Real-Time Artificial Intelligence (AI) Monitoring as Correlates of Safety Practices and Laboratory Management Effectiveness in Science Laboratories Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State

By

Elom Christian Nnanna, Abonyi Sunday Okechukwu, Agu Chinomso Nnanyere, Nwofe Lucy Lynda & Akpu Chikaodili Francisca

Department of Science Education, Faculty of Education Alex Ekwueme Federal University Ndufu Alike, Ebonyi State
Corresponding Author: chriselona82@gmail.com, 08037796586

Abstract

The study adopted a correlational research design aimed at investigating the relationship between real-time artificial intelligence (AI) monitoring and safety practices as well as laboratory management effectiveness in science laboratories at Alex Ekwueme Federal University Ndufu Alike (AEFUNAI), Ebonyi State. The total population of the study was 235 technologists. 200 Participants were selected from the population as a sample size using the purposive sampling technique. Data were collected using a structured questionnaire developed by the researchers, and was validated by the experts in science education department. Two research questions and corresponding null hypotheses guided the study. Trial testing of the instrument was carried out on 30 technologists of another institution using Cronbach' Alpha test statistic, a reliability estimate of 0.81 was obtained. Data were analyzed using mean and standard deviation to answer research questions while hypotheses were tested using Pearson product moment correlation to determine their level of significance. The result of the findings showed that a real-time artificial intelligence monitoring established a positive significant relationship with safety practices and laboratory management effectiveness. The result further showed that AI monitoring reduces response time to safety risks, improves laboratory safety protocols, and enhances overall learning experiences by creating a safer and more organized environment. The study concludes that real-time AI has stronger potential to transform laboratory management in science laboratories by minimizing risks through prompt detection of hazards. The adoption of AI-driven laboratory systems is recommended as a suitable solution for improving safety and management effectiveness in AEFUNAI science laboratories.

Keywords: Laboratory Management, Real-Time Artificial Intelligence Monitoring, Safety Practices, Science Laboratories.

Introduction

Science education is not only to teach scientific knowledge but also to develop a scientifically literate people capable of engaging seriously in critical thinking and decision-making (Almasri, 2021; Grinnell, 2021). This aligns with the "Science for All" emancipation, emphasizing the importance of science education for all students, irrespective of the careers they are pursuing (Almasri; Hewapathirana; Alhashem; Daniel & Lee, 2022; Mansour, 2009). Scientific literacy and critical thinking abilities are developed by the students through the teaching and learning of scientific theories, procedures, and experiments in science classes (Alharbi; Elfekv & Ahmed, 2022; Liu & Pásztor, 2022; Mogea, 2022; Zulyusri; Elfira; Lufri & Santosa, 2023). The nature of science class goes beyond content-based instruction to include student-centered activities and laboratory work (Almasri, 2021; Irez, 2006, Kolstø, 2001). Science laboratories are useful for teaching and learning.

Despite transformation in laboratory equipment and curriculum reform, safety concerns have continued to persist in science laboratories in Nigerian universities including Alex Ekwueme Federal University Ndufu-Alike (AE-FUNAI), Ebonyi state. This is as a result of infrastructural decay, human errors, and administrative gaps that expose students, staff, and the environment to hazards. Most Nigeria university laboratories lack basic safety facilities like functional fume hoods, fire extinguishers, eye wash stations, first aid boxes, and proper ventilation systems, but where they are existed it is either outdated or non-functional (Adeyemi & Oloruntoba, 2020). Studies have shown poor compliance from students, laboratory technologists, and teachers with standard safety practices (Owolabi & Okoro, 2021). Owolabi et al continue saying those students and other laboratory users often seen working in the laboratory without lab coats, hand gloves, goggles, and nose masks, increase their risk to chemical burns, inhalation and infections. There is limited pre-laboratory safety training for students; as a result many get to the laboratory without appropriate orientation on hazard identification, chemical handling, and emergency protocols (Nwosu & Eze, 2019). Again, overcrowding of the laboratory space, poor waste disposal, improper chemical storage, and lack of standard operating procedures were all contributing factors to safety problems (Idris & Musa, 2022). Reports from literature reveal cases of chemical spills, fire outbreaks, gas explosions, and cuts from broken glassware which often leads to injuries, loss of equipment, and disruption of academic activities in Nigerian university laboratories (Bello, Ibrahim & Danjuma, 2023). Absence of real-time AI monitoring makes it difficult to enforce safety protocols during practical classes.

