RESEARCH PAPER

Optimizing Forensic Document Examination Instruction Through Image Analysis Technology

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Abstract
The integration of technology in forensic science education has become increasingly important as institutions seek more effective, evidence-based approaches to teaching complex investigative disciplines. This study examined the perceived effectiveness of an image analysis technology system designed to optimize forensic document examination instruction at Laguna State Polytechnic University (LSPU), a state university in the Philippines. Grounded in outcomes-based education principles and aligned with the mandates of the Commission on Higher Education, the system was developed as a pedagogically sound instructional tool for the Forensic Questioned Document Examination course offered in the Criminology program. Using a descriptive survey research design, 181 respondents, including Criminology students and faculty members from five LSPU campuses, participated in the study. Respondents assessed the system across four dimensions: Academic and Curriculum Alignment, Instructional Effectiveness, Skill Development, and Usability. All four dimensions were rated within the Highly Agree range, with Academic and Curriculum Alignment receiving the highest rating and Usability the lowest, though still strongly favorable. The overall perception of the system was consistently positive across all campuses, indicating broad instructional utility regardless of campus context. To determine whether campus location influenced perceptions of effectiveness, a non-parametric comparative analysis was conducted. Results revealed no statistically significant differences across the five campuses, affirming that the system performs equitably across geographically and institutionally diverse learning environments. The null hypothesis was therefore not rejected. These findings support the viability of deploying image analysis technology as a scalable instructional framework for forensic document examination in higher education institutions, with targeted recommendations for usability improvement, infrastructure support, and future longitudinal research.

Keywords: forensic document examination, image analysis technology, instructional effectiveness, questioned documents, technology-based instruction

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1. Introduction

Questioned document examination (QDE) is a crucial sub-discipline of forensic science (Yang et al., 2024) that aims to provide the authority conducting legal proceedings with precise, accurate knowledge confirming or excluding the authenticity of a document under examination for court litigation (Cieśla, 2020). QDE involves the analysis of handwriting, printing, and typewriting and requires the presence of an expert who can analyze large datasets, extract meaningful information, and answer court queries (Kumar & Sharma, 2023).

Forensic handwriting examination is a critical part of the criminal justice system, seeking to determine whether a document can be attributed to a specific author (Kulik & Nikonets, 2016). Documents are considered written evidence when their content is relevant to the case and physical evidence when their external characteristics have evidentiary value (Kovalenko & Shapovalov, 2024). Handwriting is technically described as a brain-writing process in which images and instructions are transmitted from the brain to the arm, hand, and fingers (Morris, 2020). The scientific methodology for its forensic examination is based on individual characteristics that are significantly different from others, such as line quality, alignment, slant, letter formation, and rhythm (Yadav et al., 2021).

The comparative method is universally accepted in forensic document examination, enabling the expert to reach a technically and methodologically sound conclusion about authenticity (Kipouràs, 2022). The four main steps of this method—Analysis, Comparison, Evaluation, and Verification (ACE-V)—were identified by Crown et al. (2024) as foundational to structured forensic inquiry. However, one of the most challenging aspects of QDE arises in high-tech criminal cases, where the scientific proof of evidence, presented as expert opinion, becomes paramount (Gupta, 2020).

With the emergence of new computing technologies, additional objective examination techniques have become available to determine the authenticity of questioned signatures (Malik et al., 2014). Meena et al.

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(2025) noted that machine learning-based models are increasingly used alongside manual examination, and Chechil (2025) affirmed that artificial intelligence does not replace the forensic expert but strengthens their capabilities. The growing digitalization of handwriting provides qualitative and quantitative information about the dynamics of the writing process, leading to several frameworks being considered for analysis (Sharma & Jasua, 2024).

Despite this paradigm shift, the educational sector has been slower to adopt technology-based instructional approaches to QDE. Handwriting experts recommend that schools encourage students to systematically consider transcription, length, and content during signature analysis (Tamošiūnaitė, 2022). The importance of quality assurance programs that include verification and technical review has also been underscored (Hicklin et al., 2022). In this context, researchers at Laguna State Polytechnic University developed a forensic questioned document examination application that integrates image analysis technology and serves as a pedagogically sound instructional tool to enhance the teaching and learning of QDE.

