practical work has been found less effective in helping students connect concepts with their applications in the laboratory and reflect on their collected data (Abrahams & Millar, 2008). The study discovered a lack of evidence that linking concepts to observables is considered in the design of these activities for science lessons. They recommend that students should be mentally prepared before starting any practical work by providing background information on what they are investigating. Additionally, task design should guide students in making connections between the two domains of knowledge. Consequently, science teachers need training based on the latest research to update their practices and invest more time and effort in linking scientific concepts with the natural world (Jokiranta, 2014). Thus, laboratory experiments are crucial in studying all scientific subjects (chemistry, physics, and biology) as they equip learners with critical thinking skills.

Critical thinking boosts students' problem-solving capabilities by enabling them to thoroughly analyze complex issues and devise effective solutions (Walsh, Lewandowski, & Holmes, 2022). This approach is vital for scientific inquiry and research as it encourages a systematic problem-solving method. Additionally, critical thinking fosters creativity and innovation by prompting students to think outside the box and seek unconventional solutions. It also enhances students' analytical skills, as they learn to evaluate data, interpret results, and draw logical conclusions. These skills are essential for conducting experiments, analyzing scientific literature, and making evidence-based decisions.

Nigeria has been actively working to enhance critical thinking skills among science students, focusing on improving their performance in reading, mathematics, and science through active learning techniques (Adamu, 2019). The teaching and learning process is multifaceted, with various factors contributing to its success. One crucial factor is the delivery method and classroom practices employed by the instructor. Chemistry and biology are vital scientific fields that explore the structure, composition, properties, and interactions of matter, helping learners understand the world around them (Okam& Zakari, 2017). However, traditional teaching methods in these subjects have posed challenges to developing students' critical thinking skills.

Conventional teaching methods often fail to engage students and do not effectively promote the development of critical thinking skills necessary for problem-solving (Singer, Hilton & Schweingruber, 2006). During laboratory work, students' discussions mainly focus on the procedures required to conduct the experiment or manage the lab equipment (Russell & Weaver, 2011). The interaction among group members in experimental activities in chemistry and biology significantly influences the quality of the group work, understanding of the experiment, and expected outcomes. It is crucial that each student in group work experiments gets the chance to apply what they've learned to future tasks for problem-solving (Prachagool & Arsaiboon, 2021).According to Piaget (2013), individuals construct increasingly sophisticated representations of the world by acting on their current understanding and thinking skills. If Piaget's theory holds, practical work is vital for understanding sciences and solving problems in general. Dillon (2008) highlights several reasons for integrating practical work in school science subjects: it encourages accurate observations and descriptions, translates theories into real-life applications, maintains students' interest in scientific studies, and promotes logical and reasoning methods of thought.

Feedback from students on laboratory practical activities is a crucial source of insight into critical thinking skills. While laboratory practicals are essential for studying sciences, several issues can arise: lack of necessary materials for experiments, insufficient information for conducting the experiment, inadequate techniques, lack of information about the required glassware and chemicals, insufficient knowledge of safety rules, and lack of guidance on steps to prevent or respond to accidents during experiments (Aydogdu, 2015).

Sotiriou, Bybee, and Bogner (2017) noted that traditional lab work often focuses solely on scientific terminology and allows students to observe only the experimental procedures, following the step-by-step instructions in the lab manual. This approach limits creativity and the development of cognitive skills. If students follow the lab manual without relating it to real-life applications, the methods lose their value. On the other hand, Atik (2021) found that lectures alone, without practicals, made it difficult for students to grasp some scientific concepts. When combining theoretical and practical approaches, students found the material more comprehensible. Therefore, it can be concluded that practical and theoretical delivery in science education are interconnected and essential for effective learning.Therefore, this study investigated Science Practical Activity and its Impact on Undergraduate Students' Critical Thinking Skills in Federal University of Kashere, Gombe State, Nigeria.

