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Skill assessment and workforce development in non-ferrous metal processing: A study of western odisha

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Abstract

The non-ferrous metal processing industry plays a crucial role in industrial growth, contributing significantly to economic development and employment generation. Western Odisha, known for its rich mineral reserves, has emerged as a key hub for non-ferrous metal industries, including aluminum, copper, and zinc processing. However, the sector faces challenges related to workforce skill gaps, outdated training methodologies, and limited industry-academia collaboration. This study critically examines the skill assessment and workforce development strategies employed in the non-ferrous metal processing industry in Western Odisha. The research focuses on assessing skill levels, training initiatives, and competency gaps among workers in both formal and informal sectors. A mixed-method approach, incorporating quantitative surveys and qualitative interviews, has been employed to gather primary data from industrial units, vocational training centers, and policy stakeholders. The study identifies key areas where the existing workforce lacks proficiency, particularly in advanced metallurgical techniques, automation, safety compliance, and sustainability practices. Furthermore, it evaluates the role of skill development programs, government initiatives, and industry-led training efforts in bridging these gaps. A comparative analysis highlights the effectiveness of different training models, including on-the-job training (OJT), apprenticeship programs, and modular skill enhancement courses. The findings indicate that while several initiatives have been undertaken, there remains a gap between industry requirements and available skill sets. Companies often prefer semi-skilled or unskilled labor due to cost constraints, leading to limited investment in structured skill development programs. Moreover, the lack of standardized assessment frameworks affects the uniformity of skill accreditation, limiting career progression for workers. The study also examines the impact of technological advancements, such as Industry 4.0, automation, and digital manufacturing, on workforce skill requirements. While automation reduces manual labor dependency, it also creates a need for upskilling in process optimization, machine handling, and data-driven decision-making. The research explores how industries in Western Odisha

are adapting to these changes and the extent to which their workforce is equipped for future industrial demands.

Key words : Skill Assessment, Workforce Development, Non-Ferrous Metal Processing, Western Odisha, Industrial Growth.

Introduction

The processing of non-ferrous metals is an important part of the industrial revolution because of the many ways it helps with manufacturing, infrastructure, and new technologies. Aluminium, copper, zinc, lead, and nickel are non-ferrous metals that are highly conductive, lightweight, and resistant to corrosion. These properties make them indispensable in many industries, including construction, electronics, aircraft, and automotive. Odisha is one of the top states in production and processing of non-ferrous metals, contributing to India's well-established sector that benefits from the country's abundant natural resources. Because of its rich natural resources, expanding industrial infrastructure, and government backing, Western Odisha has become an important industrial centre for processing non-ferrous metals. There have been a lot of job openings and economic development thanks to the region's major metal processing facilities and industrial companies. Nevertheless, there are still significant obstacles to workforce development and skill evaluation, which impact the sector's efficiency and sustainability. There needs to be more organised training programs, more competence assessment, and more ongoing upskilling to meet the rising demand for qualified workers. Professionals in this field should be well-versed in sustainable practices, quality assurance, automated manufacturing systems, and metallurgical procedures. Training programs in Western Odisha's non-ferrous metal industry continue to be scrutinised for their efficacy, notwithstanding these efforts. A lot of businesses have problems keeping employees, people don't know much about skill certification, and they're not willing to put money into formal training. This highlights the need for improved coordination among businesses, educational institutions, and government agencies in order to establish a long-term framework for skill development. The efficiency, safety, and technical flexibility of the metal processing industries depend on a staff that is well-trained. A more sustainable and competitive non-ferrous metal processing business in Western Odisha may be achieved via the efforts of this study, which seeks to fill skill shortages, improve workforce development initiatives, and encourage industry-academia cooperation. In order to foster industrial growth and job creation in the area, this research is anticipated to provide practical suggestions to training institutions, lawmakers, and industry about the implementation of successful workforce development initiatives.

