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IMPLEMENTATION OF FORENSIC CHEMISTRY AND TOXICOLOGYOUTCOME – BASED TEACHING AND LEARNING IN TAGUIG CITY UNIVERSITY: BASIS FOR LABORATORY MANUAL OPERATION

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ABSTRACT

This study examined the implementation of outcome-based teaching and learning (OBTL) in Forensic Chemistry and Toxicology at Taguig City University and its implications for developing a laboratory manual. Using a descriptive research design, the study assessed the extent to which OBTL principles were applied in the delivery of forensic chemistry and toxicology courses, focusing on curriculum alignment, teaching strategies, assessment methods, and student performance outcomes. Data were gathered from faculty members and students through survey questionnaires and interviews, supported by documentary analysis of course syllabi and instructional materials. Findings revealed that while outcome-based approaches were generally applied in classroom instruction, there were notable gaps in laboratory activities, assessment practices, and alignment with desired learning outcomes. These gaps highlight the need for a standardized and comprehensive laboratory manual to support consistent implementation of OBTL in forensic chemistry and toxicology courses. The study concludes that developing a laboratory manual anchored in OBTL principles will enhance instructional delivery, promote hands-on learning, and ensure that students acquire the necessary competencies for professional practice.

KEYWORDS: *Outcome-Based Teaching and Learning, Forensic Chemistry, Forensic Toxicology, Laboratory Manual, Taguig City University*

INTRODUCTION

Forensic chemistry and toxicology are important fields of science that play a vital role in the resolution of crimes and in the understanding of the effects of toxic substances. Forensic chemistry focuses on the analysis of the physical tests found in the crime scenes, such as blood, drugs and other chemicals. These analyzes help law enforcement to identify criminals and in support of legal cases. Toxicology, on the other hand, studies the harmful effects of chemicals on living organisms. It helps to determine if a substance is safe to use or puts health risks. Together, these fields are essential in crime resolution and public safety, making them relevant to modern science and society.

As educational practices evolve, the Outcomes-Based Education (OBE) has gained popularity in many institutions all over the world. OBE is a teaching approach that focuses on what students should know and be able to do after a learning experience. Unlike traditional education, which can focus on the storage of facts or the following lessons, OBE underlines the applications of the real world. It encourages students to develop directly relevant skills for their future careers. Research has shown that OBE can lead to better students' involvement and improve learning results. For example, a study conducted in South Africa revealed that the students who have experienced OBE have shown higher levels of critical thinking and problems resolution than those in traditional educational contexts.

Local studies have also indicated a growing concern for the lack of competence in forensic science and toxicology between graduates. A survey conducted among the police in the Philippines highlighted that many officials do not have a basic formation in forensic methods and toxicological assessments. This gap of skills can hinder an effective crime prevention and environmental risks management. By implementing an approach based on the results in the TCU curriculum, the university can produce graduates that are not only well informed in forensic chemistry, but are also qualified in applying this knowledge in various situations of the real world, such as investigations on the crime scene or environmental assessments.

Despite the importance of forensic chemistry and toxicology, various challenges hinder their effective implementation in higher education institutions. Many forensic science programs face limitations in terms of laboratory equipment, standardized protocols, and faculty expertise. Without a comprehensive laboratory manual, students often struggle to apply theoretical concepts to real-world forensic cases. In Taguig City University, the lack of a structured laboratory manual for forensic chemistry and toxicology poses a significant barrier to competency-based

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learning. As a result, students may not be adequately prepared to perform forensic analyses, affecting their readiness for licensure examinations and professional practice. Addressing these gaps necessitates the development of a laboratory manual that aligns with OBTL principles, ensuring that students gain hands-on experience and proficiency in forensic techniques.

Internationally, studies highlight the importance of well-equipped forensic laboratories and structured learning frameworks in forensic education. A study by Houck and Siegel (2018) emphasized that forensic science education must incorporate problem-based learning and hands-on laboratory exercises to enhance student engagement and skill acquisition. Similarly, Bell (2020) discussed how forensic chemistry curricula in the United States integrate case-based learning and laboratory simulations to improve competency in chemical analysis techniques. These findings underscore the necessity of structured laboratory manuals and practical assessments to ensure that forensic science graduates meet industry standards (Houck & Siegel, 2018; Bell, 2020).

