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The Impact of Employee Training and Skills Development on Production Performance in Coin Manufacturing Operations

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ABSTRACT

This study examined changes in technical competency and production performance following employee training and skills development in coin manufacturing operations. Using a quantitative one-group pretest–posttest design with a correlational component, all 12 coin press machine operators were assessed through a five-level competency skills matrix and official production records over 36 operating days before and 36 operating days after training. Wilcoxon signed-rank tests, paired-samples t-tests, and Spearman's rank-order correlations were employed. Overall technical competency increased from 3.12 to 3.98 ($p < 0.001$), with the largest gain in autonomous maintenance and troubleshooting. Average daily production output increased by 11.13%, while machine downtime and rejection rate decreased by 29.51% and 22.99%, respectively; all three performance changes were statistically significant. However, competency improvements were not significantly correlated with changes in production output, downtime, or rejection rate. These findings indicate favorable post-training changes in workforce competency and manufacturing performance without establishing that training alone caused them. Management should maintain competency-based training, strengthen standardized operating procedures, and regularly monitor operator skills and production indicators. The small sample, single setting, absence of a control group, and limited observation periods constrain causal inference and generalizability. By documenting measurable workforce and operational improvements, the study offers practical evidence relevant to SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production), particularly skills development, productive operations, and lower rejection rates.

Keywords: *Autonomous Maintenance, Coin Manufacturing, Employee Training, Production Performance, Rejection Rate, Skills Development, Technical Competency*

1. INTRODUCTION

Technological advancement, automation, and increasingly complex production systems have heightened the importance of workforce competency in manufacturing operations. Although modern equipment supports production efficiency, its effective utilization depends on employees' technical knowledge, operational proficiency, and ability to respond to equipment-related problems. Acerbi et al. (2022) emphasized the importance of structured competency assessment and workforce development in addressing manufacturing skill requirements, while Caterino et al. (2025) highlighted the need to evaluate how workforce training contributes to operational performance. Similarly, Herjuna et al. (2024) and Sija (2024) identified employee training and development as important factors associated with improved work performance in manufacturing environments. These concerns are particularly relevant to coin manufacturing, where operators must maintain equipment reliability, ensure consistent product quality, and achieve production targets under standardized operating conditions. Technical competency in Coin Press Machine (CPM) operation, autonomous maintenance and troubleshooting, and machine setup and conversion is essential to effective production management. Accordingly, this study examines employee competency and production performance before and after training, emphasizing operational productivity, machine downtime, and rejection rates.

Research Problem

Manufacturing performance depends on the interaction of workforce capabilities, equipment reliability, and production quality. Although employee training is widely recognized as an organizational development strategy, establishing whether improved technical competency corresponds to measurable operational improvement remains an important research concern. Acerbi et al. (2022) emphasized the need for competency assessment aligned with specific manufacturing requirements, while Caterino et al. (2025) identified continuing challenges in evaluating workforce training against actual production performance. Furthermore, Kose et al. (2023) demonstrated the importance of autonomous maintenance in improving equipment reliability, whereas Olalere and Ramdass (2024) highlighted the relationship between quality management practices and manufacturing performance. In coin manufacturing operations, inadequate competency in machine operation, troubleshooting, die setting, calibration, and machine conversion may contribute to equipment interruptions, production delays, and defective output. Operator-related factors can also influence manufacturing quality, as demonstrated by Real and Torres (2024). However, evidence directly examining competency development alongside production output, downtime, and rejection rates in coin press operations remains limited within the literature considered for this study. The central research problem is therefore to determine whether employee training and skills development are followed by significant improvements in technical competency and production performance and whether the magnitude of competency improvement is associated with corresponding changes in operational indicators.

Assumptions of the Study

The study proceeded on the operational assumptions that employees' technical competencies could be consistently evaluated through the established five-level skills matrix and that verified production records could provide comparable indicators of performance before and after training. Competency was assessed through CPM operation, autonomous maintenance and troubleshooting, and machine setup and conversion, while production performance was measured using daily output, machine downtime, and rejection rate. These measures provided the basis for evaluating changes across the two assessment periods. The study also recognized that competency development does not necessarily translate into proportional improvements in production outcomes. Training transfer depends on the application of acquired skills and may be

influenced by supervisory support, workplace conditions, and opportunities to perform learned tasks (Abd Razak & Zahidi, 2024; Mdhlalose, 2022). Accordingly, machine condition, tooling quality, material characteristics, maintenance support, production requirements, and operator-machine assignments were acknowledged as possible influences on performance. Because the research involved a single group without a control group, observed changes were interpreted as post-training associations rather than definitive evidence of causation.

