The Effectiveness of Multimodal Learning in Enhancing Forensic Science Mastery among Third-Year Criminology Students at Isabela State University-Cauayan City Campus

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ABSTRACT

Multimodal learning, which integrates visual, aural/auditory, reading/writing, and kinesthetic methods, is increasingly recognized as an innovative approach that caters to diverse learning styles and enhances student engagement. Despite its growing application, the specific effects of multimodal learning within forensic science education remain insufficiently explored. The main objective of this study was to determine the effectiveness of multimodal learning on the academic performance and engagement of third-year Criminology students studying Forensic Science at Isabela State University, Cauayan City Campus, School Year 2024–2025. Using a pretest-posttest control group design with 118 participants, demographic data were analyzed through frequency counts and percentage distributions, while paired t-tests assessed the significance of differences between pretest and posttest scores. Results showed a statistically significant improvement in posttest scores for the experimental group, which transitioned from beginning to advanced proficient, while the control group only reached proficient. Students reported increased engagement and deeper understanding of forensic science concepts, demonstrating the positive impact of multimodal strategies on learning outcomes and involvement. A primary output of this study is the development of contextualized learning materials tailored for forensic science, providing a tangible contribution to the field. These findings emphasize the importance of integrating multimodal learning into forensic science curricula, offering evidence-based guidance for educators and curriculum developers. This pedagogical approach not only improves academic achievement but also better prepares criminology students for their future professional roles, contributing meaningfully to effective teaching practices in higher education.

Keywords: Multimodal learning, Forensic Science, Criminology education, Academic performance, Student engagement

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I. INTRODUCTION

The efficacy of multimodal learning within science education has transitioned from a contemporary pedagogical trend to a foundational requirement in diverse higher education environments. Multimodal learning involves the strategic integration of varied teaching techniques—such as visual, audio, reading, and kinesthetic—to enhance student engagement and cognitive processing (Al-Jarf, 2024). By combining information obtained through multiple sensory perceptions, educators can facilitate a unified understanding of complex subjects that a single mode of representation often fails to convey (Luo, 2023).

In the specialized field of forensic science, the limitations of traditional "trimodal" (lecture, text, and static image) instruction are particularly acute. These passive methods excel at theoretical memorization but consistently fail to bridge the critical gap to actual laboratory application, leaving students ill-equipped for the discipline's core demands. Forensic Science is inherently a performance-based field requiring high-order kinesthetic and tactile precision—skills like precise pipetting for blood typing, controlled staining of evidence samples, and methodical swabbing under simulated crime scene constraints—that cannot be adequately developed through observation alone.

According to Edgar Dale's (1969) Cone of Experience, learners retain only 10% of what they read or hear in lectures, compared to 90% of what they "do" through direct, purposeful kinesthetic experience. For third-year Criminology students, executing forensic protocols—such as blood grouping and typing—demands this shift from passive trimodal absorption to active manipulation of tools and specimens. Multimodal instruction allows students to experience learning in ways they are most comfortable with while challenging them to engage in new sensory modes (Al-Jarf, 2024). By integrating visual ensembles and interactive tools, teachers can effectively cater to the diverse modal preferences of a modern student body (Huang et al., 2023), ensuring that theoretical concepts are successfully translated into professional readiness.

The necessity for this instructional shift is further underscored by the socio-economic profile of the Isabela State University (ISU) student population. Institutional data reveals that 35.59% of the student body originates from low-income households, while a significant 75.42% utilize smartphones as their primary interface for academic engagement. In this context, multimodal learning—facilitated by Information and Communication Technologies (ICT)—serves as a critical instrument for inclusive education that bypasses traditional resource barriers.

As Fon Tabe Wilson and Falna Taubic (2022) argue, the diffusion of ICT into daily life urges a shift from conventional literacy pedagogy to contemporary approaches that integrate digital tools into daily lessons. By leveraging mobile technology, ISU can deploy "resource-light, engagement-heavy" materials that provide simulated laboratory experiences to students who may face financial or geographical barriers to consistent face-to-face instruction. This aligns with recent research at Isabela State University (ISU) indicating that well-structured multimodal approaches can mitigate the challenges of

remote education and that customized Learning Management Systems (LMS) can efficiently support a wide range of instructional needs (Paguirigan, 2023).

While existing literature highlights the positive impact of multimodal learning on student performance, there remains a scholarly void regarding its contextualization for high-stakes practical sciences like Criminology within the Philippine provincial context. Science educators must prioritize instructional strategies that cater to the predominant learning styles of their students to improve academic achievement (Alom et al., 2024).

Hence, the purpose of this study is to evaluate the effectiveness of Multimodal Learning in Forensic Science among third-year Criminology Students at Isabela State University, Cauayan Campus, for the Academic Year 2024–2025. This research seeks to provide a localized basis for the development of contextualized learning materials on blood groups and blood typing, ultimately enhancing the professional readiness and analytical proficiency of future criminal justice practitioners.

Guided by this, the study sought to answer the following questions:

1. What is the profile of the control and experimental groups in terms of:
    a. Age
    b. Sex
    c. Family monthly income
    d. Parents' occupation
    e. Previous exposure to Multimodal Learning
    f. Frequency of exposure to Multimodal Learning
    g. Preferred mode/s of learning (Visual, Aural/Auditory, Reading/Writing, Kinesthetic/Tactile learning)
    h. Internet connection availability
    i. Device/gadget availability (laptop, cellphone, tablet, desktop computer)
2. What are the pre-test scores of the control and experimental groups?
3. What are the post-test scores of the control and experimental groups?
4. Is there a significant difference in the knowledge levels of the control and experimental groups in their pretest and posttest scores?
5. What learning material can be developed in teaching Forensic Science?

