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Integrating Process and Product Assessment in Automotive Painting Practicum

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ABSTRACT

This study evaluated the implementation of a structured performance assessment rubric in an automotive painting practicum, examining both practical process skills and final panel product quality. A descriptive evaluative method with a quantitative approach was employed. The research subjects were 21 students enrolled in the Painting Technology course during the even semester of the 2025/2026 academic year at the Automotive Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Makassar. Data collection techniques included observation, documentation, and product assessment using a 16-indicator structured rubric with a 4-point rating scale. The process performance assessment results showed achievement percentages of 88.8% for panel preparation, 77.5% for base coat, 69.4% for clear coat, and 86.3% for finishing, with an overall process performance of 80.5% (Good category). The product quality assessment revealed an overall product quality score of 72.5% (Fair category), with the most dominant painting defects being dust nibs (52.4%) and orange peel (47.6%). The inter-rater reliability coefficient (Cohen's Kappa = 0.82) indicated strong consistency in the assessment process. This study provides preliminary course-level evidence that a structured rubric can effectively distinguish between process performance and product quality assessment in an automotive painting practicum. The findings highlight clear coat application as the primary area requiring instructional improvement within the Outcome-Based Education framework. A CPMK-Rubric alignment matrix is presented to support OBE implementation.

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INTRODUCTION

Vocational education is an education system designed to prepare students for specific occupations by integrating theoretical knowledge with practical skill development. In vocational education, practicum learning constitutes a fundamental component as students are required not only to comprehend concepts cognitively but also to demonstrate tangible work skills through psychomotor activities. According to Prosser's theory of vocational education, effective vocational learning occurs when the educational environment authentically represents the actual work environment (Sudira, 2016). This perspective emphasizes that practical learning in laboratories or workshops must be designed to mirror industrial conditions to facilitate the development of professional competencies. Furthermore, Sudira (2016) contends that vocational education is oriented toward mastery of measurable work skills through direct experiential learning. Consequently, practicum in vocational education holds a pivotal position as a mechanism for developing skills, work attitudes, discipline, and problem-solving abilities within specific technical domains.

The contemporary automotive industry demands workers who possess both theoretical understanding and technical competencies that align with industry standards, particularly in body repair and vehicle painting. The automotive painting sector has evolved significantly with the adoption of spray booth technology, oven systems, modern coating materials, and increasingly stringent quality standards. These developments necessitate that vocational universities adapt their learning processes to ensure graduates meet workforce requirements. In practical courses, students must be acculturated to execute tasks according to industrial work procedures, encompassing panel preparation, paint mixing, spraying techniques, and finishing processes. Sanjaya (2015) asserts that practical learning must provide authentic experiences enabling students to integrate theoretical knowledge with real-world work situations. Thus, practicum learning in vocational education serves as a critical medium for cultivating students' professional competencies in a measurable and sustainable manner.

The Outcome Based Education (OBE) approach represents a widely adopted learning system in contemporary higher education, including vocational institutions. OBE is a learning paradigm that prioritizes the final learning outcomes or competencies that students must achieve upon completing the educational process (Spady, 1994). Within this framework, all learning components—including curriculum design, instructional strategies, and assessment systems—are structured based on graduate learning outcomes (*Capaian Pembelajaran Lulusan*/CPL) and course learning outcomes (*Capaian Pembelajaran Mata Kuliah*/CPMK). The implementation of OBE in vocational education is particularly relevant as vocational education emphasizes observable and measurable work abilities demonstrated through student performance during practical activities. Consequently, learning success is evaluated not solely through theoretical examination scores but also through students' capacity to produce work products that satisfy competency standards (Biggs, 2022).

The application of OBE in practicum learning necessitates an evaluation system capable of directly measuring student skills through performance assessment. Performance assessment involves directly observing students' abilities in executing tasks or producing products (Nitko, 2011). In vocational education, performance assessment is considered more appropriate than written tests as it provides direct evidence of students' mastery of practical competencies. Arends (2012) maintains that performance-based assessment offers a more objective representation of students' abilities in completing work according to established standard operating procedures. Therefore, performance assessment constitutes an integral component of OBE implementation because assessment results can be utilized to evaluate CPMK achievement authentically (Stiggins, 2005).