These persistent gaps explain why the researchers sought to determine the relationship between real-time artificial intelligence monitoring and safety practice as well as laboratory management effectiveness. Real- time artificial intelligence (AI) monitoring refers to the frequent use of automated AI-powered systems such as computer vision, sensors, and machine learning algorithms to detect, and respond to safety-related events in a laboratory environment as they occur without human help (Zhang, Kumar & Osei, 2021). AI systems can provide 24 hours surveillance, detect personal protective equipment (PPE) non-compliance, and alert laboratory managers immediately, thereby filling the human and infrastructural gaps currently affecting

safety and laboratory management effectiveness (Gao & Chen, 2022). Artificial intelligence (AI) applications are gradually taking its shape in science laboratories due to its capacity to simulate scientific experiments and provide virtual laboratory experiences to science learners as well as its ability to detect hazards. This gives hope that students can practice and develop their scientific skills in a safe and organized environment, potentially saving expenses and offering new opportunities for exploring scientific concepts that may not be feasible in traditional laboratory settings (Wahyono; Fadlika; Asfani; Putranto; Hammad & Sunarti, 2019). However, these virtual experiences may lack the critical thinking and hands-on aspects of interaction with the physical world (Tang & Cooper, 2024).

This work explores the application of real-time artificial intelligence (AI) as an innovative approach to enhancing laboratory management and safety in science class environments. AI can automatically adapt to changing conditions and make decisions on the fly. The study emphasizes an AI-driven laboratory that integrates real-time data collection, intelligent monitoring, and automated decision-making to improve safety compliance and operational efficiency. Artificial Intelligence (AI) is a wide field in connection with various technologies that have been developed over the years to help machines perform tasks ordinarily meant for human intelligence, such as quick response to hazards and laboratory management (Firas, 2024). However, the latest advancements in generative AI, for instance models like ChatGPT, have brought individual attention to AI's transformative potential across sectors (Hong; Dou & Chem, 2022). As predictive (pre-generative) AI focuses on predictions and decision-making through a variety of machine learning and modeling techniques, generative AI specializes in creating new content, such as text, images, and codes by using models of deep learning (Dai, 2023; Tang & Cooper, 2024). The real-time AI helps to monitor laboratory conditions such as chemical handling, equipment usage, state of the environment, and student behavior. This is done by AI through the use of sensors, computer vision, and machine learning algorithms. The sensors used by AI in laboratories monitoring are smoke sensors and combustible gas sensor basically for detecting fire hazards and gas leakage risks in time (Zhu; Bian & Gao, 2025). The AI system generates immediate alerts for unsafe practices, predicts potential hazards, and supports lab technologists/teachers with data-driven insights for proactive action. The AI is currently in a high rate transforming laboratory management, using the advantages of technological advancement to introduce automation, enhance efficiency, and enable more informed decision-making (Eynav, 2026). Globally, the move towards utilization of AI technologies is attracting more productivity, innovation, and scientific excellence in laboratories. AI-driven laboratories help lab technologists to maintain an uninterrupted experiment flow, and minimize time from manual monitoring for strategic pursuits, particularly in lab inventory management (Eynav, 2026). The use of AI in education is transforming various dimensions of the education system, thereby plays an active role in the progression of science education (Firas, 2024). The application of AI in science teaching and learning is becoming more popular, and its interest is geometrically increasing (Chiu; Xia; Zhou; Chai & Cheng, 2023).

In this era of digital transformation, laboratory activities are the major parts of teaching and learning in science education. The traditional laboratory management systems always encounter problems related to safety enforcement/compliance, resource monitoring, human error, and delayed response to hazards. These problems are more noticed in educational laboratories where the class size is very high with little supervision thereby creating chances to increase the risk of accidents and inefficiencies. Laboratories are mainly risky working area, which contains a lot of toxic, flammable, corrosive or reactive compounds (Ezeliora, 2001). Ezeliora continued, saying that many laboratory reagents are poisonous and should be carefully attended as such. If the real threats in the laboratories are noticed and prompt actions taken, there is no excuse why it will not be safe as any other place of service. Safety in university laboratory became needful especially in this modern age where technology has contributed a lot for the development of humans as well as our society. However, there was limited research on AI monitoring role in laboratory safety and management in Nigerian universities including AE-FUNAI. It was on this background that the researchers want to investigate the relationship between real-time AI monitoring, and safety practices as well as lab management effectiveness in science laboratories, Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State.

Purpose of the Study

The general purpose of this study is to investigate the relationship between real-time artificial intelligence (AI) monitoring and safety practices and laboratory management effectiveness in science laboratories at Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State. Specifically, the study sought to:

1. Determine the relationship between real-time AI monitoring and laboratory safety practices.
2. Ascertain the relationship between real-time AI monitoring and laboratory management effectiveness.

Research Questions

1. What is the relationship between real-time AI monitoring and laboratory safety practices?
2. What is the relationship between real-time AI monitoring and laboratory management effectiveness?

Hypotheses

HO_1: There is no significant relationship between real-time AI monitoring and laboratory safety practices.

HO_2: There is no significant relationship between real-time AI monitoring and laboratory management effectiveness.