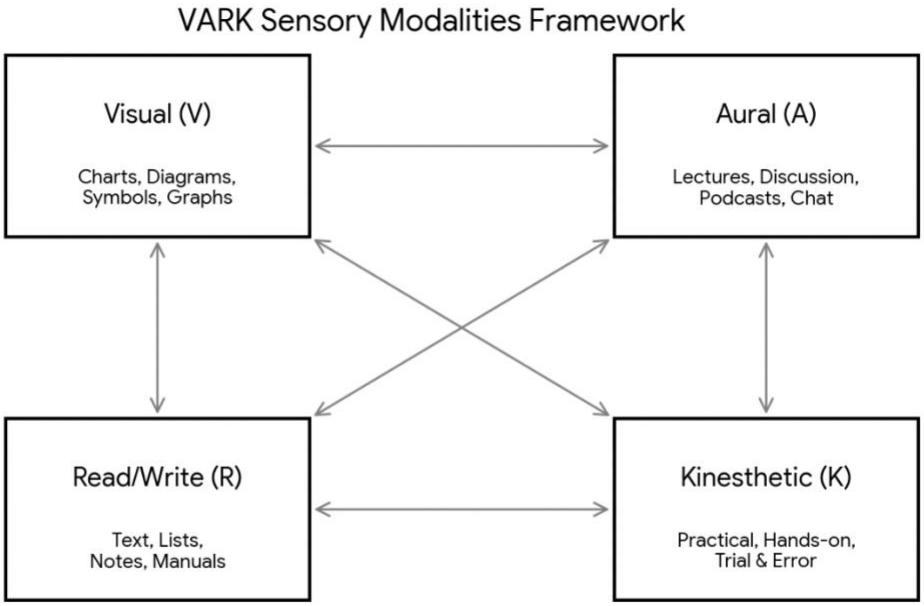
Theoretical Framework

This study used the Learning Style Theory (VARK Model) by Neil Fleming and the Cognitive Load Theory by John Sweller. The theoretical framework for this study is grounded in the principles of multimodal learning, which posit that individuals learn best when exposed to multiple modes of information presentation. This framework is particularly relevant in science education for third-year criminology students at Isabela State University, as it seeks to enhance understanding and retention of complex scientific concepts through diverse instructional strategies.

Students have different preferences in the assimilation and processing of information. The VARK model, created by Neil Fleming, is a widely recognized framework for understanding learning preferences. It categorizes learners into four styles based on how they prefer receiving and processing information: Visual, Aural (Auditory), Reading/Writing, and Kinesthetic. The researcher believes that this tool will help tailor her teaching methods to accommodate diverse learning preferences and enable her to develop effective learning strategies.

Figure 1

VARK Learning Model adapted from Alduais (2018), linking VARK learning styles with vocabulary teaching and learning theories.

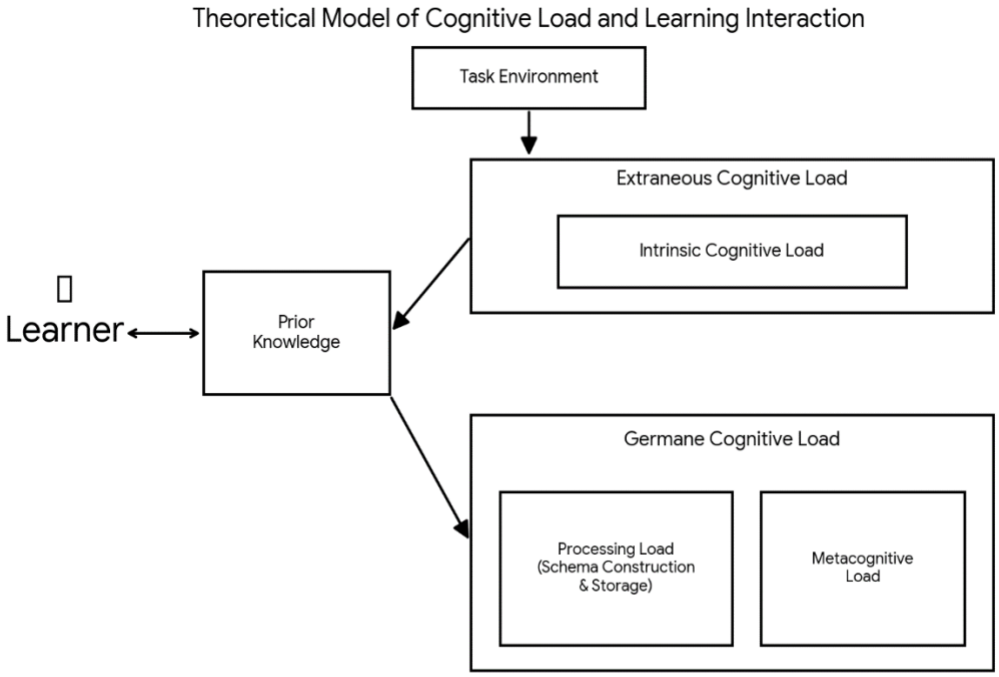


On the other hand, Cognitive Load Theory by John Sweller "suggests that our working memory can only hold a small amount of information at any one time and that instructional methods should avoid overloading it to maximize learning" (Paas & van Merriënboer, 2020). This model explains that learning is more effective when instructional design reduces unnecessary mental demands and keeps working memory load manageable. The researcher believes that multimodal learning can help manage the cognitive load by distributing information across different channels (e.g., visuals, text, audio), thereby reducing the burden on working memory. This approach will allow students to process information more efficiently and enhance their ability to retain complex concepts.

The VARK Learning Theory of Neil Fleming and the Cognitive Load Theory of John Sweller were adapted to determine the effectiveness of the multimodal instructional approach among the third-year criminology students at Isabela State University, Cauayan City Campus.

Figure 2

Cognitive Load Theory Model adapted from Parte et al. (2018)



Research Paradigm

This study's paradigm employs the Input-Process-Output-Outcome (IPOO) model to evaluate multimodal learning in Forensic Science. The input phase profiles students by demographics, socio-economic status, and technological access, while capturing baseline knowledge via pretest scores to comprehensively assess pre-intervention conditions.