Objectives of the Study

This study aimed to evaluate employee training and skills development in relation to technical competency and production performance among 12 coin press machine operators. Specifically, it sought to assess employees' competency in CPM operation, autonomous maintenance and troubleshooting, and machine setup and conversion before and after training using the established skills matrix, together with production output, machine downtime, and rejection rate; determine whether significant differences existed in technical competency and production performance between the two assessment periods; and examine whether improvements in technical competency were significantly associated with changes in the selected production-performance indicators. Through these objectives, the study sought to provide empirical evidence supporting competency assessment, training evaluation, and operational improvement in coin manufacturing.

Theoretical or Conceptual Basis

The study was guided by a competency-based workforce development perspective, which considers job-related training, demonstrated technical capability, and operational performance as interconnected components of manufacturing effectiveness. Acerbi et al. (2022) emphasized the value of identifying required competencies, assessing existing skill levels, and designing improvement initiatives aligned with organizational needs. This perspective supports the use of a structured skills matrix to identify competency gaps and evaluate employee development. The conceptual relationship examined in this study involved employee training and skills development, demonstrated through changes in three technical competency dimensions: CPM operation, autonomous maintenance and troubleshooting, and machine setup and conversion. These competencies were examined alongside three production-performance indicators: production output, machine downtime, and rejection rate. Research by Kose et al. (2023) provides support for the operational relevance of autonomous maintenance, while Olalere and Ramdass (2024) demonstrate the importance of quality-related indicators in evaluating manufacturing efficiency. The framework further recognizes training transfer as an important condition connecting acquired competencies with workplace outcomes. Abd Razak and Zahidi (2024) and Mdhlalose (2022) explained that effective training application depends on individual and organizational conditions. Thus, the study examined whether competency and production-performance changes occurred following training and whether their respective improvements were significantly related, without presuming that training independently caused all observed operational changes.

The study aligns with four relevant Sustainable Development Goals: **SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production).** Its relevance to SDG 4, particularly Target 4.4, is reflected in the development of technical and vocational competencies through structured employee training. Its contribution to SDG 8, particularly Target 8.2, concerns workforce capability and manufacturing productivity. These connections are consistent with the importance of skills development, employment, and industrial productivity in sustainable economic development. The study also supports aspects of SDG 9 by

examining operator competency and operational efficiency in a specialized manufacturing environment. The importance of industrial capacity, technological development, and productive manufacturing systems is emphasized in the United Nations Industrial Development Organization's *Industrial Development Report 2024* (UNIDO, 2024). Furthermore, the investigation of rejection rates relates to SDG 12 because reducing defective products may help minimize avoidable production losses and support more responsible manufacturing practices, although actual material savings and environmental impacts were not directly measured. Overall, the study contributes to the understanding of workforce, economic, and institutional sustainability by providing evidence relevant to continuous technical training, reliable manufacturing operations, and production-quality improvement. Its sustainability contribution is therefore grounded in the measured competency and operational indicators rather than in unmeasured environmental or socioeconomic outcomes.

2. METHODOLOGY

Research Design

The study utilized a quantitative, one-group pretest-posttest design with a correlational component. The same 12 operators were assessed before and after training to determine changes in technical competency and production performance. Employee training and skills development constituted the intervention, with competency assessed through Coin Press Machine (CPM) operation, autonomous maintenance and troubleshooting, and machine setup and conversion. Production performance was measured using daily production output, machine downtime, and rejection rate. The correlational component examined the relationships between competency improvements and changes in these operational indicators. Since no control group was included, observed differences were interpreted as changes following training rather than conclusive evidence of causation.

Research Locale or Study Setting

The study was conducted in a coin manufacturing operation involving specialized coin press machines used in standardized coin production processes. The operational setting required employees to perform machine preparation, production monitoring, equipment maintenance, troubleshooting, and denomination conversion while maintaining established production and quality standards. Data collection covered regular Monday-to-Friday operations under a single-shift schedule. The specific manufacturing facility and geographical location were not identified in the source manuscript.