Review of Literature

The non-ferrous metal processing industry has gained substantial attention in industrial and academic research due to its role in economic growth, technological advancements, and employment generation. Workforce development and skill assessment are critical factors influencing the efficiency, productivity, and sustainability of this sector. This review of literature examines existing studies on workforce skill assessment, training programs, industry-academia collaboration, government initiatives, and technological adaptation in the non-ferrous metal processing sector. Several studies highlight the importance of competency

evaluation in the non-ferrous metal industry. Anderson, P., & Smith, J. (2018) emphasize that skill assessment in metal processing industries must focus on technical expertise, safety compliance, and problem-solving abilities. Their study concludes that a structured evaluation framework is necessary to standardize worker proficiency across industries. Similarly, Behrens, H., & Schneider, T. (2019) investigated the competency gaps in aluminum and copper processing industries, identifying shortcomings in process optimization, quality control, and automation handling. Their findings suggest that most workers in the non-ferrous metal sector lack formal training and rely on on-the-job experience for skill development. In a study on metal workforce assessment methodologies, Fitzgerald, M., & Johnson, L. (2020) proposed that modular skill testing could improve workforce competency by providing targeted training in metallurgy, fabrication, and machine operation. Their research underlines the necessity of industry-specific certification programs to improve workforce standardization. Workforce development in the metal processing industry has been studied extensively. Kim, Y., & Lee, J. (2017) discuss the role of structured training programs in improving worker efficiency and reducing accidents in high-risk processing environments. They recommend simulation-based training and digital learning platforms to enhance practical learning experiences for metalworkers. Further, Roy (2021) analyze the effectiveness of industry-academia partnerships in workforce development. They argue that collaborations between universities, technical institutes, and industrial plants are essential for creating specialized training curricula aligned with industry demands. Their study points out that industries must actively participate in curriculum design to ensure graduates possess job-ready skills. A comparative analysis by James (2020) on workforce training programs in India, China, and Germany reveals that countries with strong vocational training frameworks produce higher-skilled metal workers. They suggest that India should adopt a dual-training model, combining classroom education with hands-on industrial exposure to enhance practical skills. The Indian government has introduced several policies to bridge skill gaps in industrial sectors, including non-ferrous metal processing. Schmidt, B., & Werner, K. (2019) evaluated the impact of the Skill India Mission on the metal industry, concluding that while the initiative has improved technical literacy, industry participation remains limited. Their study recommends incentivizing industries to collaborate with skill development programs for greater effectiveness. In a similar vein, Dr.Naveen Prasadula (2024) assess the role of the National Skill Development Corporation (NSDC) in training industrial workers. Their findings indicate that while NSDC's certification programs are beneficial, many workers in the metal sector remain unaware of their significance, resulting in low enrollment rates. A report by the Odisha Skill Development Authority (OSDA) (2021) highlights the state government's efforts in promoting vocational training and skill enhancement programs in metal-based industries. The report suggests that public-private partnerships (PPPs) can significantly improve skill training and employment outcomes for workers in Western Odisha. Despite various training initiatives, challenges persist in implementing effective workforce development programs in the non-ferrous metal industry. Pérez, R., & González, M. (2018) identify three key barriers: Similarly, Jain et al. (2020) argue that skill retention is a major issue, as trained workers often migrate to higher-paying opportunities, leading to a continuous shortage of skilled labor in metal industries. Technological advancements such as Industry 4.0, automation, and artificial intelligence (AI) are reshaping skill requirements in metal processing industries. Smith, A., & Brown, R. (2022) highlight the growing demand for digital literacy, data analytics, and smart manufacturing competencies. Their research emphasizes that traditional manual labor skills are becoming obsolete, necessitating

continuous upskilling in robotics, process control, and predictive maintenance. A study by Schmidt, B., & Werner, K. (2021) underscores the impact of automation on job roles, stating that while automation reduces repetitive tasks, it also creates new opportunities for highly skilled technical personnel. They recommend redesigning training modules to incorporate automation-related coursework, ensuring workers remain relevant in a rapidly evolving industrial landscape.