The process phase conducts a comparative analysis of an experimental group using quad-modal instruction against a control group with tri-modal methods, followed by statistical analysis of posttest scores. Outputs include contextualized learning materials on blood typing, driving the outcome of enhanced student competency. A feedback loop iteratively refines inputs from outcomes, optimizing future applications.

II. METHODS

This study employed a quasi-experimental pretest-posttest nonequivalent groups design to determine the effectiveness of multimodal learning in Forensic Science among third-year Criminology students at Isabela State University, Cauayan City Campus. The experimental group received a 2-hour multimodal learning intervention (integrating visual, auditory, kinesthetic, and reading/writing elements), while the control group underwent a 1-hour traditional lecture-based session on the same content. This design assessed improvements in student engagement and academic performance without random assignment, as it was neither feasible nor ethical in the intact classroom setting. As Higgins et al. (2025) note, quasi-experimental methods are best used in research aimed at identifying the effectiveness of interventions when random assignment is not feasible or ethical.

A. Respondents of the study

The Criminology students of Isabela State University, Cauayan City Campus have a total population of 711 students for the A.Y. 2024–2025. The main sources of data of this study is exclusive for the selected third-year criminology students of Isabela State University, Cauayan Campus, A.Y. 2024–2025, since the Forensic Science subject is only offered in this curriculum. The third-year criminology students of Isabela State University, Cauayan City Campus total population is one hundred sixty-six (166). There are three sections, namely, BS Crim 3A, BS Crim 3B, and BS Crim 3C.

Table 1.
Population of the Third-Year Criminology Students

Section	Male	Female	No. of Students	Male %	Female %	Sample Size
BS Crim 3A	31	22	53	58.49	41.51	**38**
BS Crim 3B	30	24	54	55.56	44.44	**38**
BS Crim 3C	32	27	59	54.23	45.76	**42**
TOTAL	**93**	**73**	**166**	**56.02**	**43.98**	**118**

The data presented in Table 1 provides a clear breakdown of the male and female student populations across the three sections, along with their respective percentages and computed sample size.

To distribute a sample proportionately across the three sections of the Bachelor of Science in Criminology program, the researcher identified the number of students in each section and calculated an appropriate sample size based on the total population and desired margin of error using Slovin's formula. Likewise, the sample size was determined using Slovin's formula, yielding 118 third-year Criminology students (experimental: 59; control: 59) from intact classes. Profile variables were analyzed via one-way ANOVA and multiple regression to control for covariates and isolate multimodal learning's effects.

Using proportional distribution based on student numbers, the researcher was able to gather insights that accurately reflect the views and experiences of students across

all three sections. This approach ensures that the sample is representative of the entire population while allowing for a focused study on the selected sections.

Table 2.
Number of respondents in the Control and Experimental Group

	Control Group *Tri-modal approach: (Visual Learning, Aural, Reading/Writing)*		**Experimental Group** *Quad-modal approach: (Visual, Aural, Reading/Writing, Kinesthetic learning)*		**Total Count**	**Percentage**
	F	%	F	%	F	%
Male	31	52.54	36	61.02	67	56.78
Female	28	47.46	23	38.98	51	43.22
Total	59	100	59	100	118	100

The data presented in Table 2 provides a clear breakdown of the male and female respondents in the control and experimental groups, along with their respective frequencies, percentages, and the instructional approach used by the researcher.

The participants in this study were assigned using a quasi-experimental design, in which random assignment was not employed. Instead, participants were grouped based on existing conditions and availability, with careful attention given to maintaining comparability between the treatment and comparison groups. Relevant characteristics, such as demographic profile and prior performance, were considered in the grouping process to reduce bias and improve the validity of the findings. This approach was deemed appropriate because it allowed the researcher to examine the effect of the intervention within a natural setting where randomization was not practical or possible.

B. Research Instruments

In gathering the data needed for the study, the researcher used two (2) kinds of instruments: Pretest and Posttest. The 25-item pretest/posttest was used to measure students' understanding of blood groups and blood typing in forensic science before and after using the traditional method for the control group and multimodal learning for the experimental group. The instrument was made by the researcher and was pilot tested on the third-year criminology students of Our Lady of the Pillar College-Cauayan. The reliability of the instrument was determined using the Kuder–Richardson formula, yielding a coefficient of a=0.78.

C. Data Gathering Procedures

To conduct this study, the researcher first sought and obtained permission from the Dean of the College of Criminal Justice and Education and the Executive Officer at Isabela State University, Cauayan City Campus. This approval allowed access to necessary documents and the use of university students as respondents.

For validity, the researcher refined the questionnaire based on feedback from her research adviser and the quality assurance team. A 25-item pretest was then administered to both groups prior to intervention: the control group received the trimodal learning approach, while the experimental group was introduced to the quad-modal learning approach. Lessons on blood groups and blood typing in forensic science followed. The experimental group experienced the quad-modal approach—incorporating visual, aural/auditory, reading/writing, and kinesthetic/tactile elements—through a PowerPoint presentation, interactive demonstrations where the researcher performed real-time blood typing with actual samples for observation, and hands-on group laboratory activities using kits with blood samples and anti-sera.

Students who donated small blood amounts completed consent forms beforehand. In contrast, the control group followed the traditional trimodal approach (visual, aural/auditory, reading/writing) via a structured lecture-discussion, with slides illustrating principles, methodologies, practical applications, agglutination reactions, and blood type charts.

After the interventions, a 25-item posttest was given to both groups. The researcher then thoroughly explained each item and its interpretation as respondents completed the questionnaire. Finally, scores were collected, tallied, tabulated, and analyzed to address the study's problems.

III. RESULTS AND DISCUSSION

This study's first research question aims to describe the profile of the control and experimental group in terms of age. Data revealed that 34 respondents from the control group are 20 years old (57.63%), 21 respondents are 21 years old (35.59%), and 4 respondents are 22 years old (6.78%). On the other hand, in the experimental group, 38 of the respondents are 20 years old (64.41%), 19 respondents are 21 years old (32.20%), and 2 respondents are 22 years old (3.39%).