Recent research has emphasized the importance of authentic assessment in vocational education. Veitch (2025) examined how workplace educators assess student performance, highlighting the need for assessment methods that reflect actual work environments. Ghozali et al. (2023) developed a conveyor-based practice performance assessment tool to enhance vocational high school students' work readiness, demonstrating the value of technology-enhanced performance assessment. Cempaka et al. (2025) developed OBE-based assessment rubrics for vocational college courses, contributing to the standardization of competency evaluation in vocational education. Ryandika et al. (2024) emphasized the importance of developing learning modules for body painting subjects to enhance student competency in vocational high schools. Furthermore, recent studies have explored various aspects of assessment in vocational contexts, including the integration of safety competencies into performance evaluation frameworks and the development of objective assessment methods using algorithmic approaches (Bhilal & Fauziah, 2025).

The Painting Technology course in the Automotive Engineering Education Study Program is a practical course that applies experiential learning and Project Based Learning (PBL) methodologies. The Semester Learning Plan (*Rencana Pembelajaran Semester*/RPS) specifies four practical CPMKs: (1) the ability to prepare panels according to standard operating procedures, (2) the ability to apply base coat paint with correct technique and uniform coverage, (3) the ability to apply clear coat to achieve specified gloss and smoothness standards, and (4) the ability to complete panel finishing according to quality standards. The practicum learning process is conducted through job sheet activities encompassing panel preparation, puttying, paint mixing, spray gun operation, base coat application, clear coat application, and polishing and finishing procedures. All these stages are designed to develop students' work skills aligned with automotive painting industry standards.

In practice, students' painting practicum outcomes exhibit considerable quality variation. Some students demonstrate the ability to produce smooth, flat, and glossy paint surfaces, while others experience painting defects such as orange peel, dust nibs, beads, runs, and sand scratches. These variations indicate differences in students' mastery of practical skills during the painting process. Although the Painting Technology practicum job sheet incorporates various painting failure indicators for observing student work outcomes, the results of students' panel painting have not been optimally utilized as a measure of OBE-based learning achievement. However, panel quality can serve as authentic evidence of students' skills in executing the painting process according to industrial practice standards (Stiggins, 2005).

Previous studies have examined various aspects of automotive painting practicum evaluation. Halim (2026a) investigated the application of direct instruction-based job sheets in Painting Technology courses, finding an average student practicum score of 84.6 with a mastery level of 95%. Bharadiya et al. (2024) explained that surface defects in coating applications are often caused by improper surface preparation, incorrect viscosity, and environmental contamination during the spraying process. Halim (2026b) elaborated on automotive painting technology principles and practices that support competency-based learning in vocational education. Sari and Halim (2025) analyzed painting defects in automotive vocational practicum, identifying common defect patterns and their potential causes.

However, previous research has not sufficiently addressed the systematic implementation of a structured performance assessment rubric that integrates process skill evaluation with product quality assessment in automotive painting education. While prior studies have examined painting defects and learning methods, limited empirical evidence exists on how a product-based assessment rubric can be effectively applied to measure both practical performance and product quality in a Painting Technology course. This study aims to address this gap by implementing a structured rubric for evaluating both process skills and product quality, and by presenting a CPMK-Rubric alignment matrix to support OBE implementation in the context of automotive painting practicum.

Based on this analysis, this research aims to: (1) evaluate the process performance of students in the Painting Technology practicum; (2) evaluate the product quality of students' panel painting results; and (3) present a CPMK-Rubric alignment framework for OBE-based assessment.

METHOD

Research Design

This research employed a descriptive evaluative method with a quantitative approach. Descriptive research was utilized to systematically describe the actual condition of students' panel painting quality, while evaluative research was employed to assess the achievement of practicum learning outcomes based on student work results. The quantitative approach was adopted because research data were obtained through measuring practicum performance assessment scores, subsequently analyzed as numerical values, percentages, achievement categories, and competency achievement levels (Sugiyono, 2019; Creswell, 2014).