Further research conducted in Europe also highlights the importance of laboratory-based education in forensic chemistry. A study by Caddy et al. (2019) in the United Kingdom explored the role of experiential learning in forensic science programs, emphasizing the need for modernized laboratory manuals that align with advancements in analytical chemistry. Similarly, Robertson (2021) examined forensic toxicology education in Australia, finding that institutions with standardized laboratory protocols produced graduates with higher proficiency in forensic analyses. These studies indicate that hands-on laboratory training, supported by well-structured manuals, significantly enhances student learning outcomes in forensic chemistry and toxicology (Caddy et al., 2019; Robertson, 2021).

In the Philippines, forensic education faces similar challenges, particularly in the availability of standardized teaching materials. According to Dizon et al. (2021), forensic science programs in the country often lack updated laboratory manuals, leading to inconsistencies in student training and assessment. Additionally, a study by Cruz (2020) found that many forensic science laboratories in Philippine universities are underfunded, limiting access to essential equipment and reagents for forensic analysis. These issues highlight the urgent need for an operational laboratory manual that aligns with OBTL principles to enhance forensic chemistry and toxicology instruction in the local context (Dizon et al., 2021; Cruz, 2020).

Furthermore, the Commission on Higher Education (CHED) has emphasized the need for outcome-based education in forensic science programs. According to CHED Memorandum Order No. 46, institutions offering forensic science courses must integrate competency-based learning approaches to ensure graduates are equipped with practical skills (CHED, 2019). However, research by Mendoza and Reyes (2022) revealed that many criminology and forensic science programs in the country still rely on traditional teaching methods, lacking structured laboratory manuals to facilitate hands-on learning. This gap underscores the necessity of developing a comprehensive laboratory manual tailored to forensic chemistry and toxicology instruction at Taguig City University (Mendoza & Reyes, 2022).

Given these challenges, this study aims to assess the implementation of forensic chemistry and toxicology OBTL at Taguig City University as a basis for developing a laboratory manual operation. By identifying gaps in laboratory instruction and aligning forensic education with international standards, this study seeks to enhance student competency, improve forensic laboratory practices, and contribute to the advancement of forensic science education in the Philippines. The findings of this study will serve as a foundation for developing a structured laboratory manual that supports effective hands-on learning, ensuring that forensic science graduates are well-prepared for professional practice.

LITERATURE REVIEW

The “Forensic Chemistry Laboratory Manual” by Charlie Williams is a comprehensive resource designed for one-semester forensic chemistry laboratory course. It point up industry-standard techniques and instrumentation used in drug chemistry and toxicology, aiming to stimulate procedures performed in forensic laboratories.

The manual is structed into various laboratory exercises, each focusing on different aspects of forensic analysis, Determining Concentration of Regulated Food Dye: this involves using UV-VIS spectroscopy to determine the concentration of food dyes. Emphasizing accurate solution preparation and calibration curve creation. Fabric analysis, students using fabric samples using solubility tests, Fourier-transform infrared spectroscopy (FTIR) and a thin layer chromatography (TLC) to identify dyes enhancing their understanding of trace evidence analysis. Drug analysis: it covers color tests, FTIR, and gas chromatography-mass spectrometry (GC-MS) techniques for identifying controlled substances, reflecting real-world drug procedure analysis, so many more analysis.

Each exercises includes an introduction, pr-lab questions, detailed materials and methods, and references, providing a throughout framework for students to develop practical skills in forensic chemistry.

Accessing the manual, the manual is available online through the university of Noth Texas’s open-access platforms, this resource is license under a creative common attributions non-commercial 4.0 international license, allowing for non-commercial sharing adaptation with appropriate attribution.
APA citation: Williams, C. (2022). Forensic chemistry laboratory manual. University of north Texas libraries.