The findings also indicate that most of the respondents are 20 years old with a total frequency of 72 respondents from the control and experimental groups (61.02%). According to Kabayan Remit (2021), "this age distribution aligns with typical trends in the Philippines, where students usually enter college at around 16 or 17 years old, making them approximately 20–21 years old by their third year." This aligns with the country's educational system, which typically sees students completing high school by age 18 due to the K-12 curriculum and entering college shortly thereafter.

Most of the respondents in the control group were males with 31 respondents (52.54%), while 28 respondents (47.46%) were females. On the other hand, most of the respondents in the experimental group were also males with 36 respondents (62.02%), while 23 of the respondents were females (38.98%). The findings indicate that out of 118 respondents, 67 respondents (56.78%) were males and 51 of the respondents were females (43.22%) in the control and experimental groups.

The findings of the study are supported by the study of Angehrn et al. (2021) that males are "predominant in criminal justice careers because of physical demands and societal stereotypes associated with roles like policing and corrections." These perceptions have historically influenced the gender distribution in such fields, contributing to a higher representation of males in criminal justice education and professions. However, this study revealed that females are becoming more visible in the male-dominated career, which gradually shifts the gender dynamics. This indicates that women are now more empowered through equality and equity in education and inclusion in criminal justice careers and other male-dominated careers.

Table 1.
Demographic Profile of Respondents (Control and Experimental Groups)

Variable	Category	Control (n=59)	%	Experimental (n=59)	%	Total (n=118)	%
Age	20	34	57.63	38	64.41	72	61.02
	21	21	35.59	19	32.20	40	33.90
	22	4	6.78	2	3.39	6	5.08
Sex	Male	31	52.54	36	61.02	67	56.78
	Female	28	47.46	23	38.98	51	43.22
Family Monthly Income	5,000–10,000	13	22.03	17	28.81	30	25.42
	10,001–15,000	23	38.98	19	32.20	42	35.59
	15,001–20,000	11	18.64	16	27.12	27	22.88
	20,001–25,000	7	11.86	4	6.78	11	9.32
	25,001–30,000	4	6.78	3	5.08	7	5.93
	30,001 and above	1	1.69	0	0.00	1	0.85
Parents' Occupation	Blue-Collar	24	20.33	17	14.41	41	17.37
	Red-Collar	31	26.27	35	29.66	66	27.96
	Pink-Collar	7	5.93	3	2.54	10	4.24
	White-Collar	2	1.69	1	0.85	3	1.27
	Gold-Collar	0	0.00	0	0.00	0	0.00
	Self-Employed/Informal	42	35.59	51	43.22	93	39.41
	Unemployed/Retired	12	10.17	11	9.32	23	9.75

Notes: Percentages are computed within each group.
Total N = 118 respondents (59 control, 59 experimental).
Parents' occupation totals reflect combined reporting for father and mother per category.

The table also shows that in the control group, most of the respondents fall within the family monthly income range of 10,001–15,000 with 23 respondents (38.98%), while the lowest frequency is in the category of 30,000 and above with 1 respondent (1.69%). In

the experimental group, most of the respondents also fall within the family monthly income range of 10,001–15,000 with 19 respondents (32.20%), while the lowest frequency is in the category of 25,001–30,000 with 3 respondents (5.08%), and there is none reported to have a family income range of 30,000 and above (0%).

The findings show that in terms of combined family monthly income, the highest frequency belongs to the range between 10,001–15,000 with a total frequency of 42 respondents (35.59%) in the control and experimental groups. This implies that the combined family monthly income of most respondents falls under low-income earners.

According to Mendoza et al. (2022), "the prevalence of the income between 10,000–15,000 range among families with members studying in state universities in the Philippines can be attributed to a combination of economic conditions, access to affordable education, and socio-economic factors that prioritize education as a means of social mobility." The prioritization of education as a pathway to social mobility is deeply rooted in Filipino cultural values and is reinforced by government policies aimed at democratizing access to higher education. The implementation of tuition-free programs in state universities, such as the Universal Access to Quality Tertiary Education Act, has significantly reduced financial barriers for low-income families, enabling more students from economically challenged backgrounds to pursue higher education.

Lastly, data revealed that in the control group, most of the respondents' parents' occupation was under the category of self-employed/informal sector, mostly farmers and small business owners, with 42 respondents (35.59%), followed by red collar jobs (public servants, military personnel, public school teachers, and healthcare workers working in public hospitals) with 31 respondents (26.27%), followed by blue collar jobs (driver, mechanic, welder, electrician, maintenance worker) with 24 respondents (20.33%), while the lowest frequencies belong to unemployed/retired with 12 respondents (10.17%), followed by pink collar jobs (housekeeper/maid, florist, secretary assistant) with 7 respondents (5.93%), and white collar jobs (private teacher, engineer) with 2 respondents (1.69%). However, there were no respondents whose parents' occupation was under the category of gold collar jobs (scientist/researcher, IT specialists) (0%).

On the other hand, in the experimental group, most of the respondents' parents' occupation was also under the category of self-employed/informal sector, mostly farmers and small business owners, with 51 respondents (43.22%), followed by red collar jobs (public servants, military personnel, government officials, public school teachers) with 35 respondents (29.66%), followed by blue collar jobs (driver, mechanic, welder, electrician, maintenance worker) with 17 respondents (14.41%), while the lowest frequencies belong to unemployed/retired with 11 respondents (9.32%) and white collar jobs (private teacher) with 1 respondent (0.85%). However, there were no respondents whose parents' occupation was under the category of pink collar and gold collar jobs, respectively (0%).

The findings reveal that a significant proportion of respondents' parents were self-employed or in the informal sector, primarily as farmers and small business owners. This category accounted for 93 respondents (39.41%) across both the control and experimental groups. This implies that many respondents came from households with potentially unstable or unpredictable income streams.