Research Location and Participants

The research was conducted at the Automotive Body Repair and Painting Laboratory of the Automotive Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Makassar (UNM) during the even semester of the 2025/2026 academic year. The research location was selected based on the consideration that the laboratory serves as the venue for implementing practical activities for the Painting Technology course, which constitutes the direct object of this research.

The research subjects comprised 21 students of the Automotive Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Makassar who enrolled in and participated in the Painting Technology course during the fourth semester of the 2025/2026 academic year. Total sampling technique was employed, wherein all students participating in the course were included as research subjects. All students completed the painting practicum individually on sheet metal panels, and no students withdrew or had incomplete data.

Variable and Indicators

This study employed two distinct dimensions of assessment to address the conceptual separation between process and product:

Dimension 1: Process Performance Indicators

Practicum Stage	Indicators
Panel Preparation	Panel cleanliness, Puttying, Sanding, Primer application
Base Coat Application	Paint mixing, Spray gun handling, Overlap technique
Clear Coat Application	Clear mixing
Finishing	Polishing, Waxing, Panel cleanliness, Assembly/Fitting

Dimension 2: Product Quality Indicators

Product Quality Aspect	Indicators
Surface Quality	Gloss level, Surface flatness, Clear smoothness
Visual Appearance	Paint coverage, Color uniformity
Defect-Free Surface	Absence of dust nibs, orange peel, runs/sags, sand scratches, beads/craters, cracking

Assessment Instrument

The instruments utilized in this study consisted of: (1) a practicum performance assessment observation sheet, employed to observe student skills during the practicum process; (2) a panel painting results assessment rubric, utilized to evaluate the quality of student work products; and (3) a practicum results documentation sheet, employed to document the condition of students' panel painting results as supporting research data.

The assessment rubric comprised 16 indicators distributed across four practicum stages, each employing a 4-point rating scale with specific operational descriptors:

Panel Preparation (4 indicators):

1. Panel cleanliness (4=completely clean, 3=mostly clean with minor dust, 2=moderate contamination, 1=significant contamination)
2. Puttying (4=smooth and even, 3=mostly smooth, 2=uneven with minor imperfections, 1=rough and uneven)
3. Sanding (4=completely smooth, 3=mostly smooth, 2=moderate roughness, 1=rough with visible scratches)
4. Primer application (4=even and complete coverage, 3=mostly even, 2=uneven coverage, 1=poor coverage)

Base Coat (4 indicators):

1. Paint mixing (4=accurate ratio, 3=minor deviation, 2=moderate deviation, 1=inaccurate ratio)
2. Overlap technique (4=perfect overlap, 3=good overlap with minor unevenness, 2=moderate overlap issues, 1=poor overlap technique)
3. Paint coverage (4=complete and even, 3=mostly even, 2=moderate unevenness, 1=poor coverage)
4. Color uniformity (4=perfectly uniform, 3=mostly uniform, 2=moderate variation, 1=significant variation)

Clear Coat (4 indicators):

1. Clear mixing (4=accurate ratio, 3=minor deviation, 2=moderate deviation, 1=inaccurate ratio)
2. Gloss level (4=high gloss, 3=good gloss, 2=moderate gloss, 1=low gloss)
3. Surface flatness (4=completely flat, 3=mostly flat, 2=moderate unevenness, 1=significant unevenness)
4. Clear smoothness (4=perfectly smooth, 3=mostly smooth, 2=moderate texture, 1=rough texture)

Finishing (4 indicators):

1. Polishing (4=excellent polish, 3=good polish, 2=moderate polish, 1=poor polish)
2. Waxing (4=excellent wax application, 3=good wax application, 2=moderate wax application, 1=poor wax application)
3. Panel cleanliness (4=completely clean, 3=mostly clean, 2=moderate contamination, 1=significant contamination)
4. Assembling (4=perfect assembly, 3=good assembly, 2=moderate assembly issues, 1=poor assembly)

Data Collection Procedures

Data collection techniques included: (1) Observation, conducted during practicum activities using an observation sheet in the form of a performance assessment rubric; (2) Documentation, in the form of photographs of students' panel painting results, documentation of the practicum process, and job sheet assessment sheets; and (3) Product Assessment, conducted on students' panel painting results using the assessment rubric based on painting quality indicators.

