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Science-based instructions and the critical thinking skills of criminology students at Occidental Mindoro State College

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Abstract

This study examined the relationship between the effectiveness of science-based instructions and the level of critical thinking skills of criminology students. It aimed to identify the instructional methods used by criminology instructors, determine their level of effectiveness, and assess students' critical thinking skills in interpreting forensic evidence, applying logical reasoning, and analyzing crime scenes using scientific methods. A descriptive-correlational design was employed, utilizing a researcher-made questionnaire to collect data from selected criminology students and instructors. Results revealed that criminology instructors frequently use science-based instructional approaches when teaching forensic and scientific subjects, with high effectiveness in forensic simulations, laboratory work, and case-based instruction. Students also demonstrated strong critical thinking skills, particularly in logical reasoning, evidence interpretation, and scientific analysis of crime scenes. Findings further indicated a significant relationship between the effectiveness of science-based instructional methods and students' critical thinking skills. This suggests that as science-based instruction becomes more effective, students' analytical, evaluative, and reasoning abilities likewise improve. The study recommends the continuous integration of science-based instructional strategies in criminology programs to enhance students' problem-solving and investigative competencies. Strengthening faculty training, curriculum design, and experiential learning opportunities are also encouraged to sustain the development of critical thinking essential for criminology practice.

Keywords: science-based instruction, critical thinking skills, forensic simulations, laboratory work, case-based instruction

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1. Introduction

Critical thinking is widely recognized as one of the essential outcomes of higher education, particularly in disciplines that require analytical reasoning and evidence-based decision-making, such as criminology. In scientific contexts, critical thinking entails the ability to evaluate data, interpret evidence, and apply logic within a structured framework. These cognitive skills are crucial for criminal investigations, forensic analysis, and legal proceedings (Facione, 2020; Lai & Viering, 2019). As criminology programs increasingly incorporate scientific disciplines such as forensic science, criminalistics, and crime scene investigation, there is a growing expectation that students develop strong analytical and reasoning skills. Studies have shown that exposure to science-based learning environments enhances students' higher-order thinking skills (Tseng et al., 2022; López-Carretero et al., 2020; Talan & Talan, 2021). However, empirical studies examining how these science-oriented criminology courses affect the development of critical thinking, especially in the Philippine context, remain scarce.

In line with this, the CHED Memorandum Order (CMO) No. 5, Series of 2018, established the Policies, Standards, and Guidelines (PSGs) for the Bachelor of Science in Criminology program. This policy emphasizes the development of analytical, ethical, and scientific competencies among criminology graduates through science-based subjects such as forensic science and criminalistics. Supporting this national vision is the College of Criminal Justice Education's institutional mission, which aims to produce public servants who are honorable, disciplined, and competent. Among its quality policy objectives are (1) providing quality education for future law enforcers, (2) instilling discipline through structured training, and (3) preparing students for board and standardized exams through comprehensive instruction. These institutional priorities underscore the importance of cultivating cognitive competencies such as critical thinking alongside technical and ethical training.

Despite this alignment between national policy and institutional goals, there remains a lack of empirical research directly correlating science-based instruction with the development of critical thinking among criminology students. Dela Cerna (2019) examined the relationship between critical thinking and academic performance in criminology but did not explore the role of science-oriented instruction in cognitive development. Moreover, Illes (2020) noted that many practitioners show limited formal reasoning and insufficient understanding of complex case contexts, attributing this to overspecialization and compartmentalized training.

This study seeks to fill that gap by correlating students' science-related critical-thinking abilities to their school performance in criminology programs within an Occidental Mindoro campus. Using a standardized measure to assess critical thinking in scientific contexts related to forensic analysis, scientific data interpretation, and the application of the scientific method, the study compares second-, third-, and fourth-year students. This study aims to strengthen justice and law enforcement education by enhancing Criminology students' critical thinking skills through science-based instruction. By improving their ability to think analytically and scientifically, future police officers will be better equipped to solve crimes, uphold truth, and deliver justice with integrity. In essence, this study helps shape criminologists who serve society with sharper minds and a stronger sense of duty. Moreover, the findings are expected to inform educators and curriculum designers about the effectiveness of current teaching methods and the integration of science throughout criminology programs. This knowledge can support further pedagogical innovations aimed at enhancing critical thinking across all year levels, ultimately improving both student academic performance and the professional competencies of future criminologists.

Statement of the Problem **-** This paper aimed to assess the effectiveness of science-based instructional methods in developing critical thinking skills in Criminalistics among second- to fourth-year Criminology students

of Occidental Mindoro State College. Specifically, it sought to answer the following questions: (1) What instructional methods do criminology instructors use in their teaching of science-based subjects? (2) What is the level of effectiveness of science-based instructional methods in teaching criminology students in terms of forensic simulations, laboratory work, and case-based instruction? (3) What is the level of critical thinking skills of criminology students based on tasks related to interpreting forensic evidence, applying logical reasoning, and analyzing crime scenes using scientific methods? (4) Is there a significant relationship between the level of effectiveness of science-based instructional methods and the level of critical thinking skills among criminology students? And (5) What intervention can be proposed to enhance the science-based instruction in the critical thinking skills of students in criminalistics?

Significance of the Study - This study aims to examine the effectiveness of science-based instructional strategies in developing criminology students' critical thinking, analytical reasoning, and evidence-based decision-making skills and to provide conclusions and recommendations based on the research findings. The results of this study will benefit students by enhancing essential cognitive skills for future criminal justice practice; instructors by offering guidance on effective, active, and inquiry-based teaching strategies in criminology and science-related courses; and law enforcement agencies by helping prepare competent and scientifically grounded future professionals. The study will also support curriculum developers and academic administrators, particularly in Occidental Mindoro State College and similar institutions, in strengthening curricula that emphasize higher-order thinking skills. In addition, the findings may assist the Local Government Unit of San Jose, Occidental Mindoro, as well as barangays and district localities, in supporting crime prevention, investigation, and community-oriented policing initiatives through improved collaboration with academic institutions. Furthermore, the study aligns with CHED MIMAROPA's goals of enhancing academic quality and program relevance in criminology education. It may serve as a valuable reference for future researchers interested in science-based instruction, instructional methodologies, and cognitive skill development in criminology and related fields.