According to Cabegin (2023), "Many students in state universities in the Isabela region of the Philippines have parents who are farmers or work in the informal sector because these occupations are prevalent in rural areas, where agriculture is a primary source of livelihood." This demographic trend reflects the broader socio-economic landscape of rural areas in the Philippines, where agriculture plays a significant role in the local economy.

Table 2 also shows the frequency and percentage distribution of the respondents according to previous exposure to multimodal learning.

Table 2.

Profile of Respondents according to Previous Exposure to Multimodal Learning

	Control Group (N=59)		**Experimental Group (N=59)**		**Total Count**	**Percentage**
	F	*%*	*F*	*%*	*F*	*%*
With previous Exposure	59	100	59	100	**118**	**100**
No Exposure	0	0	0	0	**0**	**0**

It shows that all the 118 respondents (100%) both in the control and experimental group reported having previous exposure to multimodal learning, while none reported a lack of exposure to multimodal learning (0%).

This implies that all participants in both the control and experimental groups had prior experience with multimodal learning, indicating a homogeneous background in terms of exposure to this educational approach. This uniformity could potentially influence the outcomes of the study by minimizing variability due to differences in prior exposure, allowing for a more focused analysis of the effects of the intervention being tested.

Moner et al. (2024), supported the results of this study and stated that "Multimodal learning has become prevalent in the Philippines due to the increasing integration of technology in education and the adoption of blended learning approaches." These efforts reflect a shift toward student-centered teaching practices that leverage multiple modes of learning, such as face-to-face instruction combined with digital technologies.

The Table 3 presents the frequency and percentage distribution of the respondents according to frequency of exposure to multimodal learning. It shows that most respondents in the control group are exposed to multimodal learning on a weekly basis

with 57 respondents (96.61%), followed by daily exposure with only 2 respondents (3.39%).

On the other hand, most respondents in the experimental group are also exposed to multimodal learning on a weekly basis with 53 respondents (89.83%), followed by daily exposure with 6 respondents (10.16%).

The findings indicate that most of the respondents were exposed to multimodal learning on a weekly basis with a total frequency of 110 (93.22%), followed by daily exposure with a total frequency of 8 (6.78%). There were no respondents who reported monthly, yearly, or never having exposure to multimodal learning in the control and experimental group. This consistent exposure suggests that Multimodal learning is an integral part of their educational environment, potentially influencing their learning outcomes and preferences.

Table 3

Profile of Respondents according to Frequency of exposure to Multimodal Learning

Frequency of exposure to Multimodal Learning	Control Group (N=59)		Experimental Group (N=59)		Total Count	Percentage
	F	*%*	*F*	*%*	*F*	*%*
Daily	2	3.39	6	10.16	**8**	**6.78**
Weekly	57	96.61	53	89.83	**110**	**93.22**
Monthly	0	-	0	-	0	-
Yearly	0	-	0	-	0	-
Never	0	-	0	-	0	-

According to the Department of Education (2020), such widespread adoption of multimodal learning strategies "aligns with the Philippine education system's emphasis on innovative and inclusive learning approaches." In the Philippine setting, the Department of Education (DepEd) has been promoting the use of technology and multimedia resources to enhance teaching and learning experiences. This integration of multimodal learning is consistent with the country's efforts to modernize education and prepare students for a rapidly changing global environment. As a result, it is likely that multimodal learning will continue to play a significant role in shaping educational outcomes and preferences among Filipino students.

Meanwhile, Table 7 shows the frequency and percentage distribution of respondents in terms of their preferred mode/s of learning. It is revealed that 24 respondents in the Control group (40.68%) preferred a single style of learning (Uni-modal). Of these, 7 respondents (11.86%) preferred visual style, 4 respondents preferred aural/auditory style (6.78%), 2 respondents preferred reading/writing style (3.39%), and 11 respondents preferred kinesthetic/tactile style (18.64%). Among the rest of 35 respondents who preferred more than one style of learning (Multimodal), 11 respondents (18.64%) chose two modes of learning (bimodal), 9 respondents (15.25%) chose three

modes of learning (trimodal), and 15 respondents (25.42%) chose four modes of learning (quad-modal).

On the other hand, 20 respondents in the Experimental group, (33.89%) preferred a single style of learning (Uni-modal). Of these, 4 respondents (6.78%) preferred visual style, 6 respondents preferred aural/auditory style (10.17%), 3 respondents preferred reading/writing style (5.08%), and 7 respondents preferred kinesthetic/tactile style (11.86%). Among the rest of 39 respondents who preferred more than one style (Multimodal), 7 respondents (11.86%) chose two modes of learning (bimodal), 13 respondents (22.03%) chose three modes of learning (trimodal), and 19 respondents (32.20%) chose four modes of learning (quad-modal) respectively.

Table 4

Profile of Respondents according to Preferred Mode/s of Learning

Preferred mode/s of learning	Control Group (N=59)		Experimental Group (N=59)		Total Count	Percentage
	F	*%*	*F*	*%*	*F*	*%*
Uni-modal (Single style)						
Visual	7	11.86	4	6.78	11	9.32
Aural/Auditory	4	6.78	6	10.17	10	8.47
Reading/Writing	2	3.39	3	5.08	5	4.24
Kinesthetic/Tactile	11	18.64	7	11.86	18	15.25
Total	**24**	**40.68**	**20**	**33.89**	**44**	**37.29**
Multimodal (Multiple styles)						
Bimodal	11	18.64	7	11.86	18	15.25
Tri-modal	9	15.25	13	22.03	22	18.64
Quad-modal	15	25.42	19	32.20	34	28.81
Total	**35**	**59.32**	**39**	**66.10**	**74**	**62.71**

The findings indicate that 74 respondents (62.71%) from both the Control and Experimental group preferred Multimodal learning style, among the multimodal preferences, Quad-modal was the most favored style with a total frequency of 34 (28.81%). On the other hand, the Unimodal preferences with a total of 44 respondents (37.29%) from the control and experimental group, Kinesthetic/Tactile was the most favored style with a total frequency of 18 respondents (15.25%), while reading/writing had the least preference with a total frequency of 5 respondents (4.24%).

