

DOI: <https://doi.org/10.38035/dijemss.v7i6><https://creativecommons.org/licenses/by/0/>

Educational Management and the Sustainable Development Goals (SDG): Integrating Post-Mining Reclamation into Vocational Curricula in Central Kalimantan

Aprianto¹, Ernawatie², Yesser Priono³

¹Universitas Palangka Raya, Indonesia, apriantoliun@fkip.upr.ac.id

²Universitas Palangka Raya, Indonesia, ernawatie@fkip.upr.ac.id

³Universitas Palangka Raya, Indonesia, yesserp@arch.upr.ac.id

Corresponding Author: apriantoliun@fkip.upr.ac.id¹

Abstract: The mining industry in Indonesia, particularly in Central Kalimantan, has contributed significantly to regional economic growth. However, mining activities also generate environmental degradation, including deforestation, soil damage, and water pollution. This condition highlights the importance of post-mining reclamation as a sustainable environmental recovery effort. Vocational High Schools (SMK) that focus on mining and extractive industries play a strategic role in preparing human resources capable of supporting sustainable mining practices. This article examines the integration of post-mining reclamation competencies into vocational curricula as an effort to support the Sustainable Development Goals (SDGs). Using a qualitative descriptive approach through literature review and policy analysis, the study finds that curriculum integration can strengthen students' environmental awareness, technical competence, and readiness to meet industry demands. Furthermore, collaboration between schools, industries, and government institutions is essential to ensure curriculum relevance and sustainability-oriented vocational education.

Keyword: Vocational Education, Post-Mining Reclamation, Curriculum Integration, Sustainable Development, SDGs, Central Kalimantan.

INTRODUCTION

Indonesia is one of the largest producers of mineral and coal commodities in the world. The mining sector contributes significantly to national economic growth, export earnings, and regional development. According to the Indonesian Ministry of Energy and Mineral Resources, the mining industry contributed substantially to Indonesia's Gross Domestic Product (GDP) and regional income, particularly in resource-rich provinces such as Central Kalimantan. The province has extensive coal and mineral reserves that continue to attract industrial investment and mining expansion (Ministry of Energy and Mineral Resources, 2023).

Despite its economic contribution, mining activities often generate serious environmental impacts. Open-pit mining operations frequently result in deforestation, soil degradation, biodiversity loss, water pollution, and abandoned mining pits. Data from the Indonesian Ministry of Environment and Forestry indicated that environmental degradation caused by

extractive industries remains one of the major ecological challenges in Indonesia (KLHK, 2022). In Central Kalimantan, several former mining areas experience difficulties in ecological recovery due to inadequate reclamation practices and limited environmental monitoring.

Post-mining reclamation has therefore become an essential component of sustainable mining governance. Reclamation activities aim to restore ecological functions, improve soil conditions, and rehabilitate damaged landscapes after mining operations. Indonesian Law No. 3 of 2020 concerning Mineral and Coal Mining requires mining companies to conduct reclamation and post-mining activities as part of their environmental responsibilities. This regulation demonstrates the growing emphasis on environmentally responsible mining practices in Indonesia.

The increasing global concern regarding environmental sustainability has also encouraged the integration of Sustainable Development Goals (SDGs) into education systems. The SDGs, introduced by the United Nations in 2015, emphasize the importance of balancing economic growth, social welfare, and environmental protection. Several SDGs are closely related to mining and vocational education, including SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land) (United Nations, 2015).

Vocational High Schools (SMK) play a strategic role in preparing skilled human resources for the mining industry. In Central Kalimantan, vocational schools with mining-related programs continue to grow in response to labor market demands. However, many vocational curricula still focus heavily on operational and technical extraction competencies, while environmental restoration and reclamation competencies receive limited attention. This imbalance creates a gap between industrial workforce preparation and sustainable environmental management needs.

Several previous studies have emphasized the importance of integrating environmental education into vocational learning systems. Yusuf and Rahman (2022) argued that sustainability-oriented vocational education can strengthen students' environmental awareness and improve workforce adaptability in green industries. Similarly, UNESCO (2020) highlighted that education for sustainable development should encourage practical competencies, critical thinking, and environmental responsibility among students.