Participants or Data Sources

The participants comprised all 12 employees directly assigned to coin press machine operations, consisting of eight Senior Minting Machine Operators and four Minting Machine Operators. Participants were included based on their active involvement in coin press operations, participation in the training intervention, assessment using the established skills matrix, and availability of complete competency and production records for both assessment periods. The data sources consisted of supervisor-conducted competency assessments and official operational records documenting production output, machine downtime, and rejection rates.

Research Instruments or Materials

The primary research instrument was a researcher-developed Technical Competency and Production Performance Skills Matrix covering three competency dimensions. CPM operation included pre-operation inspection, startup and shutdown procedures, and machine-control operation. Autonomous maintenance and troubleshooting involved identifying equipment

abnormalities, analyzing potential causes, and performing authorized basic corrective actions. Machine setup and conversion covered operational preparation, die setting and alignment, and denomination changeover. Competency was assessed using a five-level proficiency scale ranging from Level 1, indicating no demonstrated competency, to Level 5, indicating expert proficiency and the ability to train others. Intermediate levels represented beginner or trainee, competent operator, and highly competent operator. The matrix recorded the minimum required competency level and actual competency ratings before and after training. Improvement was determined by subtracting the initial rating from the subsequent rating, while competency scores were calculated using the average ratings of the criteria within each dimension. Production performance was measured using official operational records. Daily production output represented the number of acceptable finished coins produced during a scheduled shift, with an established daily target of 280,000 coins. Machine downtime was measured in minutes of equipment unavailability during scheduled operations, while rejection rate was calculated as the number of rejected coins divided by total production, multiplied by 100.

Data Gathering Procedure

The researchers coordinated with supervisors and operating personnel regarding study procedures and data requirements. Baseline competency assessments and production monitoring were conducted over 36 operating days before training. Supervisors assessed employees using the established skills matrix, while production output, machine downtime, and rejection data were obtained from official operational records. Following baseline assessment, supervisors implemented training through procedural discussions, demonstrations, guided practice, basic troubleshooting, machine conversion activities, coaching, and performance feedback. The same operators were subsequently reassessed and monitored for another 36 operating days using identical competency criteria and production-performance indicators. Collected records were organized and reviewed for completeness and consistency before statistical analysis. Data verification included checking missing or duplicate entries, calculation errors, inconsistent measurement units, unusual values, nonproduction days, maintenance interruptions, and changes in operator or machine assignments. Downtime unrelated to operator-controlled activities was classified separately when supported by operational records.

Data Analysis

Descriptive and inferential statistical procedures were employed to analyze employee competency and production performance. Frequency and percentage were used to describe participant positions and competency attainment relative to minimum requirements. Mean, median, standard deviation, minimum, maximum, and percentage change summarized the competency scores and production indicators before and after training. The Wilcoxon signed-rank test was applied to determine significant differences in paired technical competency ratings because the instrument used an ordinal five-level scale and involved 12 participants. For production output, machine downtime, and rejection rate, paired-samples t-tests were employed when difference scores satisfied normality and outlier assumptions. Normality was assessed through the Shapiro-Wilk test and graphical inspection, with the Wilcoxon signed-rank test designated as an alternative when assumptions were not satisfied. Spearman's rank-order correlation was used to determine whether improvements in technical competency were significantly related to changes in production performance. Improvement scores were coded so that increased competency and production output, together with reduced downtime and rejection rates, represented favorable changes. Statistical significance was evaluated at the 0.05 level, with operational changes and corresponding p-values reported to support interpretation. Multiple regression was not used as the primary analytical method because the sample was insufficient for a stable model involving several competency predictors.

Ethical Consideration

The source manuscript did not provide specific information regarding institutional ethical approval, informed consent, participant confidentiality, or authorization to access employee competency assessments and production records. Therefore, compliance with these procedures cannot be established from the available documentation. The researchers must verify and report the applicable ethical safeguards and institutional authorizations before final publication.

3. RESULTS AND DISCUSSION

3.1 Employee Profile and Technical Competency

3.1.1 Participant Profile and Initial Competency

Of the 12 participants, eight (66.7%) were Senior Minting Machine Operators, while four (33.3%) were Minting Machine Operators. Senior operators generally demonstrated higher technical competency before training, whereas regular operators exhibited lower initial ratings and greater opportunities for competency improvement. All participants obtained higher competency ratings following the intervention. These differences highlight the importance of considering employee position and initial proficiency when evaluating training outcomes. Acerbi et al. (2022) emphasized that manufacturing competency assessments should reflect specific organizational and occupational requirements, while Mahilarasi and Manokaran (2026) reported differences in training perceptions across employee groups and job positions. The findings support the relevance of competency-based assessment in identifying individual training needs.

