International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Green Science in the Lab: An Assessment-Based Proposal for Practice Refinement

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Abstract

This research on Green Science in the Lab: An Assessment-Based Proposal for Practice Refinement has objectives to reduce risks from toxic chemicals and complicated laboratory procedures, increase profits by reducing operating costs, and enhance learning and practices regarding environmental protection. Different colleges at Centro Escolar University Makati Campus—comprising Psychology, Medical Technology, Dentistry, Nursing, and Pharmacy—assessed science laboratory practices in terms of health hazards and challenges associated with waste management; the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of environmental sustainability, enhanced learning outcomes, improved waste management, and regulatory compliance; and the extent to which sustainable laboratory practices, if incorporated into the revised manual, can reduce operational costs, minimize environmental impact, and improve student safety.

There is a significant and strong relationship between the respondents' assessments regarding science laboratory practices and the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction, as shown by the Pearson R test. The test also indicates a significant relationship between respondents' assessments of the potential benefits of integrating greener materials and safer experimental procedures and the extent to which sustainable laboratory practices, if incorporated into the revised manual, can be applied. This result emphasizes the important role of sustainable laboratory practices in fostering safer, more efficient, and environmentally responsible science education.

Keywords: Green Science, Sustainable Laboratory Practices, Environmental Impact

Introduction

Green Science laboratories are research facilities whose operations prioritize environmental friendliness and sustainability. Such facilities try to reduce their environmental impact by implementing sustainable practices, such as using energy-efficient equipment, reducing waste, and encouraging recycling. Green Science laboratories serve as models for other industries to adopt sustainable efforts and reduce their environmental impact, all while improving lab workers' health and safety. Green Science laboratories actions are critical for reducing the negative impact of scientific research.

Green Science laboratories strive to develop environmentally friendly technologies and solutions that can be used indefinitely, while also encouraging innovation and educating teachers and students on how to perform experiments in an environmentally friendly manner. Eco-conscious labs can contribute to a more sustainable future by sharing and promoting sustainable practices, as well as reducing the environmental impact of scientific research (Gawkowski, 2024).

The first advantage is contributing to a healthier planet. Green Science laboratories can, however, also benefit financially by reducing waste and energy costs, as well as attracting environmentally conscious teachers and students. Going green, on the other hand, can results in benefits such as lower energy costs, improved health and safety for lab workers (everyone who performs experiments, assists and prepares the chemical for the experiments), and a positive impact on the environment.

In addition, implementing environmentally conscious practices can help the laboratory's reputation and attract environmentally conscious students. Furthermore, greening up your lab can also increase the efficiency of laboratory processes and reduce waste generation, leading to cost savings in the long run. Adopting eco-friendly practices can also help labs comply with environmental regulations and avoid penalties.

Another advantage of conducting business in an environmentally friendly manner is that it can contribute to overall efforts to reduce carbon footprint and combat climate change, which is a global concern that affects everyone. Therefore, laboratories need to prioritize sustainability in their operations and contribute to a healthier planet. By demonstrating a commitment to sustainability, labs can differentiate themselves from competitors. Overall, prioritizing sustainability not only benefits the environment but also has practical and strategic advantages for laboratories.

Background of the Study

The current laboratory practices are without a doubt proven to be a very effective way of rediscovering and creating new knowledge. Modern facilities and equipment were given room for improvement but there are still many customary processes that need enhancement in order to fully achieve more appropriate approaches as required by today's situation without compromising the learning outcomes. The use of old procedures that require limited resources of chemicals and of very high value can be duplicated with cheaper and readily available chemicals. Also, the use of aged method that use toxic chemicals can be replaced with non-toxic substitutes. Aforesaid lab processes can now be reproduced with safer and more environmentally friendly methods.

Benchmarking from other universities and different sources show that turning the usual laboratory activities into green lab practices can reduce operational expenses by 30 – 70% depending on the laboratory experiment performed. As the source of waste is reduced, other associated costs and impacts will also decrease.

Organizational Impact

The Green Science Lab Program provides the university with an opportunity to develop existing laboratory practices to enhance students' learning experiences. As a leading higher education institution, this innovative undertaking will also help validate the university's mission in environmental protection.

Necessary enhancements to current laboratory practices, such as revising laboratory manuals, fostering a culture of sustainability, transforming accustomed practices, and others, will be major outcomes of this sustainability program.

The full support and involvement of Science Laboratory stakeholders, especially academic heads, teaching staff, and support staff, are essential to making this project a reality. Therefore, providing training will be required to successfully accomplish the goals of this project. Training in different areas of Green Science

Lab, such as Green Chemistry, Microscale Chemistry, Lab Sustainability, and benchmarking, should be conducted to fully equip them.

Business Impact

Moving to environmentally friendly experiments results in a reduced quantity of laboratory materials, thus less hazardous by-products/generated waste. Smaller-scale experiments require a shorter process, which leads to lower energy consumption and use of other resources (water, energy, etc.), and as a result, lower expenses for the institution. Similarly, the innovation of laboratory mechanisms that can be replicated and digitization of laboratory forms and other pertinent documents could also save costs.
With the transition to micro-scale experiments, there is a need to purchase glassware kits in order to make this possible. The price of glassware used in microscale experiments is usually ten times higher compared to that used in traditional laboratories. However, this initial investment can last for years, as the small and durable glassware rarely needs replacement because research shows that students handle it more carefully. Smaller glassware is also harder to break because of its smaller size and mass.

Process Impact

The application of sustainable practices greatly impacts not only science laboratory procedures but also the university as a whole. From curriculum development to the disposal of laboratory waste, all processes shall be considered for modification due to the scope of the improvement project.
Since it is suggested that this project improvement proposal will be piloted at CEU – Makati, the proposed program shall be presented to the Academic Heads of the campus for recommendation to the Office of the VP for Academic Affairs. With the approval of Academic Affairs, the laboratory subjects for implementing the program shall be identified. Teachers/authors of lab manuals for the identified laboratory subjects will undergo training regarding the Green Science Lab Program for evaluation and/or revision of the manuals.

Objectives

There are three main solution objectives of this project proposal. They are:
1. Safe – reduced risks from toxic chemicals and complicated procedures.
2. Save – increased profits by reducing operating costs.
3. Secure – enhanced learning and practices regarding environmental protection.