In addition, the transition toward green economy practices has increased industrial demand for workers who possess both technical mining skills and environmental management competencies. Mining companies increasingly require employees capable of conducting land rehabilitation, environmental monitoring, waste management, and sustainable mining operations. Consequently, vocational education institutions are expected to redesign curricula that align with industry transformation and sustainability challenges.

Integrating post-mining reclamation competencies into vocational curricula can provide several benefits. Students can develop practical skills related to revegetation techniques, soil recovery, environmental monitoring, and ecosystem rehabilitation. Furthermore, curriculum integration may enhance graduate competitiveness while supporting regional sustainable development agendas. Through collaboration between schools, industries, and government institutions, vocational education can contribute to creating environmentally responsible mining practices in Central Kalimantan.

Additional data on the mining vocational education curriculum can also strengthen the urgency of this study. In Indonesia, vocational education has undergone curriculum transformation through the implementation of the Merdeka Curriculum, which emphasizes competency-based learning and stronger industry alignment. Mining vocational programs in SMKs generally focus on competencies such as mining geology, heavy equipment operation, mine surveying, occupational safety and health (K3), and mineral extraction techniques. However, environmental restoration and post-mining reclamation competencies are still relatively limited within the curriculum structure (Ministry of Education and Culture, 2021).

The Indonesian government has encouraged vocational revitalization to support industrial development and workforce readiness. According to the redesign framework for SMK expertise programs issued by the Ministry of Education and Culture, vocational curricula are expected to adapt to Industry 4.0 demands, sustainability principles, and labor market transformation. Nevertheless, environmental sustainability competencies in mining vocational education remain underdeveloped compared to operational mining competencies (Kemendikbud, 2021).

Industry collaboration programs also indicate the growing need for sustainability-oriented vocational competencies. For example, the BUMA School partnership program collaborates with vocational high schools across Indonesia to align mining education with real industrial standards. In 2024, the program supported 456 students from 17 vocational schools and emphasized industry-based competencies in mining operations and technical skills (BUMA International Group, 2024). This demonstrates that mining industries increasingly require vocational graduates with practical competencies relevant to sustainable mining practices.

Furthermore, sustainability reports from mining companies in Indonesia show that Environmental, Social, and Governance (ESG) principles are becoming central to mining operations. Mining companies are now emphasizing responsible mining, environmental monitoring, climate action, and land ecosystem restoration as part of their sustainability commitments (ABM Investama, 2024). These industrial shifts indicate that future mining workers must possess not only technical extraction skills but also competencies related to reclamation, environmental rehabilitation, and sustainable resource management.

In Central Kalimantan, where mining activities continue to expand, vocational schools have a strategic opportunity to integrate reclamation-based learning into mining education. Curriculum integration may include revegetation practices, soil rehabilitation techniques, environmental impact assessment, waste management, biodiversity conservation, and sustainable land utilization. Such competencies are highly relevant to the implementation of SDGs and the transition toward greener mining industries in Indonesia (UNESCO, 2020).

To better understand the current condition of mining vocational education in Indonesia, it is important to examine the distribution of competencies taught within SMK mining programs. The curriculum generally prioritizes technical and operational mining skills to meet industrial labor demands. However, the increasing emphasis on sustainable mining and environmental governance has encouraged the inclusion of environmental management and reclamation competencies in vocational education. The following table presents the main competency areas commonly found in mining vocational curricula and their relevance to sustainability and SDGs implementation (Kemendikbud, 2021; UNESCO, 2020).

Table 1. Distribution of Mining Vocational Curriculum Competencies in Indonesian SMKs

Competency Area	Main Learning Focus	Sustainability Integration	Relevance to SDGs
Mining Geology	Rock identification, mineral mapping, exploration	Limited	SDG 8
Heavy Equipment Operation	Mining machinery operation and maintenance	Very limited	SDG 9
Mine Surveying	Mapping and measurement techniques	Limited	SDG 11
Occupational Safety and Health (K3)	Workplace safety and hazard prevention	Moderate	SDG 3
Mineral Extraction Techniques	Drilling, blasting, and extraction processes	Limited	SDG 12

Competency Area	Main Learning Focus	Sustainability Integration	Relevance to SDGs
Environmental Management	Waste management and environmental monitoring	Moderate	SDG 13
Post-Mining Reclamation	Revegetation, land rehabilitation, ecosystem recovery	Still minimal in most curricula	SDG 15

Source: Adapted from Ministry of Education and Culture (2021), UNESCO (2020), and Indonesian vocational curriculum framework. The table is a literature-based curriculum synthesis and does not represent a national statistical survey.