This implies that most respondents in both the Control and Experimental groups tend to prefer learning through multiple modalities, with a significant preference for the Quad-modal style. This suggests that incorporating diverse learning modalities, such as visual, aural/auditory, reading/writing, and kinesthetic/tactile, could be more effective in engaging learners compared to relying on a single modality.

The preference for Multimodal learning styles over Unimodal styles indicates that educational strategies should consider integrating various teaching methods to cater to a broader range of learning preferences. Additionally, the relatively low preference for

reading/writing as a Unimodal style highlights the potential for educators to explore alternative methods beyond traditional text-based learning.

Sia and Cabanilla (2021), explored the learning styles and preferences of students in Philippine educational settings and found that "students generally preferred multimodal learning styles, which include visual, auditory, reading/writing, and kinesthetic approaches." This finding supported the present study. The study suggested that educators should incorporate diverse teaching methods to cater to these varied learning preferences. This approach not only enhances student engagement but also improves academic performance, as students are able to learn through methods that best suit their individual preferences.

Reflected in Table 8 is the frequency and percentage distribution of respondents in terms of Internet Connection Availability**.** It is revealed that in the Control group, the majority has access to mobile data with 37 respondents (62.71%), while 22 respondents (37.29%) have access to Wi-Fi.

Table 6

Profile of Respondents according to Internet Connection Availability

Internet connection Availability	Control Group (N=59)		Experimental Group (N=59)		Total Count	Percentage
	F	*%*	*F*	*%*	*F*	*%*
Mobile Data	37	62.71%	44	74.58%	81	68.64
WIFI	22	37.29%	15	25.42%	37	31.36
None	0	0	0	0	0	0

On the other hand, most of the respondents in the Experimental group have access to mobile data with 44 respondents (74.58%), while 15 respondents (25.42%) have access to Wi-Fi. There were no respondents in the Control and Experimental group who reported having no internet connection at all.

The findings indicate that majority of the respondents from the Control and Experimental group have access to mobile data with a total frequency of 81 respondents (68.64%), while a smaller proportion have access to Wi-Fi with a total frequency of 37 respondents (31.36%), there were no respondents who reported having no internet connection at all.

This implies that "the prevalence of mobile data access among respondents reflects the country's reliance on mobile networks for internet connectivity, which is often more accessible and affordable than fixed-line internet services like Wi-Fi" (DataReportal, 2025). This widespread availability of mobile data can facilitate the implementation of mobile-based services, educational programs, or interventions, especially in areas where fixed internet infrastructure is limited.

Table 5

Profile of Respondents according to Device/Gadget Availability

Device/Gadget Availability	Control Group (N=59)		Experimental Group (N=59)		Total Count	Percentage
	F	%	*F*	%	*F*	%
Smartphone	41	69.49%	48	81.36%	89	75.42
Tablet	4	6.78%	2	3.39%	6	5.08
Laptop	11	18.64%	8	13.56%	19	16.10
Desktop computer	3	5.08%	1	1.69%	4	3.39

Table 5 presents the frequency and percentage distribution of respondents in terms of Device/Gadget Availability. Findings show that in the Control group, 41 respondents have access to smartphones (66.49%), followed by 11 respondents (18.64%) have access to laptops, 4 respondents (6.78%) have access to tablets, and only 3 respondents (5.08%) have access to desktop computers. On the other hand, 48 respondents in the Experimental group have access to smartphones (81.36%), followed by 8 respondents (13.56%) have access to laptop, 2 respondents (3.39%) have access to tablet and 1 respondent (1.69%) have access to desktop computers respectively.

The findings indicate that most of the respondents in the Control and Experimental group have access to smartphones with a total frequency of 89 (75.42%), while the lowest frequency with 4 respondents (3.39%) have access to desktop computers. According to DataReportal (2025), "in the Philippine setting, mobile devices are the primary means of accessing digital information and services, reflecting a broader trend where smartphones have become ubiquitous tools for communication and information access." This widespread availability of smartphones aligns with the country's high mobile penetration rate and highlights the potential for mobile-based interventions or services to reach a large segment of the population effectively.

B. Pre-test Scores of Respondents

Research Question 2 aimed to determine the pretest scores of the Control and Experimental group. The frequency and percentage distribution of the pretest scores of the students in the Control group and Experimental group is presented in Table 6.

Table 6

Pretest Scores of the Students in the Control and Experimental Group

Scores	Control Group (N=59)		Experimental Group (N=59)		Qualitative Description
	F	%	*F*	%	
3-7	27	45.76%	36	72.88%	Beginning
8-13	31	52.54%	23	27.12%	Developing
14-17	1	1.69%	0	0%	Approaching Proficient
18-20	0	0%	0	0%	Proficient
21-25	0	0%	0	0%	Advanced Proficient

Findings show that in the Control group, the scores between 10-13 had the highest frequency of 31 respondents (52.54%) with a verbal description of developing level of proficiency. It is followed by a score of 3-9 under the beginning level of proficiency with a frequency of 27 respondents (45.76%). A score of 14-17 had the lowest frequency with 1 approaching proficient student (1.69%). However, there were no recorded students' scores between 18-20 and 21-25 (0%).

On the other hand, in the Experimental group, the highest frequency of scores is between 3-9 (36 respondents, 72.88%) with a verbal description of beginning level of proficiency, it is followed by a score of 10-13 range under developing level of proficiency with 23 respondents (27.12%), there were no respondents scoring in the highest ranges (14-17, 18-20, and 21-25). Verbal descriptions show that the students in the Control group were under developing level of proficiency while students in the Experimental group were in the beginning level of proficiency in the pretest.

This implies that the students in the Control group is slightly higher, labelled as "developing" and the Experimental group as "beginning". These findings indicate that the control group performs better than the experimental group in the pretest. This suggests that both groups started at almost similar levels of proficiency before the intervention and that any differences observed after the intervention are more likely attributable to the effects of the intervention itself rather than pre-existing disparities in proficiency levels.