With these three excellent solutions, benefits in terms of cost savings and foregone expenses are inevitable. With reduced chemical usage, increased energy efficiency, and less hazardous waste generation, significant resources can be redirected to other needs. Saved resources can be channeled to the betterment of facilities and equipment. The removal of health and safety hazards strengthens safety measures, avoids pollution and harm to the environment, and lowers the risks associated with the collection of hazardous waste (chemical spills/explosions).

Statement of the Problem

Traditional laboratory practices, while effective in knowledge discovery and scientific learning, often involve hazardous chemicals, high energy consumption, and costly operational procedures.
These factors contribute to increased institutional expenses, environmental degradation, and heightened safety risks for laboratory workers. Despite advancements in laboratory equipment and facilities, many

outdated methods remain in use, necessitating improvements that align with modern sustainability and safety standards.

This study seeks to address the challenges associated with conventional laboratory practices by exploring the implementation of Green Science in the Lab.

Specifically, it aims to:

1. What is the assessment of the respondents on the science laboratory practices in terms of:

1.1 Health hazards

1.2 Challenges associated with waste management?

2. What is the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of:

2.1 Environmental Sustainability

2.2 Enhanced Learning Outcomes

2.3 Improved waste management

2.4 Regulatory Compliance?

3. What is the extent to which sustainable laboratory practices, if incorporated into the revised manual in terms of

3.1 Reduce operational costs

3.2 Minimize environmental impact

3.3 Improved Student Safety?

4. Is there a significant relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction?
5. Is there a significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices, if incorporated into the revised manual?
6. Promote the adoption of environmentally responsible laboratory practices as an integral part of the learning process, cultivating students' and teachers' awareness, engagement, and accountability toward sustainability.

Hypothesis

1. There is no significant relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction.
2. There is no significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices, if incorporated into the revised manual.

Research Design

This study used quantitative descriptive design describing the assessment of the respondents on the conventional laboratory procedure in terms of health hazards and waste management challenges, potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of the use of less hazardous materials and improved waste management. It will determine if there is significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices, if incorporated into the revised manual and the extent to which sustainable laboratory practices, current laboratory manual, and how the adoption of environmentally responsible laboratory practices may foster greater awareness and accountability toward sustainability.

Locale of Study

The study was conducted in Centro Escolar University in Makati Campus. Centro Escolar University Makati is a satellite campus of the Centro Escolar University in Manila. Located in the Makati Central Business District, CEU's first Makati campus building is housed in the Phil trust Bank Building along Sen. Gil Puyat Sr. Avenue. The science course is taken here. The campus consists of air-conditioned classrooms, laboratories, a library and lecture halls equipped with audio-visual facilities, and a car park. It also houses the CEU School of Law and Jurisprudence which was established last 2009. The Centro Escolar University Makati Legaspi Village Unit is located at Legaspi Village along Esteban-Bolaños Streets as the extension to the Gil Puyat Unit. The non- science and the Doctor of Dental Medicine courses are located here. This building consists of air-conditioned classrooms, computer laboratories, and a library with audio-visual facilities. The new addition is the dental facility inside the building.

Participants of the Study

Target respondents in this study are the Science Laboratory teachers and 1st year students who are presently enrolled in academic year 2024-2025. The following courses were all included as participants of the study BS Medtech, BS Nursing (non-STEM), BS Nursing (STEM), BS Pharmacy, BS Psychology and BS Dentistry. Population and Sampling Techniques The total population of First year presently enrolled during academic year 2024- 2025 was five hundred eighty-seven (587), using Slovin's Formula the total sample of two hundred thirty-eight (238) were obtained.

Research Instruments

The research instrument was self-made checklist survey questionnaire. The research instrument has two parts. The first part was the profile of the respondents in terms of designation as student, teacher or laboratory staff. The second part was self-assessment which is composed of three (3) category a) Respondents assessment on the conventional laboratory procedures in terms of: health hazards and challenges associated with waste management, b) Respondents assessment on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of using less hazardous materials and improved waste management and c) assessment on the extent to which sustainable laboratory practices, if incorporated into the revised manual in terms of reduce operational costs and minimize environmental impact. The respondents have to rate using the Likert scale 4 point (4-strongly agree, 3- agree, 2-disagree and 1-strongly disagree). The following arbitrary scale will be used to better interpret the findings and results.

Result and Discussion

The results of the study interpretation of the data gathered and implication about the assessment on Green Science in the laboratory that will be the basis for proposal for practice refinement.

Health hazards

The over-all weighted mean for students and faculty were 3.57, faculty and laboratory staff were 3.67 both with verbal interpretation strongly agree. It implies that the assessment of the respondents on the Science laboratory practices in terms health hazards was strongly agree which mean continually using chemicals that are corrosive and toxic in the laboratory practices will affect their health. There is a need to explore corrosion mitigation techniques. Green corrosion inhibitors made from organic materials like plant extracts have been developed as a sustainable and environmentally friendly alternative. Thiophene, hydrazine, inorganic compounds such as phosphates, chromates, and dichromates, as well as silicates, borates, tungstates, molybdates, pyrrole compounds, arsenates, and chromium (VI), are among the most potent corrosion inhibitors currently in use. Due to their toxicity and lack of environmental friendliness, they threaten the environment and public health. (Holla et al., 2024).