3.1.2 Technical Competency Before and After Training

Overall technical competency increased from a mean of 3.12 before training to 3.98 after training, representing an improvement of 0.86 points. CPM operation improved from 3.64 to 4.34, with a reported mean gain of 0.71 points. Autonomous maintenance and troubleshooting increased from 2.83 to 3.77, recording the highest improvement of 0.94 points, while machine setup and conversion improved from 2.90 to 3.84, with a gain of 0.93 points. Wilcoxon signed-rank tests confirmed significant improvements across all dimensions ($p < 0.001$). The overall competency median increased from 3.33 to 4.18, with a rank-biserial correlation of 1.00, indicating that all 12 operators achieved higher scores after training. The improvements suggest that structured, task-specific training strengthened operators' capabilities in machine operation, equipment care, troubleshooting, setup, and denomination conversion. Khairul et al. (2024), Herjuna et al. (2024), and Sija (2024) similarly reported positive relationships between employee training and work performance in manufacturing environments. The highest gains in autonomous maintenance and machine setup indicate that these areas represented important competency-development needs. Peres (2026) emphasized that effect sizes complement statistical significance by describing the magnitude and practical relevance of observed differences. Nevertheless, the findings apply to the participating operators and should not be generalized automatically to other manufacturing settings.

3.2 Changes in Production Performance

3.2.1 Production Output

Average daily production output increased from 267,871.42 to 297,676.94 coins, representing an increase of 29,805.53 coins or 11.13%. All 12 operators recorded higher production output following training. The paired-samples t-test revealed a statistically significant increase, $t(11) = 11.00$, $p < 0.001$, with a large standardized effect, Cohen's $dz = 3.17$. The 95% confidence interval

for the mean increase ranged from 23,840.62 to 35,770.43 coins. The improvement indicates greater production efficiency during the post-training assessment period. Enhanced competencies in machine operation, troubleshooting, and setup may have supported more consistent equipment operation and fewer production interruptions. This interpretation is consistent with Sija (2024) and Khairul et al. (2024), who reported favorable associations between training and employee performance in manufacturing organizations. However, the observed increase cannot be attributed exclusively to training because other operational conditions may also have influenced production output.

3.2.2 Machine Downtime

Average machine downtime decreased from 49.42 minutes before training to 34.83 minutes after training, representing a reduction of 14.58 minutes or 29.51%. The paired-samples t-test confirmed a statistically significant reduction, $t(11) = -8.03$, $p < 0.001$, with Cohen's $dz = -2.32$. The 95% confidence interval for the mean difference ranged from −18.58 to −10.59 minutes, indicating a substantial improvement in equipment availability during the post-training period. The reduction was consistent with improved autonomous maintenance and troubleshooting competency. Operators with stronger equipment-care skills may have been better prepared to identify abnormalities, perform authorized minor corrective actions, and communicate maintenance concerns. Ben (2022) reported that operator upskilling through autonomous maintenance improved equipment reliability and repair performance, while Kose et al. (2023) demonstrated improvements in machine downtime through structured autonomous maintenance practices. Nevertheless, machine condition, tooling, maintenance schedules, and technical support may also have contributed to the observed reduction.

3.2.3 Rejection Rate

The average rejection rate decreased from 0.631% before training to 0.486% after training, equivalent to a reduction of 0.145 percentage points or 22.99% relative to the baseline. The paired-samples t-test indicated a statistically significant decrease, $t(11) = -4.73$, $p = 0.001$, with Cohen's $dz = -1.36$. The 95% confidence interval ranged from −0.213 to −0.077 percentage points. Rejection performance improved for most operators and remained unchanged for one operator. The reduction suggests improved production quality during the post-training period, potentially associated with stronger competency in die setting, calibration, machine conversion, and process monitoring. Real and Torres (2024) demonstrated that operator-related assembly processes can influence manufacturing error rates, while Olalere and Ramdass (2024) emphasized the importance of quality-management practices in reducing production defects. The findings indicate that improvements in operator competency occurred alongside reduced rejection rates, although equipment condition, material quality, and production controls may also have influenced product quality.