2. Research Methodology

2.1. Research Design

This study used a descriptive survey design to assess the perceived effectiveness of an image-analysis-technology-based system for forensic document examination instruction. This design is appropriate for systematically gathering and analyzing responses from a defined population to describe characteristics and perceptions at a given point in time (Creswell & Creswell, 2018).

2.2. Respondents

The respondents of this study were instructors teaching Forensic Questioned Document Examination and Criminology students enrolled at Laguna State Polytechnic University across five campuses. A total of 181 respondents participated, comprising 174 students (96.1%) and 7 faculty members (3.9%), distributed across the Sta. Cruz Campus (n = 58), Los Banos Campus (n = 37), Lopez Satellite (n = 33), San Pablo City Campus (n = 33), and Siniloan Campus (n = 20). All respondents provided informed consent and indicated voluntary participation before completing the survey.

2.3. Research Instrument

The research instrument was a validated 20-item survey questionnaire organized into four dimensions: (A) Academic and Curriculum Alignment, (B) Instructional Effectiveness, (C) Skill Development, and (D) Usability—each with five sub-indicators. Responses were measured on a four-point Likert scale: 4 (Highly Agree), 3 (Agree), 2 (Disagree), and 1 (Strongly Disagree). The following statistical limits and qualitative interpretations were applied:

Scale	Statistical Limit	Qualitative Description	Interpretative Description
4	3.25 – 4.00	Highly Agree (HA)	Fully supports acceptance; system is highly effective and meets instructional objectives
3	2.50 – 3.24	Agree (A)	Generally supports acceptance; system is effective and contributes positively to instruction
2	1.75 – 2.49	Disagree (D)	Does not adequately support acceptance; system has limited effectiveness
1	1.00 – 1.74	Strongly Disagree (SD)	Clearly does not support acceptance; system is ineffective and does not meet instructional objectives

The instrument underwent expert validation by specialists in forensic science and educational research. Content validity was established through a formal validation process before data collection.

2.4. Data Collection and Analysis

Data were collected via a Google Form administered to respondents across all five LSPU campuses. Descriptive statistics (mean and standard deviation) were computed for each item and dimension to address the second research question. To test the hypothesis of no significant difference in perceived effectiveness by campus location, the Kruskal-Wallis H test was used, a non-parametric alternative to one-way ANOVA appropriate for ordinal Likert-scale data with more than two independent groups. The significance level was set at $\alpha = .05$. All analyses were conducted in Python using the SciPy library.

3. Results and Discussion

3.1. Perceived Effectiveness of the Image Analysis Technology System

Table 1 presents the mean scores and standard deviations for all 20 items across the four dimensions, along with section means and an overall mean.

Table 1 Perceived Effectiveness of the Image Analysis Technology System by Dimension and Item (N = 181)

Code	Sub-Indicator	Mean	SD	Interpretation
A1	The system aligns with program outcomes and course competencies.	3.60	0.49	Highly Agree
A2	The system supports CHED/Accreditation requirements (e.g., OBE, PAASCU, ISO).	3.59	0.49	Highly Agree
A3	The system enables constructive alignment between teaching, learning, and assessment.	3.57	0.50	Highly Agree
A4	The system provides materials or tools relevant to laboratory and research courses.	3.57	0.51	Highly Agree
A5	The system supports capstone, thesis, and research activities.	3.57	0.51	Highly Agree
	Section Mean – Academic and Curriculum Alignment	**3.58**	**0.50**	**Highly Agree**
B1	The system improves students' understanding of comparative examination concepts.	3.58	0.51	Highly Agree
B2	The system helps clarify complex document examination techniques.	3.51	0.53	Highly Agree
B3	The system enhances students' ability to differentiate handwriting characteristics.	3.58	0.53	Highly Agree
B4	The use of the system strengthens the clarity of classroom instruction.	3.57	0.53	Highly Agree
B5	The system contributes to better long-term retention of lessons.	3.56	0.52	Highly Agree
	Section Mean – Instructional Effectiveness	**3.56**	**0.52**	**Highly Agree**
C1	The system improves students' accuracy in evaluating questioned documents.	3.52	0.53	Highly Agree
C2	The system enhances students' skills in identifying handwriting variations.	3.56	0.53	Highly Agree
C3	The system enhances students' ability to deduce an opinion or conclusion based on the result of the comparative examination.	3.55	0.52	Highly Agree
C4	The system promotes hands-on learning that strengthens practical skills.	3.60	0.51	Highly Agree
C5	The system helps students to compare handwriting samples more effectively.	3.60	0.51	Highly Agree
	Section Mean – Skill Development	**3.56**	**0.52**	**Highly Agree**
D1	The system is easy to use.	3.47	0.56	Highly Agree
D2	The interface is intuitive and simple to navigate.	3.49	0.52	Highly Agree
D3	The tools and features are well organized and user-friendly.	3.55	0.52	Highly Agree
D4	The system tools are easy to locate for document examination.	3.57	0.52	Highly Agree
D5	Overall, the usability of the software enhances students' learning experience.	3.57	0.52	Highly Agree
	Section Mean – Usability	**3.53**	**0.53**	**Highly Agree**
	OVERALL MEAN	**3.56**	**0.52**	**Highly Agree**