Scope and Delimitation of the Study - The main objective of this study was to determine whether science-based instructional strategies improve the critical thinking skills of second- to fourth-year BS Criminology students of Occidental Mindoro State College (OMSC). This study was limited to second-, third-, and fourth-year criminology students, as first-year students were excluded due to their limited exposure to science-based subjects with laboratory components. The scope of the study focused on criminology courses that utilize scientific methods and laboratory-based instruction, such as forensic science, criminalistics, and crime scene investigation. It was confined to formal classroom and laboratory settings. The study did not consider other factors, such as personal background, external academic exposure, or non-academic experiences, that may influence the development of critical thinking. Data were gathered using research instruments appropriate to the study, including a qualitative component with purposively selected participants. Moreover, this study was conducted during the 2025–2026 school year.

2. Methodology

Research Design - This study utilized an exploratory sequential design, which, according to Creswell (2014), begins with qualitative data collection and analysis to explore a phenomenon, followed by quantitative methods to test or generalize the initial qualitative findings. This approach incorporated both qualitative (narrative) and quantitative (descriptive-correlational) methods to investigate science-based instructions and critical thinking among criminology students. Qualitative data were collected during the first phase using a single interview guide administered to selected Bachelor of Science in Criminology students. The interviews were analyzed thematically, focusing on the instructional strategies employed and the students' insights and experiences regarding the implementation of these teaching methods. The qualitative data collected were reduced to three key variables: forensic simulations, laboratory work, and case-based instruction. In the second phase, a survey was administered to assess the effectiveness of these instructional strategies and their relationship to students' critical thinking skills, using appropriate statistical methods to analyze the data.

Respondents of the Study - The respondents of this study were Bachelor of Science in Criminology students of Occidental Mindoro State College for the academic year 2025–2026. The study employed stratified random sampling to ensure fair representation across year levels, resulting in a total sample of 199 respondents from the 408 enrolled students. In addition, 15 criminology students were randomly selected to participate in the qualitative phase of the study and were excluded from the survey phase to avoid data overlap. Thus, the researchers ensured adequate representation and data reliability for both the quantitative and qualitative components of the research.

Research Instrument - This study utilized interviews and a survey questionnaire as the primary instruments for data gathering. The research instrument consisted of two parts corresponding to the qualitative and quantitative phases of the study. The first part used an interview guide to collect in-depth information on students' experiences with science-based instructional strategies in criminology subjects, particularly criminalistics, and the responses were thematically analyzed to identify key instructional variables. The second part was a researcher-made questionnaire developed based on the qualitative findings and supported by relevant literature. The research instrument consisted of two major sections: the first section focused on science-based instructional strategies, including forensic simulations, laboratory work, and case-based instruction, with six items for each component, while the second section measured students' self-perceived critical thinking skills in interpreting forensic evidence, applying logical reasoning, and analyzing crime scenes using scientific methods, also with six items per component. All items were rated using a 5-point Likert-type scale. To ensure instrument validity, expert validation was conducted by selected faculty members with expertise in criminology and research methods, and their comments and suggestions were incorporated into the final version of the questionnaire.

The reliability of the questionnaire was assessed using the split-half method, a technique described by Fraenkel et al. (2013) that involved administering the instrument once and then dividing the items into two sets—typically the odd- and even-numbered items—to evaluate internal consistency. In undertaking the instrument's reliability test via a survey questionnaire, 30 BS Criminology students from the second to fourth year levels served as reliability respondents. The researcher ensures that they are excluded from the final administration of the questionnaire assessing the effectiveness of the instructional strategies in enhancing the learning and performance of BS Criminology students. A total of 36 items comprised the two components: science-based instructions and level of critical thinking skills. The inter-item consistency of the instrument was assessed using the split-half method, as it was administered only once. To ensure the result's correctness, the Spearman-Brown formula for equal lengths was applied, yielding the coefficients shown in the table.

Table 1

Result of Reliability Analysis

Items	Number of Items	Reliability Coefficients*	Interpretation
Science-based Instructions			
Forensic Simulations	6	0.911	Very High Reliability
Laboratory Work	6	0.870	High Reliability
Case-based Instruction	6	0.824	High Reliability
Critical Thinking Skills			
Interpreting Forensic Evidence	6	0.763	High Reliability
Applying Logical Reasoning	6	0.921	Very High Reliability
Analyzing Crime Scenes Using Scientific Methods	6	0.862	High Reliability

*Based on equal length

The reliability analysis yielded generally high reliability, with coefficients ranging from 0.763 to 0.921. This result confirms the instrument's acceptability. The questionnaire was then administered to the final group of BS Criminology students of OMSC.