The table above shows that mining vocational education in Indonesia is still dominated by operational and technical competencies. Environmental sustainability competencies, particularly post-mining reclamation, have not yet become core learning components in many SMK mining programs. This condition indicates the need for curriculum strengthening to support sustainable mining practices and SDGs implementation.

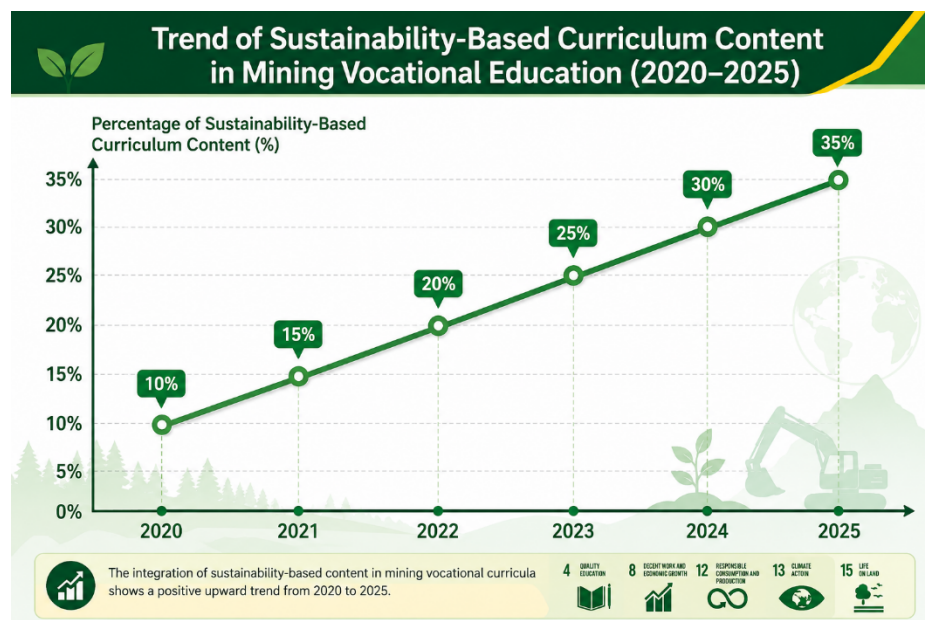


Figure 1. Conceptual Trend of Sustainability Integration in Mining Vocational Education (2020–2025)

Figure 1 presents an illustrative conceptual trend rather than an empirically measured national time series. The visual was developed by synthesizing the direction of policy change, curriculum-revitalization priorities, ESG-related industrial expectations, and sustainability-oriented vocational education literature. The figure is therefore intended to communicate the direction of curriculum change, not to claim that a nationally representative annual percentage was measured. This clarification prevents the visual from being interpreted as primary statistical data.

To understand the relevance of sustainability competencies in vocational mining education, it is necessary to examine current industry workforce demands. Mining companies no longer prioritize only technical extraction skills, but also require competencies related to environmental protection, occupational safety, and sustainable resource management. The increasing implementation of Environmental, Social, and Governance (ESG) principles has encouraged industries to seek workers who are capable of supporting responsible mining

practices. The following figure presents the most needed competencies in the mining industry and highlights the growing importance of post-mining reclamation and environmental management skills (ABM Investama, 2024; BUMA International Group, 2024).