According to WWC (2020), "when groups are similar at the beginning of a study, any observed differences after an intervention are more likely due to the intervention itself." This aligns with the idea that if both the control and experimental groups start at almost similar levels of proficiency, any differences observed post-intervention can be attributed to the effects of the intervention.

C. Posttest Scores of Respondents

The study also aimed to determine the Posttest scores of the Control and Experimental group. The frequency and percentage distribution of the post-test scores of the students in the Control and Experimental Group is shown in Table 7.

Table 7

Frequency and Percentage Distribution of the Posttest Scores of the Students in the Control and Experimental Group

Scores	Control Group (N=59)		Experimental Group (N=59)		Qualitative Description
	F	%	*F*	%	
3-7	0	0%	0	0%	Beginning
8-13	0	0%	0	0%	Developing
14-17	23	39%	1	1.7%	Approaching Proficient

18-20	27	46%	16	27.1%	Proficient
21-25	9	15%	42	71.2%	Advanced Proficient

Findings of the study show that students in the control group have the highest frequency in scores between 18–20 (27 respondents, 46%), followed by a frequency between 14–17 (23 respondents, 39%). The lowest frequencies were seen in the scores between 21–25, with only 9 respondents (15.25%) achieving scores in the highest range, while there were no respondents scoring in the two lowest score ranges of 3–9 and 10–13.

On the other hand, in the experimental group, the highest frequency of scores is between 21–25 (42 respondents, 71.2%), followed by a frequency of 18–20, with 16 respondents (27.1%). Only 1 respondent scored between 14–17 (1.7%), and notably, there were no respondents scoring in the lowest two ranges (3–9 and 10–13). Verbal descriptions show that the students in the control group were proficient and students in the experimental group were advanced proficient in the post-test.

The data clearly indicate a shift towards higher scores in the experimental group, with a significant number of students achieving scores in the 21–25 range, categorized as "advanced proficient." In contrast, the control group's scores are concentrated in the "proficient" range (18–20), with a smaller percentage reaching the highest score range. This suggests that multimodal learning strategies may lead to a better understanding and retention of the material, resulting in higher achievement on the post-test.

According to Deshmukh et al. (2025), the utilization of multimodal learning is a more effective method for improving student engagement, comprehension, and retention compared to traditional unimodal approaches. This supports the assertion that incorporating multiple learning modalities can enhance student engagement and comprehension, ultimately leading to improved academic performance. By leveraging a combination of visual, auditory/aural, reading/writing, and kinesthetic approaches, students in the experimental group were able to grasp complex concepts more effectively, which is reflected in their higher post-test scores. This outcome aligns with Doruk's findings, suggesting that multimodal learning strategies can be a valuable tool for educators seeking to optimize student outcomes.

D. Significant difference in the knowledge levels of the control and experimental groups in their pretest and posttest scores

Table 8 presents the test of difference in the pretest scores between the Control and Experimental groups.

Table 8

Test of Difference between the Pretest of the Control and Experimental Group

Groups	Mean	SD	Df	t-value	p-value
Control	21.56	10.71	48	0.805	0.4248

Experimental	19.04	11.41			

Note: Level of significance a = 0.05.

The control group (M = 21.56, SD = 10.71) and experimental group (M = 19.04, SD = 11.41) did not differ significantly in their pretest scores, $t(48) = 0.805$, p = 0.4248. The control group was classified at the developing level, while the experimental group was classified at the beginning level. These findings indicate that the control group performs better than the experimental group in the pretest. However, pretest scores are statistically the same, revealing no significant difference.

According to Moore et al. (2019), the lack of statistical significance shown in the table indicates that the observed differences in mean scores do not necessarily reflect a meaningful difference in initial proficiency levels between the control and experimental group, and that any differences observed after the intervention are more likely attributable to the effects of the intervention itself rather than pre-existing disparities in proficiency levels. This suggests that both groups started at almost similar levels of proficiency before the intervention and any observed post-intervention differences can be more confidently attributed to the intervention's impact rather than to initial disparities in proficiency levels.

Table 9

Test of Difference between the Posttest of the Control and Experimental Group

Groups	Mean	SD	Df	t-value	p-value
Control	44.4	8.86	48	-3.344	0.0016*
Experimental	51.76	6.53			

**Significant at a = 0.05.*

Findings of the study show that the control group (M = 44.40, SD = 8.86) and experimental group (M = 51.76, SD = 6.53) differed significantly in their posttest scores, t(48) = -3.344, p = 0.0016. The experimental group obtained a higher mean score than the control group after multimodal learning was utilized. The findings suggest that when students were taught and aided by Multimodal learning as an intervention, they performed better in their posttest.

According to the study of Luo (2023), which explored the effectiveness of multimodal learning in enhancing student engagement and understanding, "multimodal approaches can significantly improve learning outcomes by leveraging multiple senses and cognitive pathways, fostering deeper comprehension, retention, and engagement." This aligns with the findings of this study, where multimodal learning led to a better academic performance compared to traditional methods.

The difference between the pretest and posttest scores of the Control group is presented in Table 10. Pretest scores had a standard deviation of 10.71 while Posttest scores had 8.86. The difference between pretest and post-test had a p-value of < 0.001.

Verbal description shows that the control group were classified as under developing level of proficiency before the administration of traditional teaching then transitioning to proficient level after traditional teaching was administered. Thus, there is a significant difference between pretest and post-test scores of the Control group, rejecting the hypothesis of the study.

Table 10.

Test of Difference between the Pretest and Posttest Scores of the Control Group

Tests	Mean	SD	Df	t-value	p-value
Pretest	21.56	10.71	48	-8.217	< 0.001*
Posttest	44.40	8.86			

**Significant at a= 0.05.*

Analysis reveal that pretest scores (M = 21.56, SD = 10.71) and posttest scores (M = 44.40, SD = 8.86) differed significantly, $t(48) = -8.217$, $p < 0.001$. Verbal description shows that the control group were classified as under developing level of proficiency before the administration of traditional teaching then transitioning to proficient level after traditional teaching was administered. Thus, there is a significant difference between pretest and post-test scores of the Control group, rejecting the null hypothesis of the study.