Table 1. Assessment of the Respondents on the Science laboratory Practices in terms Health hazards

	Student		Teacher/Staff	
Health Hazards	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Chemical burns from corrosive substances like acids or alkalis damages skin and eye tissue upon contact.	3.68	Strongly Agree	3.92	Strongly Agree
Toxic inhalation of hazardous vapors (e.g., formaldehyde, solvents) leads to respiratory distress or chronic lung conditions.	3.63	Strongly Agree	3.92	Strongly Agree
Biological infections result from exposure to viruses, bacteria, or fungi, particularly when handling body fluids or cultured pathogens.	3.61	Strongly Agree	3.83	Strongly Agree
Burns are caused by Bunsen burners, hot plates, furnace and oven	3.51	Strongly Agree	3.42	Strongly Agree
Cuts/lacerations are from broken glassware or mishandled sharp instruments during sample preparation.	3.53	Strongly Agree	3.67	Strongly Agree
Allergic reactions are triggered by latex gloves, chemical sensitizers, or airborne particulates.	3.46	Strongly Agree	3.17	Agree
Cute poisoning through accidental ingestion of toxic substances is due to improper labeling or food/drink in labs.	3.50	Strongly Agree	3.67	Strongly Agree
Faulty wiring, damaged cords, or improper use of equipment (e.g., centrifuges, microscopes, or heating devices) can lead to electric shocks, burns, or fires	3.60	Strongly Agree	3.75	Strongly Agree

Over-all Weighted Mean	**3.57**	**Strongly Agree**	**3.67**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

Challenges Associated with Waste Management

Table 2 shows the assessment of the respondents on the Science laboratory practices in terms challenges associated with waste management. It reveals that respondents, faculty/staff, and students identified compliance with evolving waste management regulations as the most significant laboratory waste management challenge, with the highest weighted mean of 3.83 and 3.65, respectively, with a verbal interpretation of a strongly agree rating. This means that it is important especially in the educator that it comply to the waste management regulations. Conversely, both groups expressed the least concern regarding the accessibility of approved waste storage areas, secure storage for safety and regulatory compliance, with the lowest weighted mean scores of 3.33 and 3.47 for faculty/staff and students, respectively, with verbal interpretation of strongly agree.

Table 2. Assessment of the Respondents on the Science laboratory Practices in terms Challenges associated with waste management

	Student		**Teacher/Staff**	
Challenges Associated with Waste Management	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Difficulties in the proper segregation of hazardous chemical waste, often due to unclear labeling or lack of designated containers, which increases the risk of accidental mixing and dangerous reactions.	3.53	Strongly Agree	3.50	Strongly Agree
Lack of proper disposal methods raises concerns about the potential spread of pathogens and non-compliance with biosafety regulations.	3.55	Strongly Agree	3.50	Strongly Agree
The high cost of specialized waste disposal services for chemicals places a financial burden on laboratory operations, sometimes resulting in delayed or improper disposal.	3.49	Strongly Agree	3.58	Strongly Agree
Recurring issues with the accessibility of approved waste storage areas, secure storage for safety and regulatory compliance.	3.47	Strongly Agree	3.33	Strongly Agree
Environmental impact of improper waste disposal which can pollute the air and water bodies if not properly managed.	3.63	Strongly Agree	3.42	Strongly Agree

Safety concerns when incompatible wastes, such as acids and bases or chemical and biological materials, are mixed, sometimes due to poorly designed waste stations or lack of clear segregation protocols.	3.57	Strongly Agree	3.42	Strongly Agree
Improvement of waste management infrastructure and clearer guidelines to reduce environmental contamination.	3.69	Strongly Agree	3.75	Strongly Agree
Compliance with evolving waste management regulations.	3.65	Strongly Agree	3.83	Strongly Agree
Over-all Weighted Mean	**3.57**	**Strongly Agree**	**3.54**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

The over-all weighted mean was 3.57 and 3.54 respectively with verbal interpretation strongly agree. This implies that based on the assessment of the respondents on the Science laboratory practices challenges associated with waste management. Hassan and Saleh (2022) mentioned that the best way to deal with hazardous waste is to treat the risk from the source and not to use hazardous materials in industries. To make it safe, it needs to be recycled, burned, transformed, buried forever in controlled ground pits, or chemically, physically, or biologically treated. But these procedures are very expensive. Proper management of these wastes necessitates specific procedures for managing, treating, and disposing of them in order to minimize their detrimental impact on human health and the environment. The specific delineation and oversight of perilous waste can differ among nations and regions, conforming to both domestic legislation and global accords. Ingesting or absorbing the excrement can be detrimental or lethal. The potential long-term health hazards of this substance include chronic toxicity, carcinogenicity, teratogenicity (producing developmental abnormalities), or other systemic consequences (Aglan et al., 2023).

Environmental Sustainability

Table 3 shows the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of environmental sustainability. The views on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction for environmental sustainability. Faculty/staff identified three key benefits of using greener materials: reduced hazardous waste and pollution; cost savings due to less expensive waste disposal and lower and lower consumption of non-renewable resources; and increased environmental awareness through exposure to green chemistry and sustainable practices. These benefits received a strongly agree rating with a weighted mean of 4.00.

Table 3. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Environmental Sustainability

	Student		Teacher/Staff	
Environmental Sustainability	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Shifting to greener materials into laboratory instruction reduces the hazardous waste and pollution	3.68	Strongly Agree	4.00	Strongly Agree
Greener experimental procedures often lead to cost savings, as it reduced the need for expensive hazardous waste disposal and lower the consumption of non-renewable resources	3.68	Strongly Agree	4.00	Strongly Agree
Teaching with greener materials fosters a sense of environmental responsibility and prepares students to address global sustainability challenges in their future careers.	3.73	Strongly Agree	3.92	Strongly Agree
Integrating greener materials and safer procedures, changes as essential for protecting health, conserving resources, and ensuring the long-term sustainability of laboratory science	3.75	Strongly Agree	3.92	Strongly Agree
Exposure to green chemistry and sustainable laboratory practices develop a stronger awareness of environmental issues.	3.74	Strongly Agree	4.00	Strongly Agree
Over-all Weighted Mean	**3.57**	**Strongly Agree**	**3.97**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

Students also highly valued integrating greener materials and safer procedures emphasizing their importance for protecting health, conserving resources, and ensuring long-term sustainability of laboratory science, with the highest weighted mean of 3.75, with a verbal interpretation of strongly agree.

Conversely, while faculty/staff rated with the lowest weighted mean fostering of environmental responsibility and preparation for future sustainability challenges as important, with a weighted mean of 3.92, while students gave the lowest rating with a weighted mean of 3.68 with a verbal interpretation of strongly agree, to the reduction of hazardous waste and pollution and cost savings associated with greener materials and procedures.

The over-all weighted mean was 3.57 and 3.97 with verbal interpretation respectively. Grave consequences in the environment arise due to the collection of poisonous chemicals in soil, water, and air, all emanating from hazardous waste. These go a long way to cause problems in the atmosphere such as the greenhouse effect, global warming and climate change. The chapter aims to highlight the definition, classification of various types of hazardous waste, characteristics of hazardous waste, effect of hazardous waste on the environment and public health, hazardous waste management, structural systems employed in the collection, storage and transportation of hazardous waste as well as hazardous waste treatment and disposal (Neksumi et al.,2022).