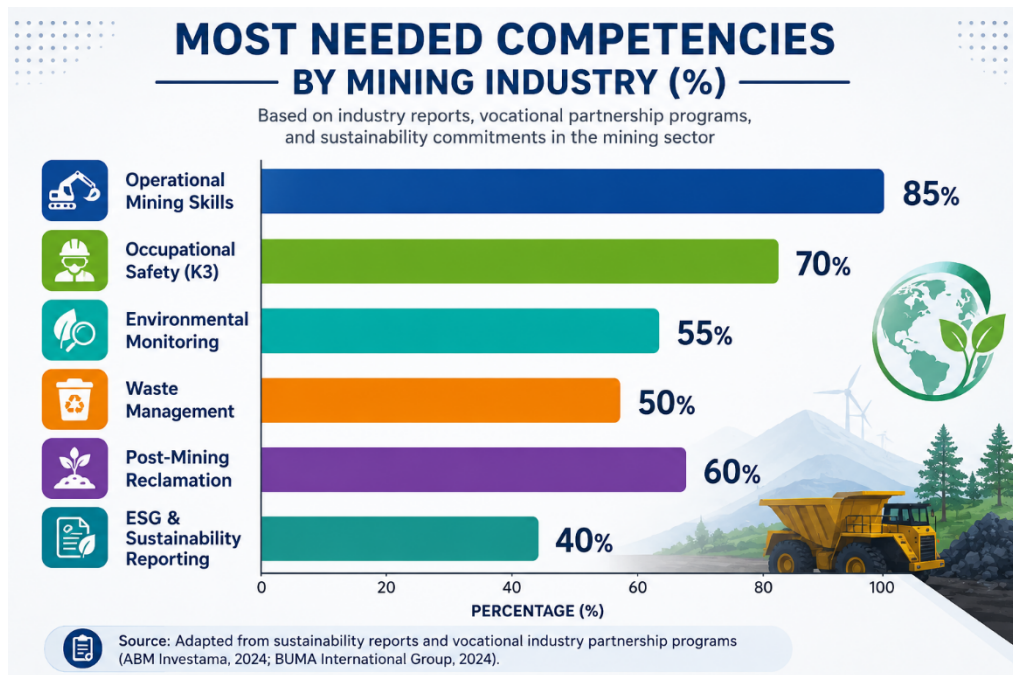


Figure 2. Illustrative Relative Competency Emphasis in Sustainable Mining Workforce Preparation (%)

Figure 2 presents an author-developed illustrative weighting of competency emphasis based on the literature, policy documents, and industry-oriented sources reviewed in this study. The percentages are not results of a survey or statistical estimation and should not be interpreted as measured industry demand. They are used only to visualize the relative emphasis assigned to operational, safety, environmental, reclamation, waste-management, and ESG competencies in the reviewed evidence base.

Within this conceptual synthesis, post-mining reclamation is assigned a higher illustrative weight than waste management, while environmental monitoring and ESG reporting are also treated as increasingly important. The purpose of this comparison is analytical: it shows why mining vocational curricula should expand beyond extraction-only competencies toward a broader green-workforce profile.

Overall, the figure indicates that the mining industry is gradually transitioning toward a more sustainability-oriented workforce model. Therefore, vocational schools, particularly mining-related SMKs in Central Kalimantan, need to integrate reclamation and environmental competencies into their curricula to better align graduate skills with current industrial and sustainable development demands.

The urgency of this research arises from the increasing environmental challenges caused by mining activities in Indonesia, particularly in resource-rich regions such as Central Kalimantan. Mining operations contribute significantly to economic growth; however, they also generate environmental degradation, including deforestation, land damage, water pollution, and biodiversity loss. Many former mining areas remain unproductive due to inadequate reclamation practices and weak environmental restoration systems (Pratiwi et al., 2025).

At the same time, global and national sustainability agendas increasingly emphasize responsible mining practices and post-mining land rehabilitation. Recent studies highlight that post-mining sustainability is no longer viewed solely as technical land restoration, but also as

part of broader sustainable development efforts involving environmental, economic, and social dimensions (Simpson et al., 2025). The integration of Sustainable Development Goals (SDGs) into post-mining planning has become essential to support climate action, ecosystem recovery, and community resilience.

Despite these developments, vocational education curricula in mining-related SMKs still primarily focus on extraction and operational competencies, while post-mining reclamation and sustainability competencies receive limited attention. This creates a competency gap between industrial transformation toward Environmental, Social, and Governance (ESG)-based mining practices and the readiness of vocational graduates. Research by Weijzen et al. (2024) and Azahar et al. (2026) emphasized that future mining industries require adaptive policies, environmental competencies, and sustainability-oriented workforce development to balance economic and ecological interests.

Furthermore, Indonesia's post-mining governance still faces institutional and implementation challenges, including limited supervision, weak coordination, and insufficient integration of sustainable reclamation strategies (Simpson et al., 2024; Pratiwi et al., 2025). Therefore, integrating post-mining reclamation competencies into vocational curricula becomes highly urgent to prepare skilled human resources capable of supporting sustainable mining governance and environmental restoration.