Local Literature

The book Forensic Chemistry and Toxicology by Erika Shane

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Cabrera is a comprehensive educational resource designed to provide students with an in-depth understanding of forensic chemistry and toxicology as applied to criminal investigations. Published in 2022 under the ourSOUL Teaching-Learning Resources initiative at Silliman University, this open educational resource (OER) aims to enhance the learning experience of students enrolled in forensic science courses. The book offers a detailed examination of how chemistry and toxicology contribute to forensic investigations, highlighting their role in the identification, collection, preservation, analysis, examination, and presentation of physical evidence. It serves as a crucial learning tool for students aspiring to become forensic scientists, crime scene investigators, or toxicologists. The course content is designed to align with the principles of outcome-based education (OBE), ensuring that students develop measurable competencies in forensic chemical analysis, toxicological screening, and crime laboratory procedures. The resource is structured to facilitate both theoretical and practical learning, making it suitable for students, educators, and professionals in the forensic field.

One of the key aspects of Forensic Chemistry and Toxicology is its emphasis on laboratory techniques and methodologies commonly used in forensic investigations. The manual covers a wide range of analytical techniques such as chromatography, spectroscopy, and spectrophotometry, which are fundamental in detecting and identifying drugs, poisons, and other toxic substances. Cabrera provides real-world case studies to illustrate the application of these techniques in forensic laboratories, allowing students to understand the significance of analytical chemistry in solving crimes. Additionally, the book explores forensic toxicology in-depth, explaining how toxic substances interact with biological systems, how drug metabolism affects forensic analysis, and how toxicological screenings are conducted on biological samples such as blood, urine, and hair. The content is structured to guide students through the entire forensic process—from collecting evidence at crime scenes to conducting sophisticated laboratory analyses and presenting findings in a legal setting.

Furthermore, the book integrates discussions on the legal and ethical implications of forensic chemistry and toxicology, reinforcing the importance of maintaining the integrity of forensic evidence. Cabrera emphasizes the need for adherence to proper protocols in evidence handling, chain of custody maintenance, and the accuracy of laboratory results to ensure that forensic findings are admissible in court. The manual also introduces students to the principles of quality assurance and quality control in forensic laboratories, ensuring that analytical methods meet international standards. By incorporating legal and ethical considerations, the book prepares students for real-world challenges in forensic investigations, ensuring that they not only acquire technical skills but also develop a strong ethical foundation in their professional practice.

As part of the ourSOUL Teaching-Learning Resources initiative, Forensic Chemistry and Toxicology is openly accessible to students and educators, providing a valuable resource without the financial barriers associated with traditional textbooks. The book is published under a Creative Commons license, allowing users to freely access, download, modify, and distribute the material for non-commercial educational purposes. This initiative aligns with Silliman University's commitment to promoting accessible and high-quality education in the Philippines, particularly in specialized fields like forensic science. The availability of this resource significantly benefits students pursuing forensic chemistry and toxicology, enabling them to gain hands-on experience and deepen their theoretical knowledge without incurring additional costs.