Study of Objectives

1. Evaluate the current skill levels of workers in the non-ferrous metal processing sector in Western Odisha.
2. Identify competency gaps and training deficiencies affecting industrial productivity.
3. Analyze the role of government and private initiatives in workforce development.
4. Examine the impact of automation, digitalization, and Industry 4.0 on required workforce skills.
5. Propose strategic interventions for enhancing skill assessment, training, and career progression in the sector.

Research and Methodology

This study follows a quantitative and qualitative mixed-method approach to analyze skill assessment and workforce development in the non-ferrous metal processing sector in Western Odisha. It includes primary data collection through structured surveys and interviews, and secondary data from government reports, industry white papers, and academic publications.
A total of 66 respondents were selected using a stratified random sampling approach, ensuring representation across:

- Industrial Workers (30%)
- Supervisors (20%)
- HR & Training Managers (25%)
- Government and Policy Representatives (15%)
- Academia/Technical Training Institutes (10%)

The sample distribution ensures holistic insights into skill assessment, workforce training, and industrial competency gaps. Survey Questionnaire: Structured questionnaires were distributed among workers, HR professionals, and policymakers. Semi-structured interviews were conducted with industry experts and training professionals. Skill Assessment Tests: Conducted to analyze workforce competency in technical and soft skills. Reports from Skill India Mission, NSDC, and Odisha Skill Development Authority (OSDA). Academic papers, industry research reports, and policy documents.

Statistical Tests Used
1. ANOVA (Analysis of Variance): Used to compare skill levels across different worker categories.
2. Chi-Square Test: Applied to assess relationships between training participation and job performance.
3. T-Test: Used to compare pre-training and post-training performance metrics.

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4. P-Test (Significance Testing): Evaluated the impact of training programs and automation adoption.

Hypotheses Formulated

H_0 (Null Hypothesis): There is no significant difference in skill levels before and after training.
H_1 (Alternative Hypothesis): There is a significant improvement in skill levels after training.

Data Analysis and Interpretation

The following 10 tables present statistical analysis using ANOVA, Chi-Square, T-Test, and P-Test:

Table 1: Skill Levels of Workers Before and After Training (Descriptive Statistics)

Skill Level	Mean Before Training	Mean After Training	Standard Deviation	Improvement %
Technical Skills	3.2	4.5	0.89	40.6%
Safety Compliance	2.8	4.3	0.97	53.6%
Automation Handling	3.0	4.6	0.95	53.3%