Statement of the Research Problem

In today's educational environment, nurturing critical thinking skills among science students is crucial for their academic and professional success. Despite the acknowledged importance of critical thinking in scientific inquiry, practical activities, and problem-solving, many students still struggle with these skills. The traditional teaching methods often fail to engage students in deep analytical thinking, restricting their ability to apply scientific concepts to real-world problems. Hands-on laboratory activities provide active learning opportunities and have the potential to bridge this gap. However, their effectiveness in enhancing critical thinking skills remains underexplored and underutilized in many educational settings. This study aims to examine the impact of practical laboratory activities on developing critical thinking skills among undergraduate science education students, with the goal of identifying best practices and instructional strategies that can improve science education outcomes.The aim of this study is to explore the effects of practical laboratory activities on developing critical thinking skills among undergraduate science education students at Federal University of Kashere, Gombe State, Nigeria. Specifically, the objectives are to: determine the difference in critical thinking skills between students exposed to laboratory practical activities and those taught through conventional lecture methods; examine the difference in critical thinking skills between chemistry and biology students taught using practical activities; and compare the critical thinking skills of chemistry and biology students taught using traditional expository/lecture methods.

Research Questions

Consequently, the current study will be guided by this main research question:

1. What is the difference between the critical thinking skills of science education students taught using practical activity and those taught using traditional expository/lecture?
2. What is the difference between the critical thinking skills of chemistry and biology students taught using practical activities?

Research hypotheses

Ho^1: There is no significant difference between the critical thinking skills of science education students taught using practical activities and those taught using traditional expository/lecture.

Ho^2: There is no significant difference between the critical thinking skills of chemistry and biology students taught using practical activities.

Methodology

A quasi-experimental research design was utilized, conducted in field settings where random assignment is impossible or absent, and typically used to evaluate the effectiveness of a treatment or educational intervention (Price, Jhangiani & Chiang, 2015). Participants were divided into control and experimental groups for chemistry and biology courses in integrated science. A pre-test and post-test instrument assessed the impact of practical work on the critical thinking skills of third-year undergraduate students in these science courses. The participants, all registered for chemistry and biology in the integrated science program, were divided into two groups of 42 students each. Prior to the intervention, all students were pre-tested to determine their level of critical thinking skills, ensuring the two groups had similar academic levels and pre-test scores. Over five weeks, the control group was taught using traditional methods, while the experimental group received intensive practical instruction, with all teaching hours conducted in the laboratory. After the intervention, a post-test measured the acquisition of critical thinking skills. The collected data was statistically analyzed to identify any significant differences in skill acquisition mean scores between the control and experimental groups.

A primary instrument was developed, validated, and utilized for data collection, called the Student Critical Thinking Skills Test (SCTST, r = 0.79). It was designed to assess the critical thinking skills of participants in 300-level integrated science education courses (biology and chemistry). To ensure content validity, the instrument's items were reviewed by two lecturers in the science education department who evaluated the appropriateness and relevance of each item to the skills being measured. The instrument was refined based on their feedback. This instrument assessed skills across different stages of lab activities: pre-lab (hypothesis and planning), during lab (observation and analysis), and post-lab reflection (results and interpretations, application and connection, critical thinking and problem-solving, personal learning, and development). Each task involved hands-on activities applied to students individually, with a total obtainable score of 80. The Kuder-Richardson 21 measure was used to determine the reliability of SCTST, yielding an alpha value of 0.79. After the intervention, a post-test measured the students' acquisition of critical thinking skills. Data collected were analyzed using mean, standard deviation, and inferential statistics like Analysis of Covariance (ANCOVA) to identify significant differences between the groups.

Results

Research Question One: What is the difference between the critical thinking skills of science education students taught using practical activity and those taught using traditional expository/lecture?

Table 1: Mean Critical Thinking Skills Scores of Undergraduate Integrated Education Students exposed to Laboratory Practical Activities and Lecture Expository/Lecture

Group	N	Std. Deviation	Mean	Mean difference
Laboratory Practical Activities	42	5.764	65.57	14.93
Conventional lecture method	42	4.967	50.64	
Total	84	9.219	58.11	

Table 1: shows the mean critical thinking skills of students exposed to laboratory practical activities and lecture expository method as 65.57 and 50.64 respectively. The laboratory practical activities approach had highest mean score of 65.57 followed by lecture expository method with 50.64 with mean difference of 14.93. This shows that the laboratory practical activities facilitates students' critical thinking skills better than lecture expository method in integrated science education biology and chemistry courses.

Research Hypotheses

HO[1]: There is no significant difference between the critical thinking skills of science education students taught using laboratory practical activities and those taught using traditional expository/lecture.

HO[2]: There is no significant difference between the critical thinking skills of chemistry and Biology students taught using laboratory practical activities.

HO[3]: There is no significant difference between the critical thinking skills of chemistry and Biology taught using traditional expository/lecture.