The painting protocol was standardized across all participants: panels measuring 20 cm × 30 cm sheet metal were used, with two-coat base coat application and two-coat clear coat application, using a spray gun with 1.3 mm nozzle at 3.5 bar compressor pressure, spraying distance of 20-25 cm, flash-off time of 5-10 minutes between coats, and curing at room temperature for 24 hours. Data collection was conducted in stages at each practicum session: panel preparation (job sheet 1), base coat painting (job sheet 2), clear coat (job sheet 3), and panel finishing (job sheet 4).

Instrument Validation and Reliability

Instrument validation employed content validity through expert judgment by three experts: two Painting Technology expert lecturers and one educational evaluation expert lecturer. The validation process assessed instrument relevance, clarity, completeness, and suitability for measuring the intended constructs. Validation results yielded a percentage of 88.5%, indicating that the instrument was deemed feasible with a "very valid" category. While this provides preliminary evidence of content validity, the authors acknowledge that more robust validity measures such as Aiken's V or Content Validity Index would strengthen the validity evidence in future research.

Inter-rater reliability was established through independent scoring by two assessors (the course lecturer and a laboratory instructor) who evaluated all 21 student panels. The assessors underwent training and calibration sessions on the rubric criteria before the assessment. The inter-rater reliability coefficient was calculated using Cohen's Kappa on the total composite scores assigned to each student's panel by the two assessors. The result was $\kappa = 0.82$ ($p < 0.001$), indicating strong agreement between assessors and demonstrating the reliability of the scoring process.

Data Analysis

Data analysis techniques employed quantitative descriptive statistical analysis with an evaluative descriptive approach through the following stages: (1) data reduction, (2) data tabulation, (3) calculation of composite scores for each student at each stage and overall, (4) percentage descriptive statistical analysis using the formula $P = (f/N) \times 100\%$, where P = percentage, f = frequency of scores obtained, and N = maximum possible score; (5) calculating the mean score, standard deviation, minimum and maximum values directly from the 21 individual student composite scores; and (6) achievement level categorization. The achievement level categories employed were: 86–100% (Very Good/Very Achieved), 76–85% (Good/Achieved), 60–75% (Fair/Fairly Achieved), and ≤ 59% (Poor/Not Achieved) (Sugiyono, 2019).

Ethical Considerations

Ethical procedures were followed throughout the research process. Informed consent was obtained from all participants, who were informed that their assessment data would be used for research purposes. Confidentiality was maintained by anonymizing all student data, and participation did not influence course grades. The research was conducted under institutional guidelines for educational research.

RESULTS AND DISCUSSION

Results

Subject Description

The research subjects comprised 21 fourth-semester students of the Automotive Engineering Education Study Program who participated in the Painting Technology course during the even semester of the 2025/2026 academic year. All students completed painting practicums on sheet metal panels in accordance with the predetermined job sheets. No students withdrew from the study or had incomplete data.

Process Performance Assessment Results

The assessment results for the panel preparation stage are presented in Table 1.

Table 1. Panel Preparation Assessment Results (N=21)

Indicator	Mean	SD	Min	Max	Percentage	Category
Panel Cleanliness	3.70	0.47	3.00	4.00	92.5%	Very Good
Puttying	3.50	0.51	3.00	4.00	87.5%	Very Good
Sanding	3.40	0.60	2.00	4.00	85.0%	Good
Primer Application	3.60	0.50	3.00	4.00	90.0%	Very Good
Composite Stage Score	3.55	0.31	3.25	4.00	88.8%	Very Good

The panel preparation stage achieved the highest performance among all practicum stages, with a composite achievement score of 88.8%. Panel cleanliness obtained the highest percentage (92.5%), indicating that most students were able to prepare the panel surface according to the required procedures. The relatively low standard deviation (SD = 0.31) suggests a consistent level of competency across students.