Enhanced Learning Outcomes

Table 4. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Enhanced Learning Outcomes

	Student		Teacher/Staff	
Enhanced Learning Outcomes	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Green chemistry principles promote critical thinking and innovation, encouraging students to seek safer and more sustainable solutions in their scientific work.	3.80	Strongly Agree	4.00	Strongly Agree
Student participation in greener and safer laboratory practices, understanding of both scientific concepts and the real-world impact of sustainable chemistry are observed.	3.75	Strongly Agree	4.00	Strongly Agree
Over-all Weighted Mean	**3.78**	**Strongly Agree**	**4.00**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

Table 4 show the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of enhanced learning outcomes. The assessment of the respondents; views on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction, focusing on enhanced learning outcomes.

Both faculty/staff and students strongly agreed that green chemistry principles promote critical thinking and innovation, encouraging students to develop safer and more sustainable scientific solutions with weighted mean 3.80 and 4.00 respectively with verbal interpretation strongly agree. Student participation in greener and safer laboratory practices demonstrably improved understanding of both scientific concepts and the real-world impact of sustainable chemistry with weighted mean 3.75 and 4.00 with verbal interpretation strongly agree.

The overall weighted mean of 4.00 for faculty/staff and 3.78 for students with verbal interpretation strongly agree. This implies that integrating greener materials and safer experimental procedures into laboratory instruction will enhance learning outcomes. It will not only reduce exposure to hazardous materials but also encourages a more comprehensive understanding of sustainability, resource management, and innovative problem-solving.

Sustainability education is crucial for creating a more sustainable future by promoting responsible and ethical energy, water, food, and waste management practices. It equips students with the knowledge and skills to address complex global challenges like climate change, resource depletion, and social inequality. These challenges require a multidisciplinary approach and a deep understanding of the interconnectedness of environmental, social, and economic systems. By providing students with a foundation in sustainability education, institutions are preparing them for the job market and ensuring that they have the skills and knowledge required to meet future workforce demands. Sustainability is becoming increasingly important in many sectors of the global economy, from renewable energy to sustainable agriculture (Pong Poo et al., 2023).

Improved Waste Management

Table 5. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Improved Waste Management

	Student		Teacher/Staff	
Improved Waste Management	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Greener materials in laboratory instruction reduces the hazardous waste, leading to improved waste management and a lower environmental impact	3.71	Strongly Agree	4.00	Strongly Agree
Eco-friendly and biodegradable laboratory materials decrease reliance on non-renewable resources and supports circular waste practices through recycling and composting.	3.73	Strongly Agree	4.00	Strongly Agree
Safer experimental procedures minimize the risk of chemical accidents and exposures, enhancing the overall safety of students and staff in the laboratory environment.	3.73	Strongly Agree	4.00	Strongly Agree
Green chemistry encouraged the use of less toxic solvents and reagents, waste disposal and reduces the burden on hazardous waste treatment facilities.	3.71	Strongly Agree	3.92	Strongly Agree
Improved waste management and safer procedures can lead to cost savings for educational institutions by reducing the need for expensive hazardous waste disposal and less laboratory accidents or contamination.	3.74	Strongly Agree	4.00	Strongly Agree

Over-all Weighted Mean	**3.72**	**Strongly Agree**	**3.98**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

Table 5 presents the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of improved waste management. The respondent views on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction, specifically regarding improved waste management. Faculty/staff and students strongly agreed that greener materials reduce hazardous waste, leading to improved waste management and a lower environmental impact. The use of eco-friendly and biodegradable materials decreases reliance on non-renewable resources and promotes circular waste practices through recycling and composting. Safer experimental procedures minimize the risk of chemical accidents and exposures, enhancing laboratory safety for students and staff.

These improvements in waste management and safety lead to cost savings by reducing the need for expensive hazardous waste disposal and minimizing accidents or contamination, with an overall weighted mean of 3.98 and 3.72 for faculty/staff and students, respectively with verbal interpretation strongly agree. Cheng et al. (2023) concluded in their study that sustainability is among the most attractive areas for researchers, scientists, and policymakers. Due to the past century's developments, the Earth faces many challenges, many of which come from industrial development. Their research contributes to outlining the importance and severity of sustainability, and looks into the impact of sustainable practices, green process innovation, and green productivity on sustainability.

The results of their study show that green process innovation and productivity directly lead to sustainability. Their study also reveals that environmental awareness moderates the relationship between green process innovation and green productivity toward sustainability. In today's industrial world, there is an urgent and critical need to educate engineers, scientists, and policymakers about environmental challenges and issues to ensure sustainability through green process innovation and productivity, and make the Earth a sustainable habitat for life.

Regulatory Compliance

Table 6. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Regulatory Compliance

	Student		**Teacher/Staff**	
Regulatory Compliance	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Incorporating sustainable practices into laboratory instruction helps meet institutional and regulatory sustainability goals.	3.72	Strongly Agree	4.00	Strongly Agree
Over-all Weighted Mean	**3.72**	**Strongly Agree**	**4.00**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

Table 6 shows the Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Regulatory Compliance. The respondents' views on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction, specifically regarding regulatory compliance were 3.72 and 4.00 respectively with verbal interpretation strongly agree. This implies that both faculty/staff and students strongly agreed that incorporating sustainable practices helps meet institutional and regulatory sustainability goals.

The over-all weighted mean of 4.00 for faculty/staff and 3.72 for students with verbal interpretation of strongly agree. Rai et al. (2024) mentioned in their study that transition to sustainable laboratory practices is not only a moral imperative to protect our planet for future generations but also a strategic necessity to ensure the long-term viability of healthcare systems worldwide. By prioritizing sustainability, laboratories can contribute to mitigating climate change and foster healthier and more productive work environments for laboratory staff and patients alike.