Note. Scale: 4 = Highly Agree (3.25–4.00); 3 = Agree (2.50–3.24); 2 = Disagree (1.75–2.49); 1 = Strongly Disagree (1.00–1.74). SD = standard deviation.

The overall mean of 3.56 (SD = 0.52), interpreted as Highly Agree, indicates that respondents across all five LSPU campuses strongly perceived the image analysis technology system as effective in supporting instruction in forensic document examination. This finding aligns with the growing body of literature affirming that technology-based instructional tools enhance learning outcomes in forensic and professional programs (Meena et al., 2025; Sharma & Jasua, 2024).

Academic and Curriculum Alignment (Section A) had the highest section mean (M = 3.58, SD = 0.50), indicating that respondents strongly agreed that the system aligns with program outcomes, CHED requirements, and OBE principles. Items A1 and A2 registered 3.60 and 3.59, respectively, affirming that the system effectively supports curriculum mandates and accreditation standards, including PAASCU and ISO. This aligns with CHED's emphasis on outcomes-based education in criminology programs, where QDE is a core competency (Bird & Yang, 2025).

Instructional Effectiveness (Section B) yielded a section mean of 3.56 (SD = 0.52), interpreted as Highly Agree. Items B1 ("The system improves students' understanding of comparative examination concepts") and B3 ("The system enhances students' ability to differentiate handwriting characteristics") both had means of 3.58, indicating robust instructional value. The slightly lower mean for B2 (M = 3.51) suggests some variability in perceived clarity of complex document examination techniques, consistent with the literature noting that high-tech QDE remains a challenging instructional domain (Gupta, 2020).

Skill Development (Section C) had a mean of 3.56 (SD = 0.52), with the highest scores on C4 ("The system promotes hands-on learning") and C5 ("The system helps students compare handwriting samples more effectively"), both at 3.60. The comparatively lower score on C1 (M = 3.52, "The system improves students' accuracy in evaluating questioned documents") suggests that while the system is highly regarded for promoting active learning, further scaffolding may be needed to develop evaluative accuracy—a complex, expert-level skill (Hicklin et al., 2022).

Usability (Section D) had the lowest section mean of 3.53 (SD = 0.53), though it was still interpreted as Highly Agree. Items D1 ("The system is easy to use," M = 3.47) and D2 ("The interface is intuitive and simple to navigate," M = 3.49) scored lowest across all 20 items, reflecting the interface learning curve noted by some respondents in their open-ended comments. This aligns with technology adoption research indicating that initial usability challenges can dampen early perceptions even when educational value is high (Harika et al., 2024). Items D4 and D5 scored higher (M = 3.57), indicating that once users are oriented, the system's organizational features and learning-enhancement value are well recognized.

3.2. Differences in Perceived Effectiveness by Campus Location

Table 2 presents the mean scores per dimension for each of the five campuses, and Table 3 presents the results of the Kruskal-Wallis H test.

Table 2 Mean Perceived Effectiveness Scores per Campus and Dimension

Campus	n	Section A Mean	Section B Mean	Section C Mean	Section D Mean	Overall Mean
Sta. Cruz Campus	58	3.57	3.60	3.58	3.57	3.58
Los Banos Campus	37	3.65	3.61	3.63	3.63	3.63
Lopez Satellite	33	3.64	3.62	3.68	3.55	3.62
San Pablo City Campus	33	3.56	3.45	3.50	3.42	3.48
Siniloan Campus	20	3.42	3.42	3.33	3.36	3.38

Note. All section means are interpreted as Highly Agree (3.25–4.00). Overall mean per campus is the average of Sections A–D.