This implies that incorporating traditional method to the control group can lead to a significant improvement in scores. This outcome indicates that even without additional interventions, the standard educational approach can yield substantial results, which may challenge the necessity of more complex or multimodal methods for the control group.

According to Gray, 2020, traditional methods can be effective when they are well-structured and when teachers provide clear guidance, feedback, and support to students. This aligns with the findings from the control group, where the significant improvement in scores suggests that traditional teaching methods can be effective when implemented correctly.

Lastly, the test of difference between the pretest and posttest scores of the experimental group is reflected in Table 11. Pretest scores (M = 19.04, SD = 11.41) and posttest scores (M = 51.76, SD = 6.53) differed significantly, $t(48) = -12.439$, $p < 0.001$. Verbal description shows that the experimental group were classified as under beginning level of proficiency before the administration of multimodal learning then transitioning to advanced proficient level after multimodal learning was administered. Thus, there is a significant difference between pretest and post-test scores of the experimental group, rejecting the null hypothesis of the study.

Table 11

Test of Difference between the Pretest and Posttest Scores of the Experimental Group

Tests	Mean	SD	Df	t-value	p-value
Pretest	19.04	11.41	48	-12.439	< 0.001*
Posttest	51.76	6.53			

**Significant at a= 0.05.*

This implies that the use of Quad-modal learning may have been more effective than tri-modal learning because it provided a more complete match to the students' preferred multimodal styles. Since 62.71% of the respondents preferred multimodal learning and quad-modal was the most favored mode, the instructional approach likely resonated with the majority of learners, leading to better engagement and higher posttest performance. Moreover, the decrease in standard deviation from 11.41 to 6.53 indicates that the intervention not only improved scores but also made performance more uniform, suggesting that multimodal instruction helped balance learning outcomes across students of different proficiency levels.

This aligns with the findings in the study of Deshmukh et al. (2025), indicating that "multimodal learning interventions are beneficial and effective in improving student learning outcomes, which can increase motivation and depth of understanding among learners." Such approaches meet the criteria for a comprehensive, engaging, and effective teaching strategy.

IV. CONCLUSION

The respondents, predominantly 20-year-old males from families with monthly incomes of ₱10,001–₱15,000 (parents mostly self-employed farmers or small business owners), had prior weekly exposure to multimodal learning; 62.71% (n=74) preferred it and owned smartphones with mobile data. Understanding this socioeconomic profile and learning preferences enables educators to tailor forensic science instruction, boosting academic performance while addressing personal challenges.

Both groups showed significant pretest-posttest gains ($p < 0.05$), but multimodal learning propelled the experimental group from beginning to advanced-proficient levels in blood groups and typing—outpacing the control group's shift from under developing to proficient levels via traditional methods. This underscores multimodal integration's superiority for criminology students.

Lastly, multimodal approaches—blending visual diagrams/videos, auditory discussions, reading/writing activities, and kinesthetic lab experiments—bridge the gap between theoretical forensic concepts and field-ready criminal investigations. By mirroring real-world complexity (evidence analysis under pressure), they cultivate critical thinking, problem-solving, retention, and adaptability, ensuring third-year criminology students at Isabela State University, Cauayan Campus, emerge not just knowledgeable, but professionally resilient investigators equipped for diverse, high-stakes scenarios in an interconnected world.

V. RECOMMENDATIONS

Based on the results of this study, the following recommendations are proposed to enhance multimodal learning in forensic science education. First, school administrators should prioritize funding for kinesthetic tools like laboratory kits, alongside professional development opportunities that emphasize multimodal learning through technology, training, and infrastructure upgrades. They must also establish robust support systems to equip teachers with the essential tools and resources needed for effective implementation, while regularly monitoring the progress and effectiveness of these initiatives to pinpoint and address areas for improvement.

Curriculum planners are encouraged to design science curricula that weave in multimodal approaches and real-world forensic science applications, thereby boosting student engagement and understanding. To stay current, they should regularly update these curricula to incorporate the latest advancements in forensic science and multimodal strategies.

Teachers play a pivotal role by shifting to mobile-accessible multimodal materials optimized for smartphones—used by 75.42% of students—and mobile data, which 68.64% rely on, while integrating kinesthetic methods to deepen lesson comprehension. They should foster active participation and collaboration via interactive multimodal activities and provide regular feedback on student performance within these environments.

Future researchers can build on this work by replicating the study with larger samples across different year levels to validate findings, examining the impacts of varied teaching strategies on academic performance and engagement, and investigating the long-term effects of multimodal learning on knowledge retention and forensic science application. Additionally, they should equalize instructional time—such as 1.5–2 hours for both groups—to better isolate modality effects from dosage differences.

Finally, the researcher is urged to pursue further studies that verify, confirm, and refine these results, collaborate with other institutions to expand the study's scope and settings, and publish findings in academic journals to advance discussions on multimodal learning in forensic science.

VI. LIMITATIONS

This study is delimited to blood groups and blood typing within forensic science. It does not extend to other forensic disciplines, such as ballistics or toxicology, and results should not be assumed to apply broadly without further testing.

The scope is limited to third-year criminology students enrolled in the Forensic Science subject at Isabela State University, Cauayan Campus, during S.Y. 2024–2025. The researcher administered a pretest to both the control and experimental groups. The control group used a traditional trimodal approach (visual, aural/auditory, and

reading/writing) via lecture discussions with PowerPoint presentations. The experimental group used a multimodal quadmodal approach, incorporating visual (PowerPoint presentations), aural/auditory (verbal explanations of concepts), reading/writing (handouts on blood groups and blood typing), and kinesthetic/tactile (hands-on laboratory activities). Its effectiveness as a teaching strategy was based on the pre-test and post-test scores of the respondents.

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