This research is also important because vocational schools play a strategic role in producing industry-ready graduates. By integrating reclamation competencies into mining vocational education, students can develop practical skills related to land rehabilitation, revegetation, environmental monitoring, waste management, and sustainable resource utilization. Such competencies are increasingly demanded by mining industries implementing ESG principles and sustainable mining frameworks.

In addition, this study contributes to the implementation of several Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land). Through curriculum transformation, vocational education can become an important instrument for strengthening environmental awareness, sustainable workforce development, and long-term ecological resilience in post-mining regions.

This study seeks to answer several important research questions related to the integration of post-mining reclamation competencies into mining vocational education in Central Kalimantan. First, the study examines how reclamation competencies are currently integrated into mining-related vocational curricula in SMKs. Second, it explores the major challenges faced by vocational schools in implementing sustainability-oriented learning, particularly in relation to post-mining reclamation education. Third, the research investigates how mining industries perceive the importance of reclamation and environmental sustainability competencies among vocational graduates. Furthermore, the study identifies potential strategies to strengthen curriculum integration in order to support Sustainable Development Goals (SDGs) and respond to industry demands for environmentally responsible workers. Finally, the research analyzes how the integration of reclamation competencies can contribute to the development of industry-ready graduates who possess both technical mining expertise and environmental awareness.

Scientific novelty and theoretical contribution. The novelty of this study lies in the development of a Curriculum Blending and Sustainability Integration Model that connects conventional mining competencies with post-mining reclamation, environmental management, ESG awareness, and SDG-oriented learning within one vocational curriculum framework. Unlike approaches that treat sustainability as a separate educational theme, the proposed model positions sustainability as an embedded management principle across existing mining subjects and links curriculum design with teacher development, project-based learning, digital learning, and school–industry–government collaboration. This contribution extends the curriculum

integration and Education for Sustainable Development literature by translating broad sustainability competencies into a sector-specific curriculum architecture for mining vocational education, while explicitly connecting educational management decisions with changing workforce requirements and post-mining governance.

Mapping of Mining Vocational Curriculum Competencies

The mapping of mining vocational curricula is important to identify the balance between technical mining competencies and sustainability-oriented competencies within vocational education programs. In Indonesia, mining-related SMK curricula are generally designed to prepare students for operational activities in the extractive industry, including exploration, production, safety procedures, and equipment operation. However, the growing implementation of Environmental, Social, and Governance (ESG) principles and Sustainable Development Goals (SDGs) requires vocational institutions to integrate environmental rehabilitation and post-mining reclamation competencies into learning systems. The curriculum mapping below illustrates the relationship between existing mining competencies and the integration of sustainability-based competencies that support environmentally responsible mining practices.

Table 2. Mapping of Mining Vocational Curriculum and Sustainability Competencies

Curriculum Area	Main Competencies	Current Orientation	Sustainability Integration Opportunity	Related SDGs
Mining Exploration	Geological mapping, mineral identification	Technical extraction	Environmental impact assessment	SDG 12, SDG 15
Heavy Equipment Operation	Equipment handling and maintenance	Production efficiency	Energy-efficient operation	SDG 13
Mine Surveying	Land measurement and mapping	Operational planning	Post-mining land contour planning	SDG 15
Occupational Safety and Health (K3)	Workplace safety procedures	Worker protection	Environmental health and safety	SDG 3
Mineral Processing	Mineral separation and processing	Industrial productivity	Waste reduction and management	SDG 12
Environmental Management	Pollution control and monitoring	Regulatory compliance	Sustainable mining practices	SDG 13
Post-Mining Reclamation	Revegetation, soil rehabilitation	Still limited in curriculum	Core sustainability competency	SDG 15
ESG and Sustainability Reporting	Environmental documentation	Rarely integrated	Green industry preparedness	SDG 8, SDG 12

Source: Adapted from Kemendikbud (2021), UNESCO (2020), and mining industry sustainability frameworks. The mapping is a conceptual synthesis based on reviewed curriculum and sustainability sources.

The table shows that most mining vocational competencies remain focused on operational and industrial productivity aspects. Sustainability-related competencies such as post-mining reclamation, ESG reporting, and environmental rehabilitation are still minimally integrated into many vocational curricula. This condition highlights the need for curriculum transformation that balances industrial technical demands with environmental sustainability objectives.