Advancing green medical laboratory practices is not merely an option but a responsibility that healthcare institutions must embrace to safeguard public health, protect the environment, and pave the way for a more sustainable future. In essence, the integration of sustainable practices within clinical laboratories is paramount for mitigating environmental impact, promoting resource conservation, and ensuring the long-term viability of healthcare systems. Through collaboration and innovation, laboratories can lead the way towards a healthier and more environmentally conscious future.

Reduce Operational Costs

In table 7- On the Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Reduce Operational Cost the highest weighted mean of 3.74 for the student was found in the statement " Implementing energy -saving measures (e.g. turning off equipment when not in use) can significantly costs in the laboratory whereas for the teacher statements " Reusing and recycling laboratory materials (such as plastics and glassware) will help decrease the expenses associated with purchasing new supplies, Using water-saving devices and procedures in laboratory activities can reduce overall water bills and statement Purchasing energy-efficient laboratory equipment will result in long-term cost savings despite higher initial investment obtained a weighted mean of 4.00.

Table 7. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Reduce Operational Cost

	Student		Teacher/Staff	
Reduce Operational Cost	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Implementing energy-saving measures (e.g., turning off equipment when not in use) can significantly lower utility costs in the laboratory.	3.74	Strongly Agree	3.83	Strongly Agree

Reusing and recycling laboratory materials (such as plastics and glassware) will help decrease the expenses associated with purchasing new supplies.	3.54	Strongly Agree	4.00	Strongly Agree
Using water-saving devices and procedures in laboratory activities can reduce overall water bills.	3.68	Strongly Agree	4.00	Strongly Agree
Purchasing energy-efficient laboratory equipment will result in long-term cost savings despite higher initial investment	3.69	Strongly Agree	4.00	Strongly Agree
Sharing laboratory equipment and resources among different groups or classes can minimize the need for duplicate purchases and reduce maintenance costs.	3.53	Strongly Agree	3.92	Strongly Agree
Incorporating sustainability guidelines (such as LEAF or My Green Lab frameworks) into laboratory operations can help identify and eliminate unnecessary expenditures.	3.66	Strongly Agree	3.83	Strongly Agree
Reducing the use of hazardous chemicals and opting for safer alternatives can lower costs related to chemical disposal and safety compliance.	3.66	Strongly Agree	3.75	Strongly Agree
Regular monitoring and auditing of resource consumption (energy, water, materials) can identify cost-saving opportunities in laboratory operations.	3.71	Strongly Agree	3.83	Strongly Agree
Over-all Weighted Mean	**3.65**	**Strongly Agree**	3.90	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

The results show that both students and teachers agree that using greener and safer methods in the lab can help save money. Students believe that simply turning off equipment when it's not being used can lower electricity costs. Teachers also shared that reusing materials like plastic and glass, saving water, and using energy-saving equipment can really help reduce lab expenses in the long run.

This shows that applying green chemistry in the lab isn't just good for the environment but it's also a smart way to manage school or lab budgets. These practices help reduce waste, save energy and water, and make the laboratories more sustainable. By doing these things, students and teachers can both learn and teach how science can be safe, eco-friendly, and cost-effective at the same time.

Minimize Environmental Impact

Table 8. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Minimize Environmental Impact

	Student		Teacher/Staff	
Minimize Environmental impact	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Incorporating energy-saving measures, such as turning off equipment and lights when not in use, will significantly reduce the laboratory's environmental footprint.	3.70	Strongly Agree	4.00	Strongly Agree
Using sustainable or biodegradable laboratory consumables (e.g., pipette tips, containers) instead of single-use plastics will help decrease plastic waste generated by school labs.	3.79	Strongly Agree	3.75	Strongly Agree
Implementing recycling programs for materials like glass, plastic, and paper in the laboratory will reduce the amount of waste sent to landfills.	3.72	Strongly Agree	3.92	Strongly Agree
Including guidelines for green chemistry, such as using safer chemicals and minimizing hazardous substances, will lower the negative impact of experiments on the environment.	3.74	Strongly Agree	4.00	Strongly Agree
Adopting water conservation practices, such as using water-efficient equipment and minimizing unnecessary water use, will help conserve resources in the school laboratory	3.75	Strongly Agree	4.00	Strongly Agree
Sourcing laboratory supplies from environmentally responsible vendors and prioritizing products with recyclable packaging will support sustainable procurement in the school setting.	3.72	Strongly Agree	4.00	Strongly Agree
Providing education and training on sustainable laboratory practices will increase awareness and encourage	3.72	Strongly Agree	4.00	Strongly Agree

environmentally responsible behavior among students and staff.				
Introducing regular environmental audits and monitoring of resource usage (energy, water, waste) will help track progress and identify further opportunities to minimize environmental impact.	3.71	Strongly Agree	3.83	Strongly Agree
Over-all Weighted Mean	**3.73**	**Strongly Agree**	**3.94**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

In Table 8 shows the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory Instruction in terms of minimize environmental impact , the statement " Using sustainable or biodegradable laboratory consumables (e.g., pipette tips, containers) instead of single-use plastics will help decrease plastic waste generated by school labs" has the highest weighted mean of 3.79 for the student while for the teachers the statement 1 " Incorporating energy-saving measures, such as turning off equipment and lights when not in use, will significantly reduce the laboratory's environmental footprint", statement 4- "Including guidelines for green chemistry, such as using safer chemicals and minimizing hazardous substances, will lower the negative impact of experiments on the environment"., statement 5 " Adopting water conservation practices, such as using water-efficient equipment and minimizing unnecessary water use, will help conserve resources in the school laboratory", statement 6 "Providing education and training on sustainable laboratory practices will increase awareness and encourage environmentally responsible behavior among students and staff" and statement 7 "Providing education and training on sustainable laboratory practices will increase awareness and encourage environmentally responsible behavior among students and staff" obtained a weighted mean of 4.00.

The results show that students and teachers both understand how important it is to protect the environment when doing experiments in the laboratory. Students agree most with the idea that using biodegradable or eco-friendly materials instead of single-use plastics (like pipette and other containers) can help reduce plastic waste in school laboratories.

Teachers also believe that the following: turning off lights and equipment when not in use can help save energy, using safer chemicals and less harmful substances can make experiments better for the environment, saving water by using water-efficient tools and not wasting it is important, teaching students about green lab practices can help everyone be more aware and responsible.