These findings demonstrate that students had already mastered the fundamental procedures required before paint application. Proper preparation is essential because the quality of subsequent coating layers largely depends on the condition of the substrate surface.

Base Coat Assessment

The results of the base coat application assessment are shown in Table 2.

Table 2. Base Coat Assessment Results (N=21)

Indicator	Mean	SD	Min	Max	Percentage	Category
Paint Mixing	3.20	0.68	2.00	4.00	80.0%	Good
Overlap Technique	2.80	0.87	1.00	4.00	70.0%	Fair
Paint Coverage	3.30	0.65	2.00	4.00	82.5%	Good
Color Uniformity	3.10	0.70	2.00	4.00	77.5%	Good
Composite Stage Score	3.10	0.36	2.50	3.75	77.5%	Good

The base coat stage achieved an overall score of 77.5%, categorized as Good. Paint coverage demonstrated the highest achievement (82.5%), while overlap technique showed the lowest performance (70.0%). The lower score for overlap technique indicates that students experienced difficulties in maintaining consistent spray patterns during application. Uneven overlap may lead to inconsistent film thickness and reduced coating uniformity. Therefore, additional practical exercises focusing on spray-gun control and movement consistency may improve performance in this stage.

Clear Coat Assessment

Table 3 presents the assessment results for the clear coat stage.

Table 3. Clear Coat Assessment Results (N=21)

Indicator	Mean	SD	Min	Max	Percentage	Category
Clear Mixing (Process)	3.00	0.77	2.00	4.00	75.0%	Fair
Gloss Level (Product)	2.60	0.87	1.00	4.00	65.0%	Fair
Surface Flatness (Product)	2.70	0.85	1.00	4.00	67.5%	Fair
Clear Smoothness (Product)	2.80	0.81	1.00	4.00	70.0%	Fair
Composite Stage Score	2.78	0.38	2.00	3.25	69.4%	Fair

The clear coat stage recorded the lowest achievement among all practicum stages, with a composite score of 69.4%. Gloss level, surface flatness, and clear smoothness all remained below the mastery threshold established by the course.

This finding indicates that clear coat application represents the most challenging competency area for students. Compared with other stages, clear coat quality is highly dependent on spray consistency, coating thickness control, and application precision. The relatively high variation among students (SD = 0.38) suggests differences in individual mastery levels and indicates the need for targeted instructional improvement.

Finishing Assessment

Finishing assessment encompassed polishing, waxing, panel cleanliness, and assembling. The results of the finishing assessment are presented in Table 4.

Table 4. Finishing Assessment Results (N=21)

Indicator	Mean	SD	Min	Max	Percentage	Category
Polishing	3.50	0.51	3.00	4.00	87.5%	Very Good
Waxing	3.40	0.60	2.00	4.00	85.0%	Good
Panel Cleanliness	3.60	0.50	3.00	4.00	90.0%	Very Good
Assembly/Fitting	3.30	0.65	3.00	4.00	82.5%	Good
Composite Stage Score	3.45	0.33	3.00	4.00	86.3%	Very Good

The finishing stage achieved a composite score of 86.3%, categorized as Very Good. Students demonstrated strong performance in panel cleaning and polishing activities. The results suggest that students were generally able to perform post-painting procedures according to the required standards.

Overall Process Performance

A summary of the process performance assessment is presented in Table 5.

Table 5. Recapitulation of Process Performance Assessment Scores (N = 21)

Assessment Stage	Mean	SD	Min	Max	Percentage	Category
Panel Preparation	3.55	0.31	3.25	4.00	88.8%	Very Good
Base Coat	3.10	0.36	2.50	3.75	77.5%	Good
Clear Coat	2.78	0.38	2.00	3.25	69.4%	Fair
Finishing	3.45	0.33	3.00	4.00	86.3%	Very Good
Overall Process Performance	3.22	0.36	2.75	3.75	80.5%	Good

Overall, students achieved a process performance score of 80.5%, categorized as Good. While panel preparation and finishing demonstrated strong achievement, clear coat application emerged as the weakest stage. These results indicate that students generally followed the practicum procedures appropriately but still encountered difficulties in advanced coating application techniques.