Data Gathering Procedure - The researcher first secured approval from the appropriate school authorities of

Occidental Mindoro State College to conduct the study. Upon approval, informed consent was obtained from the selected participants before data collection. For the qualitative phase, in-depth interviews were conducted with selected BS Criminology students using a semi-structured interview guide. For the quantitative phase, validated questionnaires were printed and personally distributed to a stratified random sample of BS Criminology students to ensure accuracy and completeness of responses. Students who participated in the interview and pilot testing were excluded from the survey to avoid bias. The data-gathering procedure, including securing permissions and distributing instruments, was conducted within the approved time frame. All completed questionnaires were retrieved immediately and processed after collection, ensuring confidentiality and ethical compliance throughout the study. This study employed both qualitative and quantitative data analysis techniques. The qualitative data obtained from interviews were transcribed and analyzed using thematic analysis to identify recurring themes related to science-based instructional strategies in criminology education. For the quantitative data, descriptive statistics such as frequency, percentage, mean, and standard deviation were used to describe respondents' perceptions of instructional methods and their levels of critical thinking skills. To determine the relationship between science-based instructional strategies and students' critical thinking abilities, structural equation modeling using partial least squares was applied. All statistical analyses were conducted using SPSS and Microsoft Excel to ensure accuracy and reliability of the results.

Statistical Treatment of the Data **-** This study employed both qualitative and quantitative data analysis techniques. The qualitative data obtained from interviews were transcribed and analyzed using thematic analysis to identify recurring themes related to science-based instructional strategies in criminology education. For the quantitative data, descriptive statistics such as frequency, percentage, mean, and standard deviation were used to describe respondents' perceptions of instructional methods and their levels of critical thinking skills. To determine the relationship between science-based instructional strategies and students' critical thinking abilities, structural equation modeling using partial least squares was applied. All statistical analyses were conducted using SPSS and Microsoft Excel to ensure accuracy and reliability of the results.

Ethical Considerations **-** Before conducting the study, the researcher obtained approval from the appropriate institutional authorities, including the research adviser and the Ethics Review Committee of Occidental Mindoro State College (OMSC). Informed consent was sought from all participants, with the purpose of the study, their role as respondents, and their right to refuse or withdraw at any stage without negative consequences clearly explained. Participants who wished to discontinue their participation at any point were fully permitted to do so, and any data collected from them up to that time were excluded from analysis to ensure respect for their autonomy and decision. Confidentiality and anonymity were strictly maintained throughout the research process. Participants' identities were not revealed, and all responses were coded to protect personal information. The data collected were used solely for academic purposes and were not shared with any unauthorized individuals or entities. The researcher ensured that participation was voluntary and that no coercion or undue influence was applied. Moreover, all procedures adhered to ethical standards for conducting human-subject research, ensuring that the dignity, rights, and welfare of the participants were fully respected.

3. Results and Discussions

After conducting a thematic analysis of the qualitative responses, the initial and final thematic maps illustrated in Figures 1 and 2 present three major instructional strategies that enhance the critical thinking skills of criminology students: Forensic Simulations, Laboratory Work, and Case-Based Instruction. The identified instructional strategies are supported by established learning theories that explain their effectiveness in developing students' critical thinking skills. Piaget's Constructivist Theory (1972, as cited in Woolfolk, 2016) emphasizes that knowledge is constructed through active engagement with the learning environment, as evidenced by forensic simulations and laboratory activities that require inquiry, analysis, and problem-solving. These learning experiences allow students to engage with scientific concepts rather than passively receive information. In addition, Kolb's Experiential Learning Theory (1984, as cited in Rahayu et al., 2023) explains learning as a continuous cycle of experience, reflection, conceptualization, and application, which is strongly

reflected in case-based instruction and mock forensic investigations. These approaches promote evidence-based reasoning and higher-order thinking. Related studies further support this framework, indicating that science-based instructional methods enhance critical thinking, academic performance, and professional competence among criminology students by requiring them to analyze real-world problems and apply scientific principles (Rahman et al., 2020; Rahayu et al., 2023)

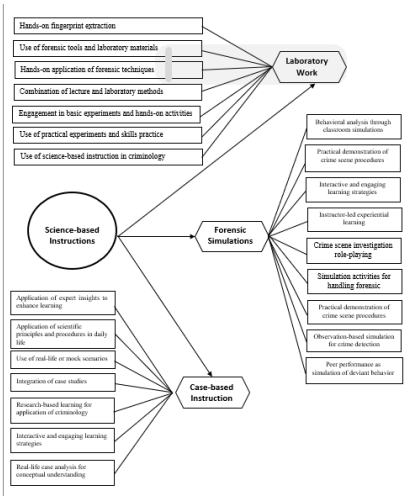

Figure 1. Initial Thematic Map for Science-based Instructions

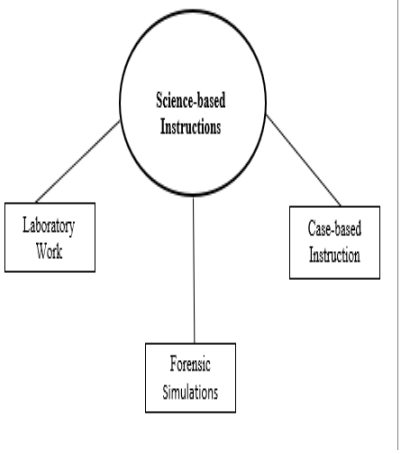

Figure 2. Final Thematic Map for Science-based Instructions

Table 2

Mean Level of Effectiveness of Science-Based Instructional Methods in Teaching Criminology Students in Terms of Forensic Simulations, Laboratory Work, and Case-based Instruction