This means that when we make small changes—like reusing materials, saving energy and water, and learning how to be eco-friendly—we can help protect the environment while still learning science in the safest and smartest way. The transition toward eco-friendly lab practices requires a comprehensive approach that encompasses not only technological solutions but also changes at the organization level in both culture and operations. Laboratories need to reassess their workflows and adopt strategies aimed at reducing their environmental impact. Advances in green chemistry are enabling the production of compounds with a reduced environmental impact on synthetic processes. Implementing effective waste management protocols is critical for minimizing environmental impact. Such practices include separating hazardous and non-hazardous waste, labeling containers appropriately, and arranging for the safe disposal of chemical waste through licensed vendors or recycling facilities (Tommasone, 2024).

Improved Student Safety

In Table 9. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Minimize Environmental Impact, the statement " Including clear procedures for the safe handling, labeling, and storage of chemicals in the revised manual will reduce the risk of accidents and exposures in the school laboratory" obtained a highest weighted mean of 3.79 for students while the statements 1,4, 5 and , 6" Including clear procedures for the safe handling, labeling, and storage of chemicals in the revised manual will reduce the risk of accidents and exposures in the school laboratory", " Requiring the use of appropriate personal protective equipment (PPE) and ensuring its availability will minimize injuries during laboratory activities.", Establishing protocols for the proper disposal of hazardous and non-hazardous laboratory waste will reduce environmental risks and improve safety in the school lab', "Incorporating routine safety audits and inspections of laboratory facilities and equipment will help identify and address potential hazards before incidents occur" obtained a highest weighted mean of 4.00.

Both the students and teachers see the importance of keeping the laboratory safe and protecting the environment. Students gave the highest score to the idea that having clear steps on how to safely handle, label, and store chemicals in the lab manual can help prevent accidents and keep everyone safe.

Teachers strongly agreed that: Wearing the right safety gear (like gloves, goggles, and laboratory gown) is important to prevent injuries. Throwing away harmful and non-harmful waste the right container with their corresponding labels helps the environment and laboratories clean and safe. Regularly checking the laboratory before leaving may prevent accident to happen. Clear safety procedures in the manual also help reduce dangers in the laboratory.

Table 9. Assessment of the respondents on the Potential Benefits of Integrating Greener Materials and Safer Experimental Procedures into Laboratory Instruction in terms of Minimize Environmental Impact

	Student		Teacher/Staff	
Improved Student Safety	**Weighted Mean**	**Verbal Interpretation**	**Weighted Mean**	**Verbal Interpretation**
Including clear procedures for the safe handling, labeling, and storage of chemicals in the revised manual will reduce the risk of accidents and exposures in the school laboratory.	3.79	Strongly Agree	4.00	Strongly Agree
Using less hazardous chemicals improves the safety of students and staff, lessen the risk of chemical exposure and accidents during experiments.	3.71	Strongly Agree	3.92	Strongly Agree

Regular training and awareness programs on laboratory safety and sustainability will increase students' and teachers' ability to prevent and respond to emergencies.	3.76	Strongly Agree	3.83	Strongly Agree
Implementing a Chemical Hygiene Plan that addresses hazardous material management will enhance overall safety for both students and staff.	3.76	Strongly Agree	3.83	Strongly Agree
Requiring the use of appropriate personal protective equipment (PPE) and ensuring its availability will minimize injuries during laboratory activities.	3.78	Strongly Agree	4.00	Strongly Agree
Establishing protocols for the proper disposal of hazardous and non-hazardous laboratory waste will reduce environmental risks and improve safety in the school lab.	3.77	Strongly Agree	4.00	Strongly Agree
Incorporating routine safety audits and inspections of laboratory facilities and equipment will help identify and address potential hazards before incidents occur.	3.73	Strongly Agree	4.00	Strongly Agree
Providing clear emergency procedures, including evacuation plans and the location of safety equipment, will improve preparedness for accidents in the laboratory.	3.77	Strongly Agree	3.92	Strongly Agree
Promoting good housekeeping practices, such as keeping workstations clean and clutter-free, will decrease the likelihood of accidents and enhance the overall safety of the laboratory environment	3.76	Strongly Agree	4.00	Strongly Agree
Over-all Weighted Mean	**3.76**	**Strongly Agree**	**3.94**	**Strongly Agree**

Legend: 3.25-4.00, Strongly Agree, 2.50-3.24 Agree, 1.75-2.49 Disagree, 1.00-1.74 Strongly Agree

This means that learning and following safety rules is not just about doing experiments correctly—it's also about keeping the whole class, and the environment safe. Students will become responsible and ready to face the real science work if they understand and follow the safety practices inside the laboratory.

Is there a significant relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms of:

Environmental Sustainability

Table 10. Test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms Environmental Sustainability

Laboratory Practices	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Health hazards	0.421	0.000	Reject	Significant
Challenges associated with waste management	474	0.000	Reject	Significant

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 10 shows the relationship between how students and teachers rated science lab practices and the benefits of using greener and safer methods in the laboratory, especially in helping environmental sustainability. For Health Hazards, the Pearson R value is 0.421 and the significance value is 0.000. Therefore, hypothesis was rejected, there is significant relationship between how the students and teachers of Centro Escolar University assessed the science laboratory practices on health hazards and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms Environmental Sustainability.

While for Waste Management Challenges, the Pearson R value is 0.474 and the significance value is 0.000. Therefore, hypothesis was rejected, there is significant relationship between how the students and teachers of Centro Escolar University assessed the science laboratory practices on challenges associated with waste management and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms Environmental Sustainability. Because both significance values are 0.000, they are less than 0.01, it means the results are statistically significant. There is a strong connection between good laboratory practices (like being careful with chemicals and managing waste properly), and the benefits of using green and safe lab methods to help protect health and the environment. Since the decision is to "Reject" the null hypothesis, it means that better laboratory practices support environmental sustainability when green and safe procedures are added.

Enhanced Learning Outcomes

Table 11 shows the connection between how students and teachers see current lab practices and the benefits of using greener and safer lab methods, especially in improving learning outcomes (like understanding lessons better, being more engaged, and staying safe while learning).