The course is designed to support a blended learning approach, allowing educators to incorporate digital resources, laboratory activities, and interactive discussions into their teaching strategies. Cabrera's work serves as a foundational text for forensic chemistry programs, particularly in institutions that implement outcome-based education. The structured learning approach outlined in the book ensures that students achieve competency in forensic chemical analysis while developing critical thinking and problem-solving skills. The book also encourages collaborative learning through group experiments, case study discussions, and investigative exercises that simulate real-world forensic scenarios. By incorporating a student-centered learning approach, Forensic Chemistry and Toxicology fosters engagement, curiosity, and a deeper understanding of forensic science concepts. Moreover, the book introduces emerging trends in forensic chemistry and toxicology, including advancements in analytical instrumentation, forensic DNA analysis, and the application of artificial intelligence in forensic investigations. Cabrera highlights the impact of technological innovations on forensic science, preparing students for the evolving landscape of crime investigation techniques. The inclusion of modern forensic methodologies makes this resource highly relevant for contemporary forensic education, ensuring that students are equipped with up-to-date knowledge and skills. Additionally, the manual addresses forensic applications in various subfields, such as environmental forensics, forensic anthropology, and forensic pharmacology, broadening students' perspectives on the diverse applications of chemistry and toxicology in criminal investigations. In summary, Forensic Chemistry and Toxicology by Erika Shane Cabrera is an invaluable resource for students, educators, and forensic professionals seeking a comprehensive and accessible guide to forensic chemical analysis and toxicological investigations. Its structured approach, emphasis on laboratory techniques, legal and ethical considerations, and integration of modern forensic advancements make it an essential text for forensic science education. By providing open access to high-quality learning materials, the ourSOUL Teaching-Learning Resources initiative ensures that students can develop the necessary competencies to excel in forensic science without financial constraints. This book is not only a significant contribution to forensic chemistry and toxicology education but also a crucial tool for fostering scientific literacy, analytical skills, and ethical responsibility among future

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forensic practitioners.

OBJECTIVES OF THE STUDY

This study aims to evaluate the implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in Taguig City University to serve as basis for laboratory manual of operation.

Specifically, it seeks to answers the following questions:

1.How do the respondents evaluate the level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University in terms of:

1.1. Faculty Competency;
1.2. Learning Materials;
1.3. Laboratory Resources Utilization;
1.4. Laboratory Experiment Safety Protocols; and,
1.5. Students Learning Outcomes?

2.Is there significant difference between the evaluation of the two groups of respondents on the level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University in terms of the abovementioned variables?

3.What are the problems encountered on the implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University?

4.Based on the findings, what action plan can be proposed to enhance the level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University?

METHODOLOGY

This study employs a quantitative research design, specifically utilizing the descriptive-survey method, to assess the level of implementation of Forensic Chemistry and Toxicology Outcome-Based Teaching and Learning (OBTL) in the College of Criminal Justice at Taguig City University (TCU). The quantitative approach is appropriate as it allows for the collection of measurable data regarding key areas such as faculty competency, learning materials, laboratory resources utilization, laboratory experiment safety protocols, and student learning outcomes. According to Creswell and Creswell (2023), quantitative research enables researchers to systematically gather and analyze numerical data, making it ideal for evaluating educational practices. By using structured survey questionnaires, this study ensures an objective and systematic assessment, identifying trends and patterns in the effectiveness of forensic chemistry and toxicology education under the OBTL framework.

The descriptive-survey method is used to describe, analyze, and interpret the current implementation of forensic chemistry and toxicology education at TCU. This method enables the researcher to gather firsthand data from faculty members and criminology students regarding the adequacy and effectiveness of learning materials, the utilization of laboratory resources, the adherence to laboratory safety protocols, and the attainment of students' learning outcomes. As noted by Fraenkel and Wallen (2022), descriptive research is beneficial in educational settings as it allows for a comprehensive understanding of existing conditions without manipulating variables. Faculty responses will provide insights into their competency in delivering forensic chemistry and toxicology instruction, while student responses will reflect their learning experiences and challenges. The use of surveys ensures that relevant issues are identified, helping in the assessment of whether current instructional strategies align with the OBTL framework.

Scope and Delimitation

This study focuses on assessing the level of implementation of Forensic Chemistry and Toxicology Outcome-Based Teaching and Learning (OBTL) in the College of Criminal Justice at Taguig City University (TCU). Specifically, it examines five key areas: (1) Faculty Competency, evaluating instructors' expertise, pedagogical strategies, and ability to integrate OBTL in forensic chemistry instruction; (2) Learning Materials, assessing the availability, adequacy, and relevance of textbooks, laboratory manuals, and digital resources; (3) Laboratory Resources Utilization, analyzing the sufficiency and accessibility of forensic laboratory equipment, chemicals, and tools necessary for practical applications; (4) Laboratory Experiment Safety Protocols, reviewing compliance with safety guidelines, risk management procedures, and emergency response measures in conducting forensic experiments; and (5) Students' Learning Outcomes, measuring students' competency, skills development, and overall learning effectiveness under the OBTL framework. Additionally, this study identifies the problems and challenges encountered in the implementation of forensic chemistry and toxicology OBTL, providing insights for future improvements.