Methodology

This study adopted a Correlational research design to explore the relationship between real-time AI monitoring, and safety practices as well as lab management effectiveness in science laboratories, AEFUNAI. The population comprised 235 laboratory technologists, in AEFUNAI. A sample size of 200 laboratory technologists was selected using purposive sampling technique. Purposive sampling technique was used to select those technologists who have more experience on laboratory activities and can as well provide relevant information on real-time AI monitoring,

safety practices and laboratory management effectiveness. The participation of laboratory technologists on answering online or hard copies of research questionnaire was voluntarily and based on informed consent. Data were collected using a structured questionnaire on real-time AI monitoring, safety practices and laboratory management effectiveness, developed by the researchers, and was validated by experts in science education as well as measurement and evaluation. Reliability was established through a trial testing of the instrument on 30 technologists from another university using cronbach's alpha test statistic, yielding coefficients of 0.81. The instrument consisted of four sections: demographic information, real-time AI monitoring practices have 5- item, laboratory safety practices have 5-item, and laboratory management effectiveness contains 5-item questions. Responses were measured on a 4points liket-scale ranging from strongly agree (SA) =4, Agree (A) =3, Disagree (D) =2, and Strongly Disagree (SD) =1 with 2.5 as accepted benchmark. After obtaining institutional approval and participants consents obtained, copies of the questionnaire were administered physically (hard copies) and electronically (soft copies) to participants by the researchers and with one trained research assistant. All completed copies of the questionnaire were retrieved, coded and prepared for analysis while non completed copies were not retrieved nor used. Data were analyzed using mean and standard deviation for research questions, and hypotheses were tested using Pearson product-moment correlation at the 0.05 level of significance. This was done to determine the relationship between real-time AI monitoring and safety practices as well as laboratory management effectiveness.

Results

Research Questions

1. What is the relationship between real-time AI monitoring and laboratory safety practices?

Table 1: Mean and Standard Deviation Scores on Real-Time AI Monitoring and Laboratory Safety Practices

Variables	N	Mean	SD
Real-time AI Monitoring	200	12.55	0.325
Lab Safety Practice	200	10.20	0.533

Table 1 shows the technologists' mean and standard deviation responses on real-time AI monitoring and laboratory safety practices. Table shows that the technologists' responses on real-time AI monitoring is high with a total mean of 12.55 and standard deviation of 0.325, which is greater than the mean benchmark of 2.50 set for the study. Table shows further that the technologists' mean and standard deviation responses on laboratory safety practices were also high with a mean of 10.20 and standard deviation of 0.533. However, the table could not establish any relationship between the technologists' response on real-time AI monitoring and laboratory safety practices. The results were therefore, subjected to correlation test of hypothesis 1 to determine the relationship between real-time AI monitoring and laboratory safety practices.

2. What is the relationship between real-time AI monitoring and laboratory management effectiveness?

Table 2: Mean and Standard Deviation Scores on Real-time AI Monitoring and Laboratory Management Effectiveness.

Variable	N	Mean	SD
Real-time AI Monitoring	200	11.24	0.532
Lab Management Effectiveness	200	10.30	0.432

Table 2 shows the technologists' mean and standard deviation responses on real-time AI monitoring and laboratory management effectiveness. The table shows that the technologists' responses on real-time AI monitoring are high, with a total mean of 11.24 and a standard deviation of 0.532, which is greater than the mean benchmark of 2.50 set for the study. The table shows further that the technologists' mean and standard deviation responses on laboratory management effectiveness were also high, with a mean of 10.30 and a standard deviation of 0.432. However, the table could not establish any relationship between the technologists' responses on real-time AI monitoring and laboratory management effectiveness. The results were therefore subjected to a correlation test of hypothesis 2 to determine the relationship between real-time AI monitoring and laboratory management effectiveness.

Hypotheses

HO_1: There is no significant relationship between real-time AI monitoring and laboratory safety practices.

Table 3: Pearson Product Moment Correlation of Real-time AI Monitoring and Laboratory Safety Practices.

Variables	N	Mean	SD	r	Sig. (2-tailed)
Real-time AI Monitoring	200	12.55	0.325		
				0.542	0.019
Lab Safety Practice	200	10.20	0.533		

Result is significant at P< 0.05

Table 3 shows the summary of Pearson's product moment correlation statistics to determine the relationship between real-time AI monitoring and laboratory safety practices. The result reveals that the correlation (r) obtained was 0.542 with a sig. (2-tailed) p value of 0.019. This result means that r was significant (r= 0.542, P=0.019< 0.05). This implies that the null hypothesis 1 which states that there is no significant relationship between real-time AI monitoring and laboratory safety practices was therefore, rejected. The study established that there is significant relationship between real-time AI monitoring and laboratory safety practice. The study also revealed that real-time AI monitoring is highly effective for lab safety detection having a mean

of 12.55. This implies that real-time artificial intelligence monitoring improves laboratory safety protocols, and enhances overall learning experiences by creating a safer and more organized environment. Therefore, the study established a positive relationship between real-time AI monitoring and laboratory safety practice.