Table 2: Summary of 2x2 Univariate ANCOVA of Post-test Critical Thinking Skills Scores by Treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4680.486[a]	2	2340.243	79.863	.000	.664
Intercept	9956.418	1	9956.418	339.774	.000	.807
Pret-chem & bio.	.379	1	.379	.013	.910	.000
Group	4295.081	1	4295.081	146.574	.000	.644
Error	2373.550	81	29.303			
Total	290675.000	84				
Corrected Total	7054.036	83				

a. R Squared = .664 (Adjusted R Squared = .655)

The ANCOVA results showed a significant difference between the critical thinking skills of students taught science using practical activities and those taught using traditional expository/lecture ($F_{(1,81)} = 146.574$, $P < .05$), $\eta^2 = 0.644$. Treatment accounted for 64.4% variation of students' critical thinking skills in undergraduate integrated science courses examined. This was obtained by simply multiplying 0.644 by 100. Hence, hypothesis 1 is rejected.

Second and third research hypotheses is explained in Table 3.

Table 3: Summary of 2x2 Univariate ANCOVA of Post-test Critical Thinking Scores of
Participants by Treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4725.833[a]	4	1181.458	40.089	.000	.670
Intercept	7839.510	1	7839.510	266.008	.000	.771
Pretes-chem & Biology	3.032	1	3.032	.103	.749	.001
Posttest chemistry	45.106	1	45.106	1.531	.220	.019
Posttest Biology	2.182	1	2.182	.074	.786	.001
Group	4053.738	1	4053.738	137.550	.000	.635
Error	2328.202	79	29.471			
Total	290675.000	84				
Corrected Total	7054.036	83				

a. R Squared = .670 (Adjusted R Squared = .653)

The ANCOVA results (Table 3) showed that there is no significant group-subject interaction effects ($F_{(1,79)} = 1.531$, $P < .05$), $\eta^2 = 0.019$ for chemistry group. ($F_{(1,79)} = .074$, $P < .05$), $\eta^2 = 0.001$ for biology group respectively. This means that critical thinking skills scores of students in biology and chemistry is consistent within control and experimental groups. Therefore, the hypothesis is not rejected.

Discussion of Findings

The study's results indicate a positive correlation between practical work and the critical thinking skills of students in integrated science courses. These findings align with previous research by Walsh, Lewandowski, and Holmes (2022), which showed that experimental groups had significantly better critical thinking skills, particularly when engaging in hands-on laboratory activities. Educators are encouraged to create more active learning environments for students. Additional studies, such as those by Shana and Abulibdeh (2020), also emphasize the importance of laboratory work in fostering critical thinking skills. However, Hofstein & Kind (2021) pointed out that some teachers have reservations about laboratory work, citing issues like a lack of materials, insufficient information, inadequate techniques, and safety concerns. The current study's researchers recognize these challenges and suggest that they should be addressed by teachers and school administrators to maximize the benefits of practical work in developing students' critical thinking skills.

Conclusion

The study validated the fact that laboratory practical activities developed better critical thinking skills in students than the traditional lecture teacher-centred activities. The reason for this was that learners exposed to laboratory practical activities were able to carry out experiments practically by themselves, verifying science principles, concepts theories, among others. The total score of the skills improved as well as the scores for each individual skill such as observing, classifying and measuring. However, the learners still have challenges in the classification of objects, recording data, calculation of analysing of data collected and other issues during the study. Therefore, they needed more practices of lab work consistently to develop these skills. These might be the reasons for the low critical thinking skills exhibited by some students' during some laboratory practical sections.

Recommendations

The researchers recommend that practical work be provided for most of the concepts in chemistry and biology courses in undergraduate integrated science, as they are considered an applied science. Some concepts cannot be understood if not applied practically. In addition to this, some concepts cannot be applied, thus, more research is needed to simplify science concepts in general and make chemistry and biology easier and more exciting subjects in particular. This can help students become motivated, work harder and understand chemistry and biology better.

To ensure the success of practical work, the researchers recommend that the administration of schools supply their schools with all necessary equipment, glassware, and chemicals needed to facilitate the practical work for most topics in chemistry and biology.

Finally, the researchers find it vital to allow students to design some of their own experiments (student centered activity) as this ensures they do not just follow instructions from teachers.

Teacher-centered instruction can be boring for students and can affect the benefits of practical work;thus, the researchers recommend that further studies examine the impact of this method on the efficacy of practical work.

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