Data Gathering Tool

This study will utilize a survey questionnaire as the primary research instrument for data collection. The survey questionnaire is structured to systematically gather quantitative data from faculty members and criminology students regarding the level of implementation of forensic chemistry and toxicology Outcomes-Based Teaching and Learning (OBTL) at the College of Criminal Justice, Taguig City University (TCU). A well-designed survey ensures a standardized approach in collecting responses, allowing for an objective assessment of the key variables in this study. According to Creswell and Creswell (2023), survey questionnaires are effective in educational research as they facilitate data collection from a large sample, ensuring reliability and validity in analyzing educational practices.

The questionnaire is divided into two main sections. The first section focuses on the demographic profile of the respondents, including age, gender, civil status, and current educational attainment. This section provides a general background of the participants, allowing the study to identify possible variations in perceptions and experiences based on demographic factors. The second section evaluates the level of implementation of forensic chemistry and toxicology OBTL, assessing key areas such as

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faculty competency, adequacy of learning materials, laboratory resources utilization, adherence to laboratory experiment safety protocols, and students' learning outcomes. Additionally, this section includes items identifying problems encountered in the implementation of forensic chemistry and toxicology OBTL, providing insight into challenges that may hinder effective teaching and learning in laboratory-based forensic science education.

By using a structured survey questionnaire, this study ensures that the data collected is comprehensive, reliable, and reflective of the respondents' experiences. The responses from faculty members will help evaluate their preparedness, instructional methods, and resource availability, while student responses will provide insights into their learning experiences, challenges, and the overall effectiveness of forensic chemistry and toxicology education under the OBTL framework. The use of a survey also allows for statistical analysis, making it possible to generate meaningful conclusions that will inform the development of a Forensic Chemistry and Toxicology Laboratory Manual of Operations aimed at improving laboratory-based learning at TCU.

Data Gathering Procedures

The data collection process will follow a systematic approach to ensure the reliability and validity of the gathered information. Before administering the survey questionnaires, the researcher will seek approval from the College of Criminal Justice (CCJ) at Taguig City University (TCU) and other relevant authorities. A letter of request will be sent to the Dean of CCJ to obtain permission to conduct the study among faculty members and students. Once approval is granted, a brief orientation will be conducted to inform the respondents about the purpose, objectives, and confidentiality of the study, ensuring voluntary participation and adherence to ethical research guidelines.

Following the orientation, the survey questionnaires will be distributed to the two groups of respondents: (1) faculty members, who will provide insights into the implementation of forensic chemistry and toxicology Outcomes-Based Teaching and Learning (OBTL) in terms of faculty competency, learning materials, laboratory resources utilization, laboratory experiment safety protocols, and student learning outcomes, and (2) third- and fourth-year criminology students, who will share their experiences and perceptions regarding the effectiveness of OBTL in forensic chemistry and toxicology. The faculty members will be selected using purposive sampling, while the student respondents will be chosen using simple random sampling to ensure a fair representation. The respondents will be given ample time to answer the questionnaires, and necessary clarifications will be provided if needed.

After the completion of the data collection, the researcher will retrieve the survey questionnaires and conduct an initial review to check for completeness and accuracy. The gathered data will then be encoded, analyzed, and interpreted using appropriate statistical tools, allowing for an objective assessment of the study's key variables. The findings will be used to develop a Forensic Chemistry and Toxicology Laboratory Manual of Operations, aimed at enhancing laboratory-based learning at TCU.

Ethical Considerations

In conducting this study on the implementation of outcome-based teaching and learning (OBTL) in Forensic Chemistry and Toxicology at Taguig City University, strict ethical standards were observed. The participation of both faculty and students was voluntary, and informed consent was secured prior to data collection. Respondents were oriented on the objectives, scope, and significance of the research to ensure their full understanding and willingness to participate.