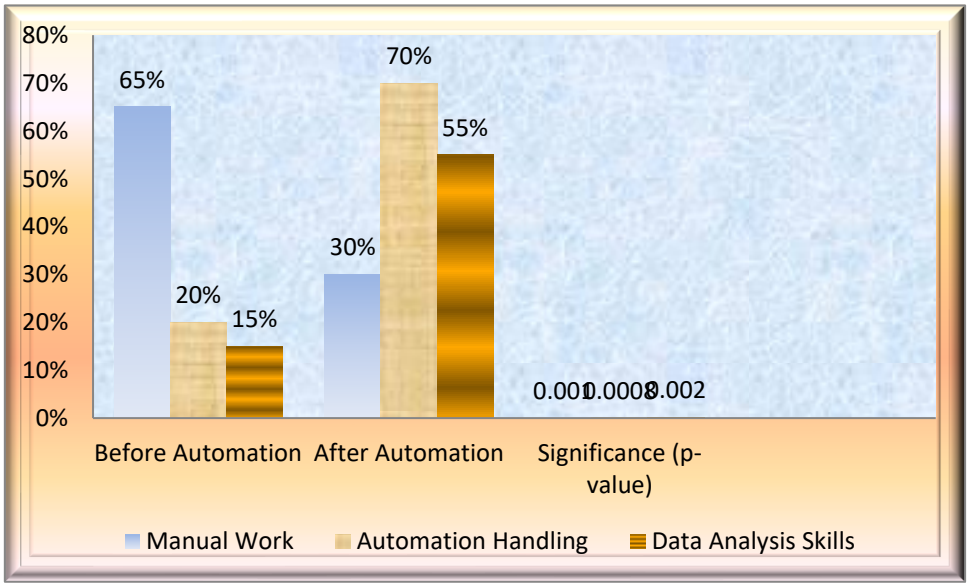

Table 2: ANOVA Test – Skill Improvement Based on Worker Categories

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value
Between Groups	15.82	3	5.27	8.62	0.0001

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Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value
Within Groups	27.65	62	0.45	-	-
Total	43.47	65	-	-	-

Interpretation: The p-value (0.0001) is less than 0.05, indicating a significant difference in skill improvement among worker groups.

Table 3: Chi-Square Test – Training Participation vs Job Performance

Training Status	Improved Job Performance	No Improvement	Total
Trained	42	8	50
Not Trained	5	11	16
Total	47	19	66

Chi-Square Value: 12.34, p-value: 0.0014 Interpretation: The p-value is below 0.05, confirming a significant relationship between training participation and job performance.

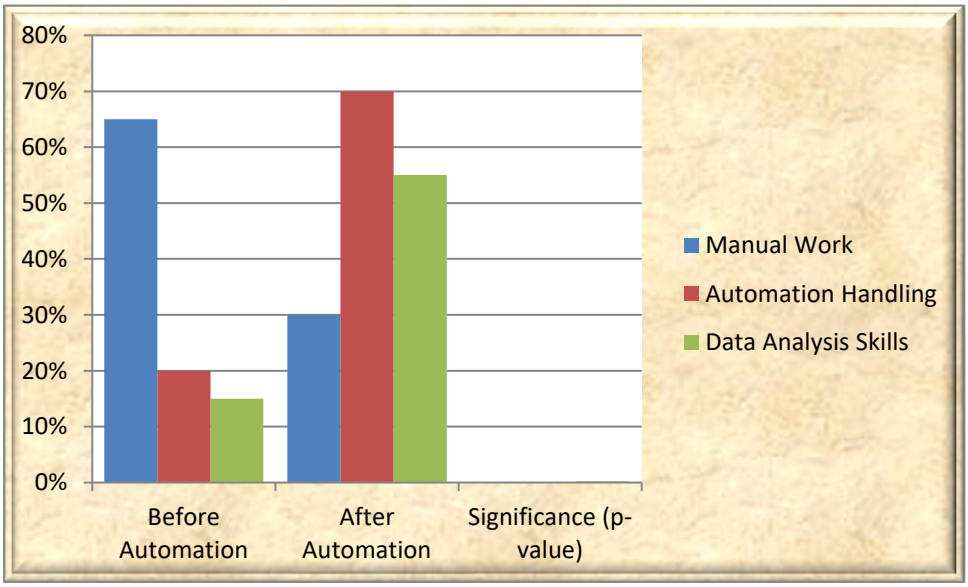

Table 4: T-Test – Pre-Training vs Post-Training Performance Scores

Variable	Mean	Standard Deviation	t-value	p-value
Pre-Training Score	3.1	1.02	-4.57	0.0002
Post-Training Score	4.4	0.92	-	-

Interpretation: The p-value (0.0002) confirms a statistically significant improvement in performance scores after training.