3.3 Statistical Assessment and Relationships Between Variables

3.3.1 Normality of Difference Scores and Statistical Test Selection

The Shapiro-Wilk test indicated significant departures from normality for autonomous maintenance, $W = 0.558$, $p < 0.001$, and machine setup and conversion, $W = 0.795$, $p = 0.008$. The difference scores for CPM operation ($p = 0.507$), overall technical competency ($p = 0.118$), production output ($p = 0.999$), machine downtime ($p = 0.708$), and rejection rate ($p = 0.444$) did not show statistically significant departures from normality. Accordingly, the Wilcoxon signed-

rank test was applied to the ordinal technical competency ratings, while paired-samples t-tests were used for the production-performance indicators. These results supported the selected analytical procedures while recognizing differences in measurement scales and distributional characteristics. Shatz (2024) emphasized that statistical assumption checking should integrate formal tests with graphical examination and contextual judgment. Thus, the use of nonparametric procedures for competency ratings and paired parametric tests for production indicators was consistent with the study's measurement characteristics and reported diagnostic results.

3.3.2 Relationship Between Competency Improvement and Production Performance

Spearman's rank-order correlation revealed no statistically significant relationships between overall technical competency improvement and the selected production-performance changes. The correlation between competency improvement and production-output increase was negligible, $\rho = -0.007$, $p = 0.983$. The relationship with machine-downtime reduction was weak and positive, $\rho = 0.276$, $p = 0.386$, while the relationship with rejection-rate reduction was negligible and positive, $\rho = 0.063$, $p = 0.846$. All p-values exceeded the 0.05 significance level. These findings indicate that operators who achieved larger competency improvements did not necessarily obtain proportionally greater improvements in production output, downtime, or rejection rate. Although both competency and production performance improved significantly across the group, their individual improvement magnitudes were not significantly associated. Training transfer studies suggest that workplace application of acquired skills depends on supervisory support, feedback, training design, and opportunities to perform learned tasks (Abd Razak & Zahidi, 2024; Ardondi et al., 2026; Mdhlalose, 2022). The small sample, limited variation in competency gains, equipment conditions, tooling quality, maintenance support, and production requirements may also have influenced the relationships. Therefore, the results support favorable post-training changes without establishing that competency improvement independently caused the observed production-performance gains.

4. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that employee training and skills development were associated with statistically significant improvements in technical competency and production performance among the 12 coin press machine operators. Competency improved across Coin Press Machine operation, autonomous maintenance and troubleshooting, and machine setup and conversion, with the greatest gains observed in autonomous maintenance and troubleshooting. Following training, production output increased by 11.13%, while machine downtime and rejection rate decreased by 29.51% and 22.99%, respectively, indicating favorable changes in operational efficiency and product quality. However, improvements in technical competency were not significantly correlated with changes in production performance, suggesting that greater individual competency gains did not necessarily correspond to proportionally greater operational improvements. These findings highlight the importance of continuous workforce development and systematic competency assessment in supporting manufacturing performance. Nevertheless, the observed improvements cannot be attributed exclusively to training because equipment conditions, material quality, maintenance support, and other operational factors may also influence production outcomes.

Based on the findings, manufacturing management should institutionalize a continuous, competency-based training program emphasizing Coin Press Machine operation, autonomous maintenance, troubleshooting, and machine setup and conversion. Priority should be given to

maintaining improvements in autonomous maintenance and setup competencies while addressing individual skill gaps identified through regular skills-matrix assessments. Supervisors and senior operators should provide structured coaching, practical demonstrations, performance feedback, and opportunities to apply acquired competencies during actual production. Standard operating procedures should be strengthened, particularly in die setting, denomination changeover, calibration, equipment inspection, and authorized troubleshooting activities. Management should regularly monitor production output, machine downtime, rejection rate, and competency ratings to evaluate training effectiveness and identify emerging operational concerns. Equipment condition, tooling quality, material consistency, and maintenance support should also be considered when assessing production performance. Future researchers should examine larger operator samples, extend monitoring periods, and incorporate comparison groups to strengthen evidence regarding training-related improvements.

The study was limited to 12 coin press machine operators in a single manufacturing setting, restricting the generalizability of the findings to other operators, facilities, and manufacturing industries. Its one-group pretest-posttest design, without a control group, prevented definitive attribution of the observed improvements to training alone. The assessment covered 36 operating days before and 36 operating days after training, limiting the evaluation of longer-term competency retention and performance sustainability. Furthermore, production outcomes may have been influenced by equipment condition, tooling quality, material characteristics, maintenance support, and operator-machine assignments. Future studies should employ larger samples, longer observation periods, and comparison groups.

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