Forensic Simulations	Weighted Mean	Interpretation
1. The simulation activities encourage me to participate actively.	4.46	Highly Effective
2. The simulations help me understand how forensic techniques are applied in real-life settings.	4.53	Highly Effective
3. I feel confident demonstrating the skills I have learned during simulation exercises.	4.15	Effective
4. The simulated scenarios enhance my problem-solving skills in Criminalistics.	4.35	Highly Effective
5. I find the simulations engaging and beneficial to my overall academic learning.	4.38	Highly Effective
6. The feedback I receive from simulations helps improve my future performance.	4.39	Highly Effective
Composite Mean	4.38	Highly Effective
Laboratory Work		
1. I can perform laboratory procedures related to forensic analysis effectively.	3.96	Effective
2. Laboratory work helps me grasp and reinforce theoretical concepts discussed in class.	4.14	Effective
3. I follow proper safety and technical protocols during laboratory sessions.	4.48	Highly Effective
4. I feel confident using laboratory tools and equipment for science-based tasks.	4.13	Effective
5. Laboratory activities improve my accuracy and attention to detail.	4.27	Highly Effective
6. I complete and submit lab reports accurately and on time.	4.14	Effective
Composite Mean	4.19	Effective
Case-based Instruction		
1. Case study analysis helps me apply theoretical knowledge to real-life scenarios.	4.25	Highly Effective
2. I can identify relevant forensic techniques when solving case-based activities.	4.13	Effective

3. Case-based instruction helps me understand how science contributes to criminal investigations.	4.33	Highly Effective
4. I am able to explain the logical outcomes of the assigned forensic cases.	4.08	Effective
5. Case-based discussions enhance my ability to think critically.	4.22	Highly Effective
6. I feel motivated and engaged when dealing with real-life case scenarios in class.	4.34	Highly Effective
Composite Mean	4.23	Highly Effective
Overall Mean	4.26	Highly Effective

Scale: *4.20-5.00 Highly Effective; 3.40 -4.19 Effective; 2.60-3.39 Moderately Effective; 1.80-2.59 Least Effective; 1.00-1.79 Not Effective*

Table 2 presents the mean effectiveness of science-based instructional methods for teaching criminology students, including forensic simulations, laboratory work, and case-based instruction. The overall mean of 4.26, interpreted as highly effective, signifies that the integration of science-based instructional strategies, namely forensic simulations, laboratory work, and case-based instruction, greatly enhances criminology students' learning outcomes, motivation, and analytical skills. Among these, forensic simulations achieved the highest composite mean of 4.38, interpreted as highly effective, indicating that hands-on, realistic investigative activities enable students better to apply theoretical knowledge in practical, real-world crime-solving contexts. The findings of this study support the literature emphasizing the effectiveness of laboratory-based and simulation-driven instruction in criminology education. The overall assessment of forensic simulations yielded a composite mean of 4.38, interpreted as highly effective, indicating that these instructional strategies significantly enhance students' learning, engagement, and practical understanding of forensic concepts. This aligns with Franz and Green (2018), who noted that experiential education enables learners to connect theoretical knowledge with real-world applications, particularly in science-based fields such as forensic science. The highest-rated statement, in item no. 2 (4.53), underscores the importance of bridging the gap between theory and practice, echoing Byrne's (2022) findings that immersive mock crime scenes enhance students' ability to retain and apply key forensic concepts.

Case-based instruction, with a mean of 4.22, is also highly effective, highlighting that engagement with authentic forensic cases effectively develops critical thinking and scientific reasoning. This indicates that case-based instructional strategies substantially enhance criminology students' learning, engagement, and critical thinking skills. These results support findings by Magwilang (2022), who found increased motivation, engagement, and performance among students in forensic chemistry when case-based instruction is used compared with traditional lecture-based approaches. The use of real-life forensic cases promotes conceptual understanding and problem-solving, consistent with the current study's findings regarding engagement and knowledge application. Similarly, Cresswell et al. (2017) noted that engaging in authentic crime-scene laboratory activities enhanced students' investigative reasoning and learning in an interdisciplinary, supported-inquiry unit. Meyer et al. (2018) also corroborated this evidence, arguing that structured case-based teaching develops students' critical thinking by breaking down complex problems into more logical steps, with the same type of reasoning that is prominent in required forensic analysis. Moreover, Byrne et al. (2019) found that challenge-based, virtual forensic casework improved student motivation, investigative competence, and medico-legal reasoning, similar to how criminology students in this study benefited from realistic case-based instruction. Yang et al. (2021) also confirmed that combining flipped and case-based learning yields significantly higher levels of understanding, analytical ability, and application of knowledge in practice than traditional teaching. Together, these studies provide evidence that case-based instruction nurtures deeper learning, critical thinking, and professional development in criminology by immersing students in authentic, problem-based contexts where they can apply principles of forensic science to realistic investigative situations.

Meanwhile, laboratory work received a slightly lower mean of 4.19, interpreted as effective, suggesting that while laboratory-based learning remains valuable, further enhancement in resources or instructional support could maximize its impact. These findings align with the literature emphasizing the significance of experiential and inquiry-based learning in criminology education. Franz and Green (2018) highlighted that lab-based education serves as a link between theory and applied environment, with students practicing scientific concepts

in real circumstances. Dealey (2020) revealed that experiential activities, such as real-world case analysis, enhance the critical thinking and problem-solving of criminology students. Likewise, Nilyani et al. (2023) found that STEM-integrated laboratory instruction enhances scientific literacy and critical thinking, the competencies vital for investigative and forensic tasks. Nicol (2021) has emphasized that guided inquiry is particularly helpful for complex laboratory activities, such as crime scene reconstruction and evidence analysis, because it offers a balance of structure and exploration. Lastly, Byrne (2022) emphasized the enduring educational merits of crime-scene simulations in promoting deep understanding, long-term knowledge retention, and real-world preparedness. Collectively, these studies support the present findings, underscoring that laboratory-based and experiential learning approaches are effective pedagogical strategies for developing the technical competence, analytical reasoning, and investigative skills essential to criminology education.

These findings are consistent with Manuel and Paglinawan (2025), who emphasized that while criminology students often encounter challenges in mastering complex scientific concepts and terminologies, well-designed and supportive instructional approaches significantly enhance their ability to connect scientific principles with criminological applications. The high effectiveness of science-based instructional methods in this study demonstrates that strategies emphasizing hands-on learning and problem-solving can foster critical thinking, analytical reasoning, and practical competence—skills essential for success in law enforcement and forensic fields.