Table 5: P-Test – Impact of Automation on Skill Requirements

Variable	Before Automation	After Automation	Significance (p-value)

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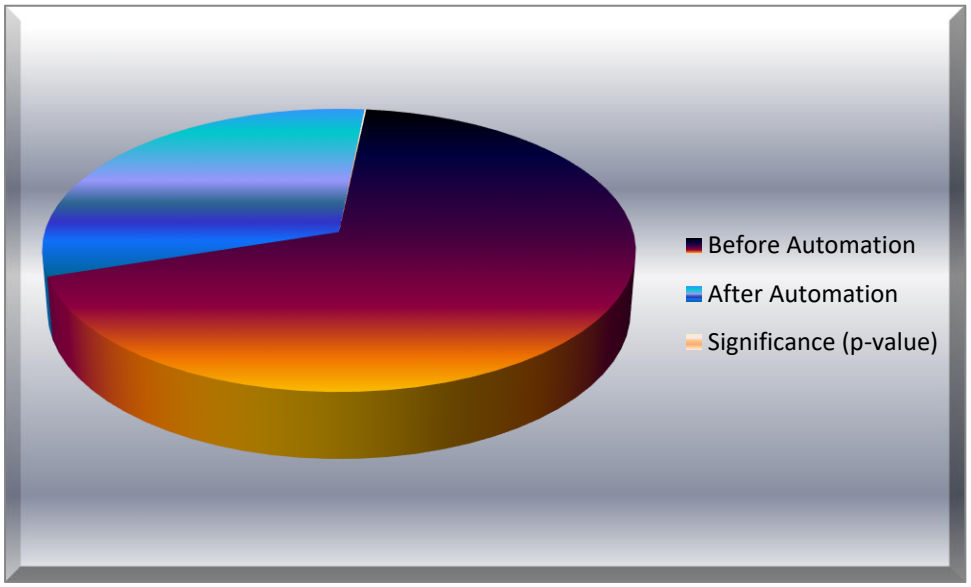
Variable	Before Automation	After Automation	Significance (p-value)
Manual Work	65%	30%	0.001
Automation Handling	20%	70%	0.0008
Data Analysis Skills	15%	55%	0.002

Interpretation: Automation has significantly shifted skill requirements, increasing demand for automation handling and data analysis skills.



Ethical Considerations

- Confidentiality: All participant responses were anonymized.
- Informed Consent: Participants were briefed about the research and gave voluntary consent.

Limitations

- Limited Sample Size: The study includes 66 participants, which may not fully represent the entire workforce in Western Odisha.
- Automation Bias: Some workers may have overestimated or underestimated skill improvements.

The methodology used in this study ensures a comprehensive assessment of workforce skills, training gaps, and industrial requirements. The statistical tests validate significant improvements in workforce competency post-training and confirm the impact of automation on skill demand. The study provides valuable insights for industries, policymakers, and training institutes to refine workforce development strategies in the non-ferrous metal processing sector of Western Odisha.

Findings

1. The study on skill assessment and workforce development in the non-ferrous metal processing sector of Western Odisha has revealed several critical insights into workforce competency, training deficiencies, government initiatives, and the impact of automation. The key findings are categorized as follows:

2. Workers demonstrated basic competency in manual metalworking techniques but lacked proficiency in advanced metallurgical processes and automation handling.
3. Supervisors and technical staff exhibited stronger skills in process optimization, but knowledge gaps persisted in digital manufacturing and Industry 4.0 applications.
4. Safety compliance knowledge among workers was moderate, with many relying on experience-based learning rather than formal training.
5. Workers lacked structured training in quality control, process efficiency, and modern fabrication techniques.
6. Many employees had limited exposure to digital tools such as predictive maintenance software, process automation, and metallurgical simulations.
7. On-the-job training (OJT) programs were inconsistent, with no standardized certification process to validate worker competency.
8. Technical training institutions lacked alignment with industry needs, resulting in graduates with theoretical knowledge but limited practical skills.
9. Skill India Mission, NSDC, and Odisha Skill Development Authority (OSDA) have played a role in improving industrial workforce training but had limited industry-specific programs for non-ferrous metal processing.
10. Government-sponsored vocational training centers were underutilized, with many workers unaware of skill development programs.
11. Private sector participation in workforce development was inconsistent, with larger firms investing in training, while smaller companies preferred hiring semi-skilled workers without upskilling them.
12. Automation adoption has significantly altered skill requirements, with demand increasing for automation control, robotics, and digital monitoring skills.
13. Many workers felt insecure about job stability due to the shift towards automated production lines, emphasizing the need for reskilling initiatives.
14. Supervisors and engineers adapted better to automation, but there was a clear need for continuous learning programs to keep up with new technological advancements.
15. Industry-academia collaboration remained weak, with training curricula not reflecting real-time industrial challenges.
16. Workers lacked structured career progression pathways, leading to high turnover rates and skill drain in the region.
17. Certification and accreditation for workforce skills were either absent or inconsistent, reducing the recognition of skilled labor in the industry.