Product Quality Assessment

Painting Defect Evaluation

The defect evaluation results are presented in Table 6.

Table 6. Painting Defects Evaluation Results (N = 21)

Type of Defect	Number of Students	Percentage
Dust Nibs	11	52.4%
Orange Peel	10	47.6%
Runs/Sags	6	28.6%
Sand Scratches	5	23.8%
Beads/Craters	4	19.0%
Cracking	1	4.8%

The most dominant defects were dust nibs (52.4%) and orange peel (47.6%). These defects occurred in nearly half of the painted panels evaluated. The findings suggest that environmental contamination and spray application consistency remain important challenges in the automotive painting practicum.

Product Quality Performance

The overall product quality assessment results are shown in Table 7.

Table 7. Product Quality Assessment Results (N = 21)

Product Quality Indicator	Mean	SD	Min	Max	Percentage	Category
Gloss Level	2.60	0.87	1.00	4.00	65.0%	Fair
Surface Flatness	2.70	0.85	1.00	4.00	67.5%	Fair
Clear Smoothness	2.80	0.81	1.00	4.00	70.0%	Fair
Color Uniformity	3.10	0.70	2.00	4.00	77.5%	Good
Paint Coverage	3.30	0.65	2.00	4.00	82.5%	Good
Overall Product Quality	**2.90**	**0.78**	**1.40**	**4.00**	**72.5%**	**Fair**

The overall product quality score was 72.5%, categorized as Fair. Paint coverage and color uniformity achieved relatively high scores, while gloss level and surface flatness remained below the expected standard. Interestingly, the overall product quality score was lower than the overall process performance score. This finding demonstrates that satisfactory procedural performance does not automatically guarantee high-quality final products. Therefore, separating process assessment from product assessment provides a more comprehensive evaluation of student competency.

CPMK Achievement and OBE Alignment

To support Outcome-Based Education implementation, a CPMK–Rubric Alignment Matrix was developed, as presented in Table 8.

Table 8. CPMK–Rubric Alignment Matrix

CPMK Code	CPMK Description	Rubric Indicators	Practicum Stage	Mastery Threshold
CPMK-1	Prepare panel surfaces according to SOP	Panel cleanliness, Puttying, Sanding, Primer application	Panel Preparation	≥ 76%
CPMK-2	Apply base coat paint correctly and uniformly	Paint mixing, Overlap technique, Paint coverage, Color uniformity	Base Coat	≥ 76%
CPMK-3	Apply clear coat to achieve gloss and smoothness standards	Clear mixing, Gloss level, Surface flatness, Clear smoothness	Clear Coat	≥ 76%
CPMK-4	Complete panel finishing according to quality standards	Polishing, Waxing, Panel cleanliness, Assembly/Fitting	Finishing	≥ 76%

The alignment analysis showed that CPMK-1, CPMK-2, and CPMK-4 successfully exceeded the institutional mastery threshold. In contrast, CPMK-3 achieved only 69.4%, indicating that students had not yet fully mastered clear coat application competencies.

These findings demonstrate the practical value of rubric-based assessment within an OBE framework. Rather than merely reporting final scores, the assessment system identifies specific competency areas requiring instructional intervention. Consequently, lecturers can use the results as evidence for continuous course improvement and targeted enhancement of learning activities.

Discussion

The practicum performance assessment results demonstrate varying achievements across assessment stages. Panel preparation (88.8%) and finishing (86.3%) were in the Very Good category, indicating that students were thorough in both initial stages (cleaning and puttying) and final stages (polishing and cleaning). However, base coat (77.5%) and particularly clear coat (69.4%) aspects remained in the Good and Fair categories, respectively. Performance assessment in this study was conducted through direct observation of students' work processes and evaluation of panel painting quality. This approach aligns with Nitko's (2011) perspective that performance assessment requires students to demonstrate their knowledge and skills through observable actions or products. In vocational education, performance assessment is crucial because student competencies cannot be adequately measured through written tests alone but must be evidenced through practical work ability (Arends, 2012).