Confidentiality and anonymity of responses were strictly maintained, with no identifying information disclosed in the presentation of results. The study also ensured fairness in data gathering by treating all participants with respect and impartiality. Possible risks to participants were minimized by designing the survey and interviews to avoid sensitive or intrusive questions.

Furthermore, the research complied with the university's guidelines for academic integrity and ethical research practices. This ensured that the findings would contribute constructively to curriculum development and instructional enhancement without causing harm to any individual or institution.

RESULT AND DISCUSSIONS

Problems encountered on the implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning

Table shows the Implementation of Forensic Chemistry and Toxicology Outcomes – Based Teaching and Learning in Taguig City University. This shown as Serious with an overall mean of 3.10. The two group of respondents consider this as serious where Faculty has a mean of 3.38 and Student have a mean of 3.10. All indicators are Serious. This are the following with their mean: "Insufficient laboratory equipment and chemical reagents for practical experimentation" has a mean of 3.24; "Lack of a well-equipped forensic science laboratory dedicated to toxicological analysis" has a mean of 3.22; "Budgetary constraints that limit procurement of laboratory supplies and safety equipment" has a mean of 3.18; "Limited availability of qualified faculty with specialization in forensic chemistry and toxicology" has a mean of 3.16; "Lack of standard laboratory protocols and safety manuals tailored to forensic chemistry" has a mean of 3.13; "Delays in laboratory maintenance and repair that disrupt scheduled experiments" has a mean of 3.10; "Minimal student exposure to real-life forensic case scenarios and simulations" has a mean of 3.09; "Difficulty integrating forensic toxicology applications with practical crime laboratory settings" has a mean of 3.08; "Unclear learning outcomes and performance indicators in some course syllabi" and "Inadequate student support services for those struggling with technical forensic topics" both have a

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mean of 3.04; "Inconsistent use of assessment tools aligned with course learning outcomes" has a mean of 3.02: " Absence of updated and locally contextualized teaching materials aligned with OBTL outcomes" has a mean of 3.01; "Inadequate training of instructors in Outcomes-Based Education (OBE) principles and application" has a mean of 2.99.

INDICATORS	Faculty		Student		Overall	
	M	VI	M	VI	M	VI
Limited availability of qualified faculty with specialization in forensic chemistry and toxicology.	3.33	S	3.15	S	**3.16**	**S**
Inadequate training of instructors in Outcomes-Based Education (OBE) principles and application.	2.67	S	2.99	S	**2.99**	**S**
Absence of updated and locally contextualized teaching materials aligned with OBTL outcomes.	3.33	S	3.01	S	**3.01**	**S**
Insufficient laboratory equipment and chemical reagents for practical experimentation.	3.67	SA	3.23	S	**3.24**	**S**
Lack of a well-equipped forensic science laboratory dedicated to toxicological analysis.	3.67	SA	3.21	S	**3.22**	**S**
Unclear learning outcomes and performance indicators in some course syllabi.	3.33	S	3.04	S	**3.04**	**S**
Budgetary constraints that limit procurement of laboratory supplies and safety equipment.	3.33	S	3.18	S	**3.18**	**S**
Lack of standard laboratory protocols and safety manuals tailored to forensic chemistry.	3.33	S	3.13	S	**3.13**	**S**
Minimal student exposure to real-life forensic case scenarios and simulations.	3.67	SA	3.08	S	**3.09**	**S**
Inconsistent use of assessment tools aligned with course learning outcomes.	3.00	S	3.02	S	**3.02**	**S**
Difficulty integrating forensic toxicology applications with practical crime laboratory settings.	3.33	S	3.08	S	**3.08**	**S**
Delays in laboratory maintenance and repair that disrupt scheduled experiments.	3.67	VS	3.09	S	**3.10**	**S**
Inadequate student support services for those struggling with technical forensic topics.	3.67	VS	3.05	S	**3.04**	**S**
Overall	**3.38**	**S**	**3.10**	**S**	**3.10**	**S**