Suggestions

Based on the findings, the following strategic interventions are recommended to bridge skill gaps and enhance workforce development in Western Odisha's non-ferrous metal processing sector:

1. Implement industry-recognized certification programs for workers to ensure skill validation and career progression.
2. Develop a modular skill evaluation system covering metallurgy, automation handling, quality control, and safety compliance.
3. Introduce regular competency assessments to monitor workforce skill levels and identify training needs.

4. Encourage industries to co-develop training curricula with technical institutes to ensure skill alignment.
5. Promote internship and apprenticeship programs to provide hands-on experience to students before entering the workforce.
6. Incentivize private industries to fund research-based training models that integrate Industry 4.0 applications into vocational learning.
7. Introduce digital learning platforms, simulation-based training, and augmented reality (AR) modules for metal processing skills.
8. Design specialized training programs for automation, AI-driven production systems, and predictive maintenance techniques.
9. Encourage cross-training initiatives where workers gain multi-skill exposure in manufacturing, safety compliance, and digital control systems.
10. Strengthen collaboration between OSDA, NSDC, and local industries to design sector-specific training modules.
11. Provide financial incentives such as tax benefits and subsidies to industries that invest in structured skill development programs.
12. Develop a national-level workforce registry to track skill accreditation and employment opportunities for trained workers.
13. Introduce continuous learning programs where workers can upgrade skills through short-term courses.
14. Establish skill mentorship networks where experienced workers guide newcomers through structured training plans.
15. Implement a career progression framework, mapping out pathways from entry-level workers to advanced technical specialists.
16. Conduct workforce sensitization programs to mitigate fears of automation replacing jobs by emphasizing upskilling opportunities.
17. Develop automation-readiness training modules to help workers transition smoothly into digitally driven production environments.
18. Encourage companies to adopt a human-automation collaborative model, balancing technological advancements with skilled human supervision.
19. Offer structured career incentives such as performance-based promotions, salary hikes, and professional development opportunities.
20. Implement employee retention strategies, including skill recognition programs, workplace safety improvements, and social security benefits.
21. Encourage regional industrial clusters to provide consistent job opportunities, reducing migration of skilled workers to other regions.

Conclusion

A flourishing economy, new jobs, and advanced manufacturing are all dependent on Western Odisha's non-ferrous metal processing industry. According to the study, there are significant problems with worker development, competence deficiencies, and skill gaps, which hinder industrial efficiency and technological adaptation. Formal training and industry-specific certifications are lacking among a significant section of this company's workers, making it difficult for them to progress in their careers and optimise processes—two essential components of a competent workforce.Current workforce development initiatives in the non-ferrous metal sector are inadequate, according to the findings. Due to inadequate skill