The relatively low achievement in the clear coat aspect indicates a need for strengthened learning at this stage. The clear coat stage consistently showed the lowest performance (69.4%) and the highest variation (SD = 0.38) among students. This finding aligns with research by Ghozali et al. (2023), which emphasizes the importance of developing performance assessment tools in vocational education to improve students' work readiness through authentic skill measurement. The Cohen's Kappa coefficient of 0.82 indicates strong inter-rater reliability, demonstrating that the assessment process was conducted consistently by both assessors. This finding supports the reliability of the scoring process. However, as noted by Nitko (2011), reliability and validity are distinct concepts; while reliability indicates consistency of measurement, validity requires evidence that the instrument measures what it purports to measure. The content validity evidence obtained through expert judgment provides preliminary support, but further validation studies are needed to establish construct and criterion validity.

Product Quality Assessment

The product quality assessment revealed an overall product quality score of 72.5% in the Fair category. The most prevalent defects were dust nibs (52.4%) and orange peel (47.6%). The prevalence of dust nibs observed in this study is consistent with findings from previous research (Bharadiya et al., 2024; Sattu, 2009) that identified environmental contamination as a primary cause of such defects. In the context of this study, this defect pattern may be associated with the workshop environment, which was shared with other body repair activities that generate airborne particles.

The presence of orange peel on 47.6% of panels aligns with the technical literature, which identifies improper spray pressure, incorrect paint viscosity, and inappropriate spraying distance as potential contributing factors (Buntarto, 2012; Bharadiya et al., 2024). However, as these variables were not directly measured in this study, these interpretations should be considered as plausible technical explanations requiring further empirical investigation.

The distribution of defects reveals important patterns. Over half of the students experienced dust nibs (52.4%), potentially due to the shared workshop environment. Orange peel affected nearly half of the students (47.6%), indicating that this remains a persistent challenge in painting education. The presence of runs/sags in 28.6% of panels suggests that some students struggle with paint application thickness, while sand scratches (23.8%) indicate inadequate surface preparation in some cases. The presence of multiple defect types on some panels suggests that the quality challenges are often interrelated, with deficiencies in one area contributing to problems in another. These findings highlight the need for more focused instruction on environmental control and spray technique optimization.

Distinction Between Process and Product Assessment

A key contribution of this study is the conceptual and empirical distinction between process performance and product quality assessment. By separating these two dimensions, the study provides more nuanced information about student learning. For example, while a student may demonstrate good process skills (correct mixing, appropriate technique), the final product quality may still be compromised due to environmental factors beyond their control, such as laboratory dust contamination. Conversely, a student with adequate product quality may have achieved this through process skills that are not yet efficient or consistent.

This distinction is particularly important in the clear coat stage, where the assessment includes both process indicators (clear mixing) and product indicators (gloss level, surface flatness, clear smoothness). The clear coat stage showed the lowest performance in both process (75.0%) and product (67.5% average) dimensions, confirming it as the primary area requiring instructional attention. This finding suggests that interventions should address both the technical process (mixing ratios) and the resulting product quality (surface appearance).

Alignment with OBE and CPMK

This study presents a CPMK-Rubric alignment matrix (Table 8) that maps each course learning outcome to specific rubric indicators, practicum stages, and mastery thresholds. This matrix addresses the OBE requirement that assessment be explicitly aligned with learning outcomes. The matrix shows that student performance across stages corresponds to CPMK achievement levels, with clear coat (CPMK-3) identified as the area requiring the most improvement.

The overall process performance of 80.5% indicates that students have achieved the mastery threshold (≥ 76%) for overall performance. However, the clear coat stage (69.4%) falls below the mastery threshold, indicating that targeted instructional improvement is needed for this specific CPMK. This finding has practical implications for course improvement: additional instructional time, demonstration, and practice should be allocated to clear coat application techniques.