Likewise, the results resonate with Russano et al. (2024), who found that science-based training methods improved investigators' ability to apply evidence-based, ethical, and effective techniques in real-world interrogation scenarios. Their study showed that structured, research-informed instruction not only improved professional performance but also enhanced ethical decision-making and cooperation during investigations. Similarly, the effectiveness of science-based instruction observed among criminology students in the present study reflects how scientific approaches to teaching can build both the technical proficiency and the ethical awareness necessary for professional investigative practice. Overall, the results affirm that science-based instructional methods are highly effective in criminology education, as they foster engagement, deepen understanding, and promote the integration of theory into practice—ultimately preparing students to become competent, reflective, and evidence-based practitioners in criminal justice.

Table 3

Respondents' Level of Critical Thinking Skills in Terms of Interpreting Forensic Evidence, Applying Logical Reasoning, and Analyzing Crime Scenes Using Scientific Methods

Interpreting Forensic Evidence	Weighted Mean	Interpretation
1. I can evaluate the credibility of forensic evidence presented in a case.	4.17	Effective
2. I can identify inconsistencies in forensic reports or findings.	3.97	Effective
3. I understand the importance of physical evidence in crime scene investigations.	4.43	Highly Effective
4. I can draw logical conclusions based on different types of forensic evidence.	4.01	Effective
5. I can distinguish between relevant and irrelevant forensic data in a case.	4.09	Effective
6. I can critically assess how the presented evidence supports or contradicts a hypothesis.	4.07	Effective
Composite Mean	4.12	Effective
Applying Logical Reasoning		
1. I use logical thinking when analyzing patterns of criminal behavior.	4.34	Highly Effective
2. I apply step-by-step reasoning when solving criminology-related problems.	4.32	Highly Effective
3. I form conclusions based on facts and objective analysis	4.29	Highly Effective
4. I avoid assumptions and rely on evidence when solving forensic scenarios.	4.30	Highly Effective
5. I connect multiple sources of information to reach sound conclusions.	4.29	Highly Effective

6. I verify my interpretations of crime scenes through logical validation.	4.29	Highly Effective
Composite Mean	4.31	Highly Effective
Analyzing Crime Scenes Using Scientific Methods		
1. I understand how scientific principles are applied to crime scene analysis.	4.30	Highly Effective
2. I can identify correct procedures for collecting and preserving physical evidence.	4.29	Highly Effective
3. I am familiar with the tools and instruments used in scientific crime scene investigations.	4.16	Effective
4. I follow a systematic and scientific approach when analyzing crime scene evidence.	4.22	Highly Effective
5. I apply prior knowledge in chemistry, biology, or physics when assessing evidence.	4.18	Effective
6. I can reconstruct crime scenes using scientific reasoning based on the evidence collected.	4.19	Effective
Composite Mean	4.22	Highly Effective
Overall Mean	4.21	Highly Effective

Scale: 4.20-5.00 Highly Effective; 3.40 -4.19 Effective; 2.60-3.39 Moderately Effective; 1.80-2.59 Least Effective; 1.00-1.79 Not Effective

Table 3 presents the level of critical thinking skills in interpreting forensic evidence, applying logical reasoning, and analyzing crime scenes using scientific methods, with an overall mean of 4.21, interpreted as highly effective. This indicates that the science-based instructional methods implemented in the study effectively enhanced the students' ability to think critically, reason logically, and analyze forensic evidence through scientific inquiry. Among the indicators, applying logical reasoning obtained the highest composite mean of 4.30, interpreted as highly effective, suggesting that students were able to make sound judgments and draw evidence-based conclusions in criminological contexts. This indicates that criminology students possess strong logical reasoning skills essential in analyzing evidence and solving criminology-related problems. Overall, the results show that the respondents effectively apply logical reasoning in investigative contexts, suggesting a mature level of analytical and evaluative thinking necessary in criminology practice.

These results align with Arquero et al. (2022) and Magwilang (2022), who found that simulation and case-based learning strengthen students' analytical reasoning in forensic contexts. Likewise, Valdez and Bungihan (2019) and Meesamran and Polyiem (2024) reported that problem-based instruction promotes higher-order thinking and logical problem-solving—similar to this study's findings. Overall, this indicates that science-based instructional strategies such as simulations, laboratory activities, and case-based investigations effectively enhance students' logical reasoning, enabling them to draw factual conclusions, connect evidence, and apply rational analysis in criminological practice.

This is followed by the analysis of crime scenes using scientific methods (4.22), which is also highly effective, demonstrating that students can competently apply analytical and systematic approaches when examining evidence. Overall, the results indicate that criminology students can think critically and scientifically when examining crime scenes. They can integrate theoretical science concepts with investigative techniques and can form a basis for valid conclusions in forensic studies. These findings are consistent with Bracewell and Jones (2022), who found that active learning through simulated crime scenes enhances procedural accuracy and analytical thinking among students. Similarly, Guanzon et al. (2023) demonstrated that using a digital crime scene simulator improved learners' scientific reasoning and procedural competence. Acampora (2023) and Albeedan et al. (2024) further support this, noting that immersive and mixed-reality forensic training systems enhance observational, deductive, and spatial understanding skills that are crucial to forensic science education. Additionally, Birch et al. (2023) emphasized the importance of revitalizing scientific inquiry within criminology to bridge the gap between academic theory and field application, reinforcing the value of integrating scientific methods into criminology curricula.