For Health Hazards, the Pearson R is 0.457, and the significance value is 0.000. For Waste Management Challenges, the Pearson R is 0.522, and the significance value is also 0.000. Since the significance values are 0.000 (which is less than 0.01), the relationship is considered significant. The decision is to reject the null hypothesis, meaning the results are important and not just by chance. There is a strong relationship between: Practicing safe and proper lab habits (like managing waste well and avoiding health risks), and helping students learn better when green and safe lab procedures are used. In short: Better and safer lab practices lead to better learning!

Table 11. Test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction in terms Enhanced Learning Outcomes

Laboratory Practices	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Health hazards	0.457	0.000	Reject	Significant
Challenges associated with waste management	0.522	0.000	Reject	Significant

****. Correlation is significant at the 0.01 level (2-tailed).**

Improved Waste Management

Table 12. Test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedure in terms of Improved waste management

Laboratory Practices	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Health hazards	0.521	0.000	Reject	Significant
Challenges associated with waste management	0.544	0.000	Reject	Significant

**. Correlation is significant at the 0.01 level (2-tailed).

Table 12 shows the test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedure in terms of Improved waste management. The computed Pearson R was 0.521 and 0.544 respectively for health hazards and challenges associated with waste management. Since the computed significance value was 0.000 which is less than 0.01, therefore the decision was to reject the null hypothesis. There is significant relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedure in terms of Improved waste management.

The data indicated that laboratory practices that account for health and waste-related concerns are significantly linked to better waste management outcomes when integrating greener materials and safer experimental procedures were employed. The findings aligned with the principles of green chemistry and sustainable laboratory operations, which have gained increasing emphasis' Hill and Finster (Laboratory Safety for Chemistry Student", 2nd ed.,2026), stress that integrating safe experimental techniques with sustainable practices leads to a reduction in both immediate risks and long-term environmental impacts. The framework suggested that safety and sustainability should be treated as interdependent goals within laboratory education and practice.

Regulatory Compliance

Table 13. Test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures in terms of Regulatory Compliance. The computed Pearson R was 0.521 and 0.544 respectively for health hazards and challenges associated with waste management. Since the computed significance value was 0.000 which is less than 0.01, therefore the decision was to reject the null hypothesis. There is significant relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedure in terms of Regulatory Compliance.

It indicates that both laboratory practices factors- health hazards and challenges associated with waste management- had statistically significant positive correlations with regulatory compliance when greener materials and safe procedure are adopted.

Table 13. Test of relationship between the assessment of the respondents with regards to science laboratory practices and potential benefits of integrating greener materials and safer experimental procedures in terms of Regulatory Compliance

Laboratory Practices	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Health hazards	0.521	0.000	Reject	Significant
Challenges associated with waste management	0.544	0.000	Reject	Significant

****. Correlation is significant at the 0.01 level (2-tailed).**

This implies that improving laboratory safety and environmental responsibility not only enhances internal practices but also aligns institutions more closely with external regulatory standards. As efforts to reduce health hazards in laboratories increase, there is a corresponding increase in regulatory compliance when green and safe practices are implemented while addressing challenges associated with waste management through greener laboratory practices is positively associated with enhanced compliance with regulations.

Reduce Operation

Table 14, Test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Reduce Operation

Reduce Operation	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Environmental Sustainability	0.736	0.000	Reject	Significance
Enhanced Learning Outcomes	0.690	0.000	Reject	Significance
Improved waste management	0.775	0.000	Reject	Significance
Regulatory Compliance	0.790	0.000	Reject	Significance

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 14 shows the test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Reduce Operation. The computed Pearson R were Environmental Sustainability 0.736, Enhanced Learning Outcomes 0.690, Improved waste management 0.775, Regulatory Compliance 0.790. Since the computed significance value in all category was 0.000 which is less than 0.01 therefore null hypothesis was Rejected, there is significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Reduce Operation.

The findings detailed that the respondents strongly associated the integration of greener materials and safer experimental procedures with achieving the goals of reduce operation in laboratory instruction. These goals include enhancing sustainability, improving learning instruction. This goal includes enhancing sustainability, improving learning, managing waste efficiently, and ensuring Regulatory compliance. The consistent statistical significance of all correlations at the 0.01 level confirms that these relationships are not due to chance. This aligned with the current academic perspectives emphasizing that sustainable laboratory practices were not only environmentally sound but also pedagogically and operationally beneficial.

Minimize Environmental Impact

Table 15. Test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures laboratory practices in terms Minimize Environmental Impact

Minimize Environmental Impact	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Environmental Sustainability	0.791	0.000	Reject	Significant
Enhanced Learning Outcomes	0.769	0.000	Reject	Significant
Improved waste management	0.819	0.000	Reject	Significant
Regulatory Compliance	0.840	0.000	Reject	Significant

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 15 shows the test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures laboratory practices in terms Minimize Environmental Impact. The computed Pearson R were Environmental Sustainability 0.791, Enhanced Learning Outcomes 0.769, Improved waste management 0.819, Regulatory Compliance 0.840. Since the computed significance value in all category was 0.000 which is less than 0.01 therefore null hypothesis was Rejected, there is significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Minimize Environmental Impact.

A strong positive correlation generally exists between positive perceptions of integrating greener materials and safer experimental procedures in laboratory instruction and the extent to which sustainable laboratory practices are implemented to minimize environmental impact. In simpler terms, if students and instructors believe that these sustainable practices are beneficial and feasible, they are more likely to actively adopt and integrate them into their lab work, leading to a more environmentally conscious laboratory environment.

It should be evident that the environmental performance of science and laboratories is not optimal. Scientific research is at the center of creating more sustainable materials or processes and thus should be at the forefront of developing and embedding sustainability into their own practices. As academic science is funded by public money, there is a social responsibility to operate with the environment and future in mind. There are several Green Lab examples and initiatives (>146) seeking to address the environmental footprint of research. Driven by the voluntary efforts of researchers, they are educating other researchers, developing sustainability guidelines and maintaining accreditation frameworks. Without the need to reinvent the wheel, scientists across the planet can join these initiatives, form a grassroots group themselves, gather all the information and recommendations needed and ultimately improve their own research operations. Here accreditation processes and scientific publications can guide the progress more effectively. Importantly, these sustainability considerations are in alignment with other priority areas in the research system, such as reproducibility and open science (Freese et al. 2024).