Table 3 Kruskal-Wallis H Test: Perceived Effectiveness by Campus Location

Dimension	H-statistic	df	p-value	Decision	Interpretation
Academic and Curriculum Alignment	5.4064	4	0.2481	Fail to Reject H_0	No significant difference
Instructional Effectiveness	5.7664	4	0.2173	Fail to Reject H_0	No significant difference
Skill Development	9.4157	4	0.0515	Fail to Reject H_0	No significant difference
Usability	7.7555	4	0.1010	Fail to Reject H_0	No significant difference

Dimension	H-statistic	df	p-value	Decision	Interpretation
Overall	8.4576	4	0.0762	Fail to Reject H_0	No significant difference

Note. df = degrees of freedom (4 campuses - 1 = 4). α = .05.

As shown in Table 2, all five campuses registered section means within the Highly Agree range across all four dimensions. Los Banos Campus recorded the highest overall campus mean (approximately 3.63), while Siniloan Campus recorded the lowest (approximately 3.36). Both remain within the Highly Agree range. The slight variation in scores—particularly the lower Usability means for San Pablo City Campus (3.42) and Siniloan Campus (3.36)—may reflect differences in device availability, internet connectivity, and prior technology exposure across campuses.

The Kruskal-Wallis H test results in Table 3 indicate that there are no statistically significant differences in perceived effectiveness across campus locations for any of the four dimensions: Academic and Curriculum Alignment ($H = 5.41$, $p = .248$), Instructional Effectiveness ($H = 5.77$, $p = .217$), Skill Development ($H = 9.42$, $p = .052$), and Usability ($H = 7.76$, $p = .101$). The overall Kruskal-Wallis test was likewise not significant ($H = 8.46$, $p = .076$). Accordingly, the null hypothesis—that there is no significant difference in the perceived effectiveness of the system by campus location—is not rejected.

These results are noteworthy for two reasons. First, they affirm that the image analysis technology system is perceived as equally effective across campus contexts, demonstrating instructional consistency across geographically and demographically distinct learning environments. Second, the p-value for Skill Development ($p = .052$), which narrowly missed significance, warrants attention in future studies with larger samples per campus, as it may indicate emerging differences in how students across campuses develop practical forensic skills through technology-mediated instruction.

4. Conclusions

The image analysis technology system developed for forensic document examination instruction at Laguna State Polytechnic University was perceived as highly effective across all four dimensions—Academic and Curriculum Alignment, Instructional Effectiveness, Skill Development, and Usability—by 181 respondents from five campuses. The overall mean of 3.56 (Highly Agree) affirms the system's instructional value and its alignment with CHED requirements and OBE principles. No significant differences in perceived effectiveness were found across campuses, supporting the system's equitable instructional utility institution-wide.

5. Recommendations

Based on the findings, the following recommendations are offered for the development and refinement of the technology-based instructional framework:

- Usability enhancement should be prioritized in the next iteration of the system. Given that D1 and D2 registered the lowest item means, developers should conduct user experience testing and revise the onboarding and navigation interface to reduce initial learning barriers.
- Scaffolded instructional modules targeting evaluative accuracy (C1) should be integrated into the system, incorporating guided comparative exercises and expert-curated feedback to bridge the gap between system exposure and expert-level judgment.
- Infrastructure support—particularly device and internet access—should be strengthened on campuses recording lower Usability scores (San Pablo City and Siniloan), as disparities in technological access may limit the system's full potential.
- The image analysis tool should be expanded to incorporate juxtaposition features (e.g., layered comparison with opacity control) and a live monitoring module, as respondents specifically suggested in open-ended comments.
- Future research should include a longitudinal or experimental design to assess actual learning outcomes—beyond perceived effectiveness—and expand the sample to include respondents from other HEIs that offer QDE-related courses.

6. Limitations

The present study involved only one state university in the Philippines, specifically the Laguna State Polytechnic University. Instructors teaching Forensic Questioned Document Examination and Criminology students served as respondents. The study relied on self-reported perceived effectiveness measured by a Likert-scale survey, which may be subject to response bias. Furthermore, the cross-sectional design does not allow causal inferences about the system's impact on actual learning achievement.

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