Meanwhile, interpreting forensic evidence (4.12), interpreted as effective, indicates that while students demonstrate adequate proficiency, there remains room for improvement in deepening their interpretive and evaluative skills related to forensic data. Overall, the findings suggest that criminology students possess a strong foundation of critical thinking skills necessary for interpreting forensic evidence effectively. These abilities enable them to connect theory with practice, evaluate information objectively, and draw evidence-based conclusions, which are essential in the field of criminal investigation. These findings are supported by previous studies emphasizing the value of evidence-based education in forensic science. Nilendu (2024) highlighted that evidence-based instruction bridges academic learning and forensic practice, strengthening students' analytical reasoning and empirical understanding. Likewise, Dror et al. (2020) and Morrison (2022) underscored the need for transparent, data-driven reasoning to minimize cognitive bias in forensic decision-making. Van Straalen et al. (2023) further revealed that interpretive ability and sensitivity to uncertainty in forensic analysis are shaped by both training and cognitive development. Together, these studies affirm that systematic, science-based instruction enhances critical thinking and interpretive accuracy among criminology students.

Also, these findings support Howes (2017), who emphasized that the development of critical thinking in criminology requires reflective learning experiences that encourage students to question assumptions, understand social justice issues, and form nuanced perspectives on crime and criminal behavior. The engagement of students in analytical and reflective activities allows them to develop empathy, critical insight, and intellectual maturity—qualities essential for ethical and informed decision-making in criminal justice practice. Furthermore, the results align with Kakar (2025), who highlighted the effectiveness of experiential learning strategies—such as simulations, fieldwork, and case-based activities—in promoting deeper understanding, active engagement, and enhanced critical thinking and problem-solving skills. The high effectiveness ratings observed in this study indicate that criminology students benefit significantly from experiential and science-based methods that connect theory with real-world practice. Such learning environments provide meaningful opportunities for students to apply logical reasoning and scientific analysis to authentic investigative scenarios, thereby strengthening their cognitive abilities and professional preparedness.

Overall, the findings affirm that science-based and experiential instructional approaches are highly effective in cultivating critical thinking skills among criminology students. By encouraging logical reasoning, reflective analysis, and evidence-based inquiry, these methods equip future professionals with the intellectual tools necessary to navigate complex criminal justice situations with competence, integrity, and sound judgment.

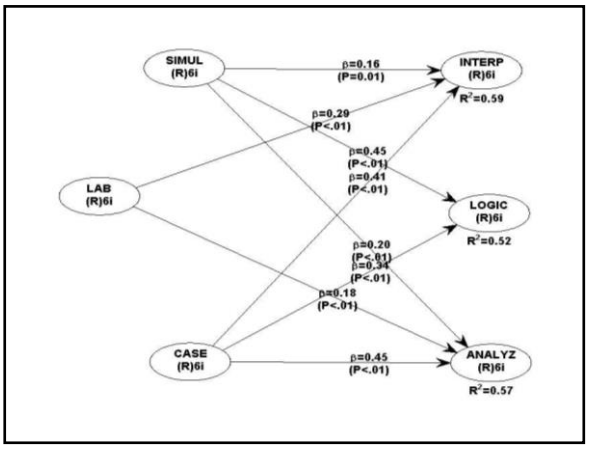

Figure 3. The Emerging Model of the Relationship Between the Level of Effectiveness Science-based Instructional Methods and the Level of Critical Thinking Skills

A new model, as shown in Figure 3, emerges from structural equation analysis. The two variables, forensic simulation and case-based instruction, maintained a solid, direct link to the endogenous variable, level of critical thinking skills. However, the laboratory shows only two connections to the endogenous variable. Maintaining almost the same values of R^2 as in the structural model, the emerging model in Figure 6 reflects the percentages

(0.59, 0.52, 0.57) of the variability in the critical thinking skills level that can be attributed to the variations in the effectiveness of science-based instructional methods. The standardized path estimates in the model are presented in Table 14.

Table 4

Standardized Estimates of the Path in the Emerging Model

Hypothesis	Standardized Estimates (β)	Standard Error	*p*-value	Effect Coefficient*	Effect Size
Ho: Level of Effectiveness→Level of Critical Thinking Skills					
Simul→Interp	0.159	0.069	0.011	0.100	Small
Simul→Logic	0.455	0.065	<0.001	0.308	Large
Simul→Analyz	0.202	0.068	0.002	0.127	Small
Lab→Interp	0.289	0.067	<0.001	0.202	Medium
Lab→Analyz	0.185	0.068	0.004	0.122	Small
Case→Interp	0.406	0.066	<0.001	0.291	Large
Case→Logic	0.338	0.066	<0.001	0.215	Medium
Case→Analyz	0.450	0.065	<0.001	0.322	Large

*Effect size coefficient **0.02 – small, 0.15 – medium, 0.30 – large*

Table 4 reports significant direct effects of the effectiveness of science-based instructional methods on criminology students' critical thinking skill levels, suggesting the rejection of the null hypothesis. It should be noted that the effect size coefficients range from 0.02 to 0.30, which denote small, medium, and large effects. The effect coefficients from 0.100 to 0.127 indicate a small effect of forensic simulation on interpreting forensic evidence and analyzing crime scenes, and of laboratory work on interpreting forensic evidence. Medium effect sizes, ranging from 0.202 to 0.215, are reported in laboratory work on interpreting forensic evidence and in case-based instruction on applying logical reasoning. Large effects are also evident in the three connections among case-based instruction, interpreting forensic evidence, and analyzing crime scenes, and between forensic simulation and applying logical reasoning, as reflected in effect coefficients of 0.291, 0.322, and 0.308. Standard error values are low, ranging from 0.065 to 0.069, indicating a more precise predictive model and confirming the accuracy with which the study samples represent the population.