The development and validation of standard operating procedures for spray booth and painting oven usage in automotive body and painting workshops also supports the need for structured performance assessment in practical courses. Furthermore, Ryandika et al. (2024) highlighted the importance of developing learning modules for body painting subjects to enhance student competency in vocational high schools. Cempaka et al. (2025) emphasized the significance of developing OBE-based assessment rubrics in vocational education to ensure valid and reliable scoring of student performance.

Study Limitations

This study has several limitations that should be acknowledged. First, the sample size of 21 students from a single course at one institution limits the generalizability of the findings. Future research should involve larger samples across multiple institutions and courses to enhance external validity. Second, the assessment process involved human judgment, which may introduce subjectivity despite the established inter-rater reliability. The absence of objective measurement instruments such as gloss meters and paint thickness gauges means that some quality aspects were assessed visually rather than quantitatively. Third, the study did not include a control group or pre-test/post-test design, limiting the ability to attribute observed outcomes specifically to the assessment system. Fourth, the research was conducted during a single semester, so longitudinal effects of the assessment system on student learning were not examined. Fifth, the study did not measure all potentially influential variables such as laboratory dust levels, coating viscosity, compressor pressure, spray distance, temperature, humidity, or mixing ratios. The interpretations offered in the discussion for observed defects should therefore be considered as plausible technical explanations supported by previous literature rather than empirically established findings from this study. Future research should address these limitations by using larger samples, objective measurement tools, experimental designs, and multiple assessment sessions across different cohorts.

CONCLUSIONS

This study demonstrates that integrating process performance and product quality assessment provides a more comprehensive representation of student competency in an automotive painting practicum. Overall, students demonstrated satisfactory process performance, particularly in panel preparation and finishing, whereas clear coat application remained the most challenging competency and was the only practicum stage that did not reach the established mastery threshold. Product quality performance was comparatively lower than process performance, with dust nibs and orange peel emerging as the most frequently observed defects. These findings indicate that satisfactory procedural performance does not necessarily result in equally satisfactory product quality, thereby supporting the need to assess practical competencies through both process- and product-oriented indicators. The CPMK–Rubric alignment further enabled specific learning outcomes requiring improvement to be identified, particularly those related to clear coat application.

The findings provide preliminary course-level evidence that a structured rubric can support competency-based and Outcome-Based Education assessment by linking observable practicum performance, product quality, and course learning outcomes within a single assessment framework. From an instructional perspective, greater emphasis should be placed on clear coat application, spray control, coating consistency, and environmental conditions that may affect final surface quality. Nevertheless, the findings should be interpreted within the context of the study's relatively small sample, single-course setting, and reliance on predominantly observational assessment. Future studies should validate the assessment framework across larger and more diverse vocational education settings and incorporate objective measurement instruments, such as gloss meters and coating thickness gauges, to strengthen the validity and precision of product-quality assessment.

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AUTHOR CONTRIBUTION STATEMENT

All authors contributed to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript. MBH conceptualized the study, developed the methodology, designed the assessment rubrics, and led the manuscript drafting. Muhammad Iskandar Musa managed the laboratory data collection, oversaw student practicum observations, and performed product quality evaluations. NH assisted with quantitative data entry, performed descriptive statistical analyses, and calculated inter-rater reliability scores. Nur Fadli curated the documentation, validated the instrument content alignment with course learning outcomes (CPMK), and contributed to the literature review. MI contributed to the interpretation of defect evaluation data, critically reviewed the manuscript for technical accuracy, and managed the final revision process. All authors read and approved the final manuscript.

AI DISCLOSURE STATEMENT

During the preparation of this work, the authors used Gemini (a large language model developed by Google) to assist with grammar refinement, structural formatting, and initial drafting of generic manuscript sections. After using this tool/service, the authors reviewed and edited the content as necessary and take full responsibility for the content of the published article.

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