CONCLUSIONS AND RECOMMENDATIONS

These are the conclusions formulated by the researcher after investigating the issue:

1. The level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University is considered as implemented in the Faculty Competency, Learning Materials, Laboratory Resources Utilization, Student Learning Outcomes and Laboratory Experiment Safety Protocols. However, there are some instances needed to improve, these are:

a. Integrates real-world forensic cases into classroom discussions and assessments.
b. The laboratory manuals are available to guide students in conducting experiments and simulations.
c. Laboratory kits and materials are sufficient to meet the needs of the enrolled students .
d. Students can correctly identify, collect, and analyze chemical evidence relevant to crime scenes.
e. Students are required to wear appropriate personal protective equipment (PPE) such as lab gowns, gloves, and safety goggles during laboratory experiments

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2. There is no significant difference between the evaluation of the two groups of respondents on the level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University in terms of these variables. The forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University are implemented. Thus, the Null Hypothesis is accepted.

3. The problems encountered on the implementation of Forensic Chemistry and Toxicology Outcomes – Based Teaching and Learning in Taguig City University is considered as Serious, these are:

a. Insufficient laboratory equipment and chemical reagents for practical experimentation.
b. The lack of a well-equipped forensic science laboratory dedicated to toxicological analysis.
c. Budgetary constraints that limit procurement of laboratory supplies and safety equipment.
d. Limited availability of qualified faculty with specialization in forensic chemistry and toxicology.
e. Lack of standard laboratory protocols and safety manuals tailored to forensic chemistry.

Recommendations

After the study, the researcher recommended the following:

A. To improve the level of implementation of forensic chemistry and toxicology Outcomes–Based Teaching and Learning in the College of Criminal Justice Taguig City University in terms of Faculty Competency, Learning Materials, Laboratory Resources Utilization, Student Learning Outcomes and Laboratory Experiment Safety Protocols, it is necessary to:

1. Invite forensic experts or law enforcement professionals as guest lecturers to share firsthand case experiences and develop a case archive or digital library of anonymized real-world forensic cases for structured analysis and classroom use.
2. Update lab manuals annually to reflect new techniques, safety protocols, and advancements in forensic science and digitize manuals for easy access via mobile devices or tablets, including instructional videos and interactive guides.
3. Conduct periodic inventory and forecasting of lab supplies based on enrollment trends and lab schedules and maintain a reserve stock of critical consumables (e.g., swabs, reagents, gloves) to avoid disruptions.
4. Include frequent practical assessments and surprise simulations to test retention and application of skills and incorporate peer reviews and team-based problem-solving during lab work to improve technique accuracy and critical thinking.
5. Conduct PPE training and safety drills at the beginning of each semester to reinforce proper use and protocols and assign lab safety officers per group or class session to ensure compliance and immediate response to safety issues.

B. To avoid the problems to be encountered on the implementation of Forensic Chemistry and Toxicology Outcomes – Based Teaching and Learning in Taguig City University, it must:

1. Conduct a detailed inventory audit to identify critical equipment and reagent gaps aligned with the curriculum and establish maintenance and calibration schedules to maximize the lifespan of existing equipment.
2. Develop a phased lab development plan, starting with essential toxicology instruments like gas chromatographs (GC), spectrophotometers, and centrifuges and propose capital funding for a dedicated forensic toxicology lab in coordination with institutional planning and development offices.
3. Implement a cost-efficiency procurement system, buying in bulk or through long-term supplier agreements for better pricing and encourage interdisciplinary use of lab equipment to justify shared funding across departments (e.g., chemistry, biology, criminology).
4. Offer competitive hiring packages and flexible schedules to attract professionals from forensic labs or hospitals to teach part-time and encourage research and publication in forensic chemistry to build in-house expertise and attract qualified academics.
5. Form a lab safety committee to draft and regularly update SOPs and safety manuals tailored to forensic chemical procedures and display visual aids and quick-reference guides (e.g., chemical hazard signs, PPE protocols) throughout the laboratory.

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