Overall, the effectiveness of science-based instructional methods directly affects criminology students' level of critical thinking. This implies that hands-on learning tools such as simulations, laboratory experiments, and case-based instruction help students develop the capacity to evaluate evidence, think critically about concluding it, and apply theoretical ideas to real-world investigative scenarios. Consistent with Bracewell and Jones (2022), who found that simulated crime scene investigations significantly strengthen inferential reasoning and decision-making abilities among criminology students. Similarly, Acampora (2023) pointed out that mixed-reality and forensic simulation tools support deep engagement and enhanced analytical thinking required for criminal investigations. Moreover, the results support Guanzon et al. (2023), who demonstrated that crime scene simulation training improves students' skills in evidence handling, interpretation, and analytical reasoning. Thus, the inclusion of such techniques in criminology programs enables students to apply critical thinking in realistic investigative settings.

In practical terms, these findings suggest that science-based, inquiry-driven pedagogies in criminology education can strengthen the competence of future law enforcers and forensic practitioners. Through real-world experiences that refine critical and logical thinking, graduates are better equipped to analyze forensic data, detect

anomalies, and formulate conclusions based on evidence. Consequently, this improves the quality and accuracy of criminal investigations, thereby enhancing the integrity and effectiveness of the criminal justice system.

Table 5

Proposed Intervention for Enhancing Critical Thinking Skills of Criminology Students

Area / Intervention Component	Rationale	Proposed Activities/Initiatives	Objectives	Expected Outcomes	Responsible Unit / Personnel
Laboratory Skills Development Initiative	To improve the scientific inquiry and analytical reasoning through practical experiments and forensic testing	Upgrade and modernize laboratory facilities and equipment, and design and implement inquiry-based, experiment-driven activities that actively engage students in hypothesis testing, data analysis, and problem-solving relevant to criminalistics.	To enhance the application of scientific methods in crime analysis	Improved laboratory competence and evidence-based reasoning among students	Laboratory Head, Science and Criminology Departments
Area/Intervention Component	Rationale	Proposed Activities/Initiatives	Objectives	Expected Outcomes	Responsible Unit / Personnel
Case-Based Instruction Integration	To enhance critical analysis and reasoning through the discussion of real or simulated criminal cases	Reinforce the use of real-world forensic case studies, mock investigations, and collaborative analysis in instruction.	To train students to evaluate evidence and make sound judgments using scientific reasoning	Stronger evaluative and logical thinking abilities in criminal case interpretation	Subject Instructors, Curriculum Committee
Area / Intervention Component	Rationale	Proposed Activities / Initiatives	Objectives	Expected Outcomes	Responsible Unit / Personnel
Forensic Simulation Enhancement Program	To improve students' logical reasoning and analytical abilities through realistic investigation experiences	Enhance the integration of advanced digital and physical crime scene simulations in both laboratory and classroom settings through updated forensic technology and scenario-based learning.	To provide hands-on learning experiences that strengthen students' ability to analyze evidence logically	Enhanced critical thinking and problem-solving skills in forensic contexts	Criminology Faculty, Laboratory Coordinator, Program Chair
4. Faculty Capability-Building Program	To ensure instructors are equipped with updated pedagogical	Conduct continuous professional development seminars and workshops on innovative, simulation-based, and	To strengthen faculty expertise in implementing effective science-based	Faculty equipped with advanced teaching strategies that foster critical thinking	Dean of Criminology, HRD Office, Research and Extension

	and forensic science knowledge.	inquiry-driven teaching strategies.	instructional strategies		Office
5. Student Research and Innovation Forum	To upgrade analytical thinking and independent inquiry among students	Organize research presentation competitions and provide support for student-led investigative research projects. Partner with agencies for research utilization	To encourage evidence-based investigation and critical reflection on criminological problems	Increased student engagement in research and application of scientific methods	Research Coordinator, Student Affairs Office
Area/Intervention Component	Rationale	Proposed Activities/Initiatives	Objectives	Expected Outcomes	Responsible Unit / Personnel
6. Continuous Evaluation and Monitoring	To strengthen the effectiveness of implemented instructional programs	Enrich the criminology curriculum by integrating modern science-based methodologies and technology-supported modules in criminalistics.	To ensure the ongoing improvement of science-based instruction in criminology education	Sustainable enhancement of teaching quality and student outcomes	Quality Assurance Office, Program Chair, Faculty Evaluation Committee

Science-based instructional methods are pedagogical approaches grounded in inquiry, experimentation, and empirical reasoning that actively engage students in the learning process. In criminalistics education, these methods bridge theoretical understanding and real-world forensic application by allowing learners to simulate investigative procedures, handle evidence, and analyze cases systematically. Such approaches foster higher-order cognitive processes, particularly critical thinking, which is essential for criminology students who will eventually take part in solving crimes and promoting justice. Based on the study's findings, the following program and recommendations are proposed to strengthen the use of science-based instruction and further enhance critical thinking skills among criminology students.

To begin with, regular forensic simulation workshops can be held to expose students to realistic investigative scenarios requiring analytical reasoning and decision-making. Simulated crime scenes promote authentic learning experiences that develop students' observational, evidence-evaluation, and deductive-reasoning skills. According to Bracewell and Jones (2022), simulation-based learning enables students to connect classroom theories with forensic practice, thereby improving their accuracy and confidence in handling evidence. Similarly, Elhaw and Alshehhi (2023) found that virtual reality and digital simulations enhance learners' spatial understanding and problem-solving skills—essential components of critical thinking in forensic analysis.