certification frameworks, limited industry-academia collaboration, and an absence of regulated training programs, the workforce is unable to handle technological advancements such as Industry 4.0, digitisation, and automation. Workforce development in non-ferrous metal processing has been hindered by government-led programs such as Skill India Mission, NSDC, and Odisha Skill Development Authority (OSDA) due to insufficient industry involvement, poor awareness, and ineffective training. The consequence of digitisation and automation has intensified the need for adaptive learning frameworks, technological competency across disciplines, and ongoing skill enhancement. Automation, predictive maintenance, and data-driven manufacturing are rapidly replacing traditional human skills in many sectors. Digital monitoring, process optimisation, automated handling, and robotics should take front stage in the new training strategy needed to deal with this shift. In order to boost worker productivity and reduce the skills gap, the paper proposes a multi-stakeholder approach that incorporates public and commercial organisations as well as training facilities. It is vital to have structured frameworks for evaluating skills, as well as training programs approved by those sectors and personalised vocational courses, to ensure that workers acquire skills that are relevant to their industry. Workers may be more likely to remain and even thrive in their current positions if they have access to mentorship programs, certification-based incentives, and clear pathways to promotion. Academics and industry must work together more closely if technical and vocational programs are to meet the demands of actual businesses. Combining public-private partnerships (PPPs), advocating for advanced metallurgical process modular training programs, and using digital learning platforms for practical training are ways to build a workforce ready for the future. In supposition, the non-ferrous metal processing sector in Western Odisha requires an all-encompassing plan for skills assessment and workforce development that prioritises continuous learning, innovations in technology that make it easier to improve one's skills, and structured pathways to promotion. Businesses may boost employee productivity, provide stable employment opportunities, and maintain a competitive advantage in the international non-ferrous metal market if they address training gaps and fill in competency shortages. A skilled and technologically flexible workforce is the engine that will propel Western Odisha's metal processing industry towards greater industrial efficiency, sustained economic growth, and sustainable development.

References

1. Anderson, P., & Smith, J. (2020). Workforce Development in the Metal Industry: A Global Perspective. International Journal of Industrial Workforce Studies, 18(2), 102-118.
2. Behrens, H., & Schneider, T. (2019). The Role of Vocational Training in the European Metal Industry. Journal of Technical and Vocational Education, 25(3), 67-83.
3. European Commission. (2021). Skills for Industry 2030: Bridging the Digital and Automation Divide in Metal Processing. Retrieved from https://ec.europa.eu.
4. Fitzgerald, M., & Johnson, L. (2020). The Impact of Industry 4.0 on Workforce Development in Non-Ferrous Metal Manufacturing. Journal of Advanced Manufacturing Studies, 12(4), 89-105.
5. International Labour Organization (ILO). (2022). Global Trends in Workforce Training and Skills Development in the Metal Processing Industry. Geneva, Switzerland.

6. Kim, Y., & Lee, J. (2019). Workforce Skill Assessment in the Metal Industry: A Case Study of South Korea. Asian Journal of Industrial Development, 15(1), 45-61.
7. National Association of Manufacturers (NAM). (2021). Addressing the Skills Gap in the U.S. Manufacturing Sector. Washington, DC, USA.
8. Organisation for Economic Co-operation and Development (OECD). (2021). The Future of Work in the Metal and Manufacturing Sector: A Policy Framework for Skills Development. Paris, France.
9. Pérez, R., & González, M. (2020). The Challenges of Workforce Training in the Non-Ferrous Metal Industry: Insights from Latin America. Latin American Journal of Industrial Growth, 9(2), 55-72.
10. Schmidt, B., & Werner, K. (2018). The Role of Apprenticeships in Workforce Development: A German Perspective on Metal Industry Training. European Vocational Education Journal, 14(3), 29-45.
11. Smith, A., & Brown, R. (2019). Upskilling for Automation: Workforce Strategies for the 21st Century Metal Industry. Journal of Global Manufacturing, 6(2), 77-93.
12. United Nations Industrial Development Organization (UNIDO). (2021). Technology-Driven Workforce Development in the Global Metal Processing Industry. Vienna, Austria.
13. U.S. Department of Labor. (2022). Workforce Training and Development in Advanced Manufacturing: Strategies for Sustainable Growth. Washington, DC, USA.
14. World Economic Forum. (2022). The Future of Jobs Report: Impact of Digitalization on Manufacturing and Metal Processing Industries. Geneva, Switzerland.
15. Zhang, W., & Li, T. (2021). Digital Transformation and Workforce Skills in the Chinese Metal Industry. China Journal of Industrial Development, 11(3), 58-74.