$H0_2$: There is no significant relationship between real-time AI monitoring and laboratory management effectiveness.

Table 4: Pearson Product Moment Correlation of Real-time AI Monitoring and Laboratory Management Effectiveness.

Variable	N	Mean	SD	r	Sig. (2-tailed)
Real-time AI Monitoring	200	11.24	0.532	0.622	0.024
Lab Mgt Effectiveness	200	10.30	0.432		

The result is significant at P<0.05

Table 4 shows the summary of Pearson's product moment correlation statistics to determine the relationship between real-time AI monitoring and laboratory management effectiveness. The result reveals that the correlation (r) obtained was 0.622 with a sig. (2 tailed) p value of 0.024. This result means ''r'' was significant (r=0.622, p=0.024< 0.05). This implies that the null hypothesis 2 which states that there is no significant relationship between real-time AI monitoring and laboratory management effectiveness was therefore, rejected. The study established that there is significant relationship between real-time AI monitoring and laboratory management effectiveness. The study also revealed that real-time AI monitoring is highly effective for laboratory management having a mean of 11.24. This implies that real-time artificial intelligence based on laboratory management significantly reduces response time to safety risks and enhances efficiency for lab management.

Discussion of the findings

The discussion of the findings was based on two research questions and corresponding null hypotheses that guided the study.

The results of this study as presented in table 1 shows technologists' high mean response, but the table could not establish any relationship between the technologists' response on real-time AI monitoring and laboratory safety practices. The results were therefore, subjected to correlation test of hypothesis 1 to determine the relationship between real-time AI monitoring and laboratory safety practices. Table 2 result also shows technologists' high mean response but could not establish any relationship between the technologists' response on real-time AI monitoring and laboratory management effectiveness, and equally subjected to correlation test of hypothesis 2. The result of table 3 shows that there is a statistically significant relationship between real-time AI monitoring and laboratory safety practice in science laboratories in Alex Ekwueme Federal University Ndufu-Alike (aefunai) in Ebonyi State. The study revealed that real-time AI monitoring is highly effective for lab safety detection. This study is consistent with Zhu; Bian & Gao (2025), who discovered that integrating real-time AI monitoring in laboratory environment

will ensure rapid emergency response to safety and improve the overall safety management level. Ali, (2022), supported the findings saying real-time AI monitoring enhances lab safety awareness. The result is also in line with Sharma, (2024), who in his study highlighted the role of real-time monitoring in enhancing industrial automation and safety.

The result in table 4 shows that there is significant relationship between real-time AI monitoring and laboratory management effectiveness. The study also revealed that real-time AI monitoring is highly effective for laboratory management having a mean of 11.24. The findings are consistent with the result of Zhu; Bian & Gao (2025), who discovered that AI can be applied in monitoring equipment and personnel by image recognition as well as environment by sensors, building an intelligence early warning, and emergence response system to improve the efficiency of laboratory management. The findings of this study is similar with Sharma, (2024) who revealed how the real time AI monitoring has shown significant effectiveness in enhancing safety and management efficiency across various industries. The finding is also in line with Lauren (2025), who revealed that Labs without real time monitoring face more downtime and inefficiencies. Johnson and Lee (2023) also supported the findings; their work revealed that AI Monitoring correlates with improved safety practices and management effectiveness in labs. The result is also in line with Smith, Brown & Davis (2022), who revealed that Real-Time AI has shown to enhance lab management efficiency. Smith, et al continuing saying that AI-driven monitoring systems can predict and prevent lab incidents, streamlining management processes.

Conclusion

This study focuses on investigating the relationship between real-time AI monitoring and safety practices as well as lab management effectiveness in science laboratories, Alex Ekwueme Federal University Ndufu-Alike (AEFUNAI), Ebonyi State. The problems encountered by traditional laboratory management systems such as those related to safety enforcement, resource monitoring, human errors, and delayed response to hazards, becomes the things of the past with real time AI monitoring integration. The real-time artificial intelligence monitoring has stronger potential to transform laboratory management in science laboratories by minimizing risks, optimizing resource utilization, and supporting technologists in maintaining high safety standards. Real-time AI has shown significant effectiveness in enhancing safety and management efficiency across all laboratories.

Recommendations

The researchers make the following recommendations:

1. Educational institutions should adopt AI-driven laboratory systems to improve safety practices and laboratory management effectiveness in various laboratories.
2. There should be regular training of Laboratory technologists on AI application.
3. The school management of AEFUNAI should install real time AI powered systems in her various laboratories for quick detection of anomalies/hazards.

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