Improved Student's Safety

Table 16. Test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Improved Student's Safety

Improved Student's safety	Computed Pearson R	Significance Value	Decision	Verbal Interpretation
Environmental Sustainability	0.504	0.000	Reject	Significant
Enhanced Learning Outcomes	0.541	0.000	Reject	Significant
Improved waste management	0.751	0.000	Reject	Significant
Regulatory Compliance	0.734	0.000	Reject	Significant

****. Correlation is significant at the 0.01 level (2-tailed).**

Table 16. Test of relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Improved Student's Safety. The computed Pearson R were Environmental Sustainability 0.504, Enhanced Learning Outcomes 0.541, Improved waste

management 0.751, Regulatory Compliance 0.734. Since the computed significance value in all category was 0.000 which is less than 0.01 therefore null hypothesis was Rejected, there is significant relationship between the assessment of the respondents on the potential benefits of integrating greener materials and safer experimental procedures into laboratory instruction and the extent to which sustainable laboratory practices in terms Improved Student's safety.

Research indicates that when respondents understand the positive impacts of sustainable practices, they are more inclined to adopt them. This applies to laboratory settings as well. If respondents, who could be students, instructors, or researchers, see the value of using greener materials and safer procedures (e.g., reduced waste, improved safety, cost savings), they are more likely to support and participate in their implementation. The relationship is likely to be positive, meaning that a higher assessment of the potential benefits corresponds to a greater likelihood of successful integration. For example, if respondents strongly believe that using less hazardous chemicals will lead to a safer lab environment, they will be more likely to actively participate in the transition to such chemicals.

Awoyode (2024), mentioned in his study that Green Chemistry is a technique used to defeat environmental problems both in terms of chemicals formed, methods, or reaction stages. This technique is based on decreasing the use and synthesis of toxic chemicals in procedures. The chemical risks area is a part of the Green Chemistry concept include a variety of threats to human health and the environment, physical hazards, consists of toxicity, exhaustion of natural resources, and global climate change. The Green Chemistry targets to study the use of various chemical principles in the design or synthesis of chemicals in reducing the use or making of toxic compounds that can interfere with the health and conserve the environment. The Green chemistry is a crucial part of an inclusive plan to guard human health and the environment. The Green chemistry is linked to matters in reducing waste at the source, the use of catalysts, safe reagents, increased economic efficiency, use of renewable materials, solvents that are safe and can be recycled. The idea of sustainability was driven by environmental and disastrous events and worried about the pollution of chemical and resource exhaustion.

Conclusions

Faculty/staff and students strongly agree that chemical burns and inhalation of toxic vapors are the most significant health hazards in the science laboratory. Additionally, they both recognize compliance with evolving waste management regulations as the primary challenge, highlighting the critical need for ongoing safety training and strict adherence to regulatory standards, especially among educators.

Faculty/staff and students strongly agree that integrating greener materials and safer experimental procedures into laboratory instruction offers significant benefits, including enhanced environmental sustainability, improved learning outcomes, and better waste management. These practices also support regulatory compliance, reduce hazardous waste, and foster critical thinking and innovation among students. Overall, the findings highlight the importance of adopting green chemistry principles to create safer, more sustainable, and compliant laboratory environments.

Students and faculty strongly agree that integrating greener materials and safer experimental procedures in laboratory instruction can significantly reduce operational costs through energy-saving measures, recycling, and efficient resource use. Additionally, these practices minimize environmental impact by promoting sustainable consumables, water conservation, and comprehensive safety protocols. The consistent high ratings emphasize the importance of education, clear safety guidelines, and routine audits in fostering a safer, more cost-effective, and environmentally responsible laboratory environment.

There is a significant and strong relationship between how students and teachers assess science laboratory practices—particularly regarding health hazards and waste management challenges—and the perceived benefits of integrating greener materials and safer experimental procedures. This relationship holds true across key areas such as environmental sustainability, enhanced learning outcomes, improved waste management, and regulatory compliance. These findings highlight the critical role that safe and sustainable laboratory practices play in promoting both effective education and environmental responsibility. There are significant positive relationships between the respondents' assessment of the benefits of integrating greener materials and safer experimental procedures and the extent to which sustainable laboratory practices reduce operational costs, minimize environmental impact, and improve student safety. The strong Pearson correlation values across environmental sustainability, enhanced learning outcomes, improved waste management, and regulatory compliance indicate that adopting green and safe lab practices effectively supports these key areas. These findings emphasize the important role of sustainable laboratory practices in fostering safer, more efficient, and environmentally responsible science education.

Recommendations

The following recommendations were drawn from the summary of findings and conclusions:

Programs to Enhance Science Laboratory Safety, Sustainability, and Education.

Comprehensive Laboratory Safety Training Program**-** Ensure strict adherence to safety protocols and regulatory standards, particularly targeting educators for leadership in safety culture. It will focus on addressing the critical health hazards such as chemical burns and toxic vapor inhalation. Regular workshops for faculty, staff, and students emphasizing hazard recognition, emergency response, and compliance with evolving waste management regulations.

Green Chemistry Integration Program **-** Enhance environmental sustainability, improve learning outcomes, and support regulatory compliance while fostering innovation and critical thinking. It will focus on incorporating greener materials and safer experimental procedures into laboratory curricula. Curriculum redesign to include sustainable reagents, waste reduction techniques, and environmentally friendly protocols.

Sustainable Laboratory Operations Program **-** Create cost-effective labs that minimize environmental footprint and maintain high safety standards. It will focus on reducing operational costs and environmental impact through sustainable practices. Implement energy-saving measures, recycling initiatives, water conservation strategies, and efficient resource management.

Safety and Sustainability Audit Program**-** Strengthen the relationship between safety assessments and sustainable practices, ensuring continuous improvement and accountability. It will focus on the routine evaluation of laboratory practices related to health hazards, waste management, and green chemistry adoption. Periodic audits involving faculty and students to assess compliance, identify gaps, and recommend improvements.

Integrated Education and Compliance Program**-** Promote a culture of environmental responsibility, operational efficiency, and student safety through informed and engaged learning communities. It will focus on the link educational outcomes with regulatory compliance and sustainable lab practices. Develop educational modules that emphasize the benefits of green and safe lab practices, aligned with regulatory requirements.

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