Another essential recommendation is to integrate laboratory-based inquiry activities into criminalistics courses. Laboratory exercises allow students to apply the scientific method—formulating hypotheses, conducting experiments, and interpreting results—which strengthens logical reasoning and analytical abilities. Belga (2022) highlighted that inquiry-driven laboratory instruction significantly improves scientific reasoning and reflective thinking, skills that are directly transferable to forensic investigation and evidence interpretation. The use of case-based discussions is also highly recommended. Presenting students with real or hypothetical forensic cases encourages them to analyze scenarios, identify relevant information, and justify conclusions based on evidence. Magwilang (2022) noted that case-based instruction increases student motivation and promotes deeper conceptual understanding in forensic chemistry. Likewise, Qu et al. (2018) demonstrated that case-teaching methods enhance critical thinking and professional judgment among forensic students. By engaging in case analyses, criminology students develop investigative and evaluative skills that can contribute meaningfully to solving crimes and supporting the justice system.

Furthermore, collaborative research and fieldwork projects may be strengthened to cultivate teamwork, communication, and problem-solving abilities. When students work together to analyze evidence or reconstruct crime scenes, they practice scientific reasoning and collective decision-making similar to real forensic teams. Magwilang (2022) emphasized that collaborative learning fosters analytical dialogue and reflection, which help students develop more disciplined reasoning processes. Another important aspect is the training of faculty members in science-based instructional design. Teachers must be equipped to facilitate inquiry-based, simulation-driven, and case-oriented learning environments. Bracewell and Jones (2022) stressed that educators play a vital role in guiding observation, reflection, and analysis during forensic simulations. Professional development programs can ensure that instructional delivery remains consistent, evidence-based, and aligned with modern forensic education practices.

Lastly, strong partnerships with law enforcement agencies and forensic laboratories are encouraged to provide authentic learning opportunities through internships, field immersions, and joint research. These collaborations allow students to apply classroom learning to real-world contexts, bridging the gap between theory and practice. Elhaw and Alshehhi (2023) found that such experiential learning experiences improve procedural accuracy, situational awareness, and investigative reasoning. In the long run, these partnerships contribute to a more competent and scientifically grounded criminology workforce, enhancing the overall quality of crime investigation and justice delivery. In summary, implementing these science-based instructional strategies will not only enhance the critical thinking and investigative competence of criminology students but also contribute to a more effective justice system. By developing evidence-based reasoning and analytical decision-making through scientific pedagogy, future criminologists will be better prepared to interpret complex crime scenes, make sound judgments, and uphold the integrity of forensic practice in real-world investigations.

4. Conclusions

The study reveals that criminology instructors employ various science-based instructional methods, including forensic simulations, laboratory work, and case-based instruction, to enhance students' learning in science-based subjects. These approaches provide students with meaningful opportunities to apply theoretical knowledge in realistic and investigative contexts. The study concludes that forensic simulations are highly effective in promoting experiential and reflective learning, enabling students to analyze evidence, draw logical conclusions, and make sound judgments. This instructional method supports social and constructivist learning by strengthening students' investigative and analytical abilities.

Laboratory work and case-based instruction significantly contribute to students' understanding of scientific concepts, critical observation, and decision-making skills. While laboratory activities enhance precision and evidence-based reasoning, limitations in facilities and resources indicate the need for continuous improvement to maximize hands-on learning experiences. The findings show that students exhibit high levels of critical thinking, particularly in interpreting forensic evidence, applying logical reasoning, and analyzing crime scenes using scientific methods. These competencies reflect the effectiveness of science-based instruction in developing systematic, objective, and inquiry-driven thinking that is essential to criminology practice. A significant relationship exists between the effectiveness of science-based instructional methods and students' levels of critical thinking, indicating that improvements in instructional strategies lead to corresponding enhancements in analytical and reasoning abilities. Overall, the study addresses a gap in local pedagogical research by demonstrating that the strengthened integration of science-based instructional methods into the criminology curriculum is vital for improving students' critical thinking, problem-solving, reasoning, and decision-making skills, thereby enhancing their academic performance and professional readiness in the field of criminal justice.

Recommendations **-** The research findings presented in the conclusions explain the significant role of science-based instructional methods in enhancing criminology students' critical thinking skills. The recommendations below are presented to address the identified needs and strengthen instructional practices. The study suggests that criminology instructors and academic institutions should further utilize and expand

science-based instructional approaches, such as forensic simulations, laboratory work, and case-based instruction, as these methods provide meaningful learning experiences that strengthen students' analytical, logical, and decision-making abilities. Strengthening the integration of these strategies allows students to apply theoretical knowledge to realistic investigative situations, thereby improving engagement and higher-order thinking.

The research indicates that forensic simulations should be emphasized as an effective instructional tool, as they promote experiential and reflective learning. Institutions may enhance these activities by increasing their complexity and aligning them with real or locally contextualized investigative scenarios, including possible collaboration with law enforcement agencies, to further develop students' problem-solving and professional judgment. The study also suggests that laboratory-based instruction should be improved by investing in up-to-date facilities and equipment, as well as continuous faculty development. Redesigning laboratory activities to focus on inquiry-based, hypothesis-driven learning rather than purely procedural tasks may strengthen students' evidence-based reasoning, logical thinking, and ability to integrate theory with practice. In addition, the findings imply that case-based instruction should be more consistently integrated into criminology courses to help students connect scientific concepts with real-world crime analysis. This approach can enhance critical inquiry, evaluative skills, and systematic reasoning in investigative contexts. Overall, the research suggests that educational institutions should prioritize the effective implementation of science-based instructional methods in alignment with CHED Memorandum Order No. 5, Series of 2018. A balanced instructional approach that integrates cognitive, psychomotor, affective, experiential, and reflective learning may further enhance students' critical thinking, professional competence, and readiness for practice in criminal justice. For future studies, the researchers suggest examining the long-term and contextual effects of science-based instructional methods on the development of critical thinking through longitudinal or mixed-methods research designs. Exploring factors such as instructional fidelity, learning modalities, and learner characteristics may provide deeper insights to refine evidence-based practices in criminology education.

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