The mapping also demonstrates that sustainability competencies can be integrated into almost every mining-related subject area. For example, mine surveying subjects can incorporate

post-mining land rehabilitation planning, while mineral processing courses can emphasize waste reduction and environmentally friendly processing systems. Through curriculum integration, vocational education can better prepare graduates to support sustainable mining governance and ecological restoration efforts in post-mining regions such as Central Kalimantan.

Curriculum Blending Model in Mining Vocational Education

Curriculum blending refers to the integration of technical mining competencies with sustainability-oriented competencies within vocational education learning systems. In mining vocational education, curriculum blending is important to ensure that students not only master operational mining skills but also understand environmental responsibility, post-mining reclamation, and sustainable resource management. This approach supports the transition toward green mining industries and aligns vocational education with Sustainable Development Goals (SDGs) (UNESCO, 2020).

The blending model combines conventional mining subjects with environmental and sustainability components through interdisciplinary learning, project-based activities, and industry collaboration. As a result, students can develop both technical expertise and environmental awareness simultaneously. According to Kemendikbud (2021), vocational curriculum transformation in Indonesia increasingly emphasizes industry relevance, sustainability competencies, and adaptive learning systems to respond to Industry 4.0 and green economy transitions.

Table 3. Curriculum Blending Model for Mining Vocational Education

Conventional Mining Subject	Blended Sustainability Component	Learning Outcome	Related SDGs
Mining Geology	Environmental impact analysis	Students understand ecological risks of mining activities	SDG 13, SDG 15
Heavy Equipment Operation	Fuel efficiency and emission reduction	Students apply environmentally friendly operational practices	SDG 13
Mine Surveying	Post-mining land rehabilitation planning	Students design sustainable land contour systems	SDG 15
Occupational Safety and Health (K3)	Environmental safety management	Students integrate worker and environmental protection	SDG 3
Mineral Processing	Waste minimization and recycling	Students apply sustainable production systems	SDG 12
Mining Project Practice	Post-mining reclamation simulation	Students practice revegetation and soil rehabilitation	SDG 15
Industrial Internship	ESG-based mining practices	Students understand sustainable mining governance	SDG 8, SDG 12

Source: Adapted from UNESCO (2020), Kemendikbud (2021), and ESG-based vocational education frameworks. The model is conceptual and was not empirically tested in this study.

The curriculum blending model demonstrates that sustainability competencies do not need to stand as separate subjects but can be integrated directly into existing mining vocational learning components. This integration allows vocational schools to optimize existing curriculum structures while gradually strengthening environmental and reclamation competencies. Research by Yusuf and Rahman (2022) emphasized that integrated

environmental learning can improve students' sustainability awareness and practical problem-solving abilities in vocational education contexts.

Furthermore, blended curricula encourage experiential and project-based learning approaches. Students can participate in reclamation simulations, environmental monitoring projects, and industry internships focused on sustainable mining practices. Such approaches improve practical understanding and strengthen workforce readiness for industries implementing Environmental, Social, and Governance (ESG) principles (ABM Investama, 2024).

In the context of Central Kalimantan, curriculum blending becomes highly relevant due to the region's dependence on extractive industries and the increasing environmental impacts of mining activities. Through blended vocational curricula, SMKs can contribute to producing graduates who are technically competent, environmentally responsible, and capable of supporting sustainable post-mining development. This curriculum approach also supports the implementation of SDG 4 (Quality Education), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land) (United Nations, 2015).

Literature Review

Vocational Education and Mining Industry Transformation

Vocational education plays an important role in preparing skilled human resources that align with industrial workforce demands. In Indonesia, Vocational High Schools (SMKs) are designed to provide competency-based education that combines theoretical learning and practical industrial experience. According to Kemendikbud (2021), vocational education transformation in the Industry 4.0 era requires adaptive curricula that integrate technical competencies, digital literacy, and sustainability principles. In mining sectors, vocational education traditionally focuses on operational competencies such as mining exploration, mineral extraction, heavy equipment operation, and occupational safety.

However, the global mining industry is currently experiencing a transition toward sustainable and environmentally responsible practices. Mining companies increasingly adopt Environmental, Social, and Governance (ESG) frameworks to reduce environmental impacts and improve sustainability performance. This transformation has changed workforce competency demands, requiring workers to possess not only technical mining expertise but also environmental management and sustainability competencies (Weijzen et al., 2024; Azahar et al., 2026).

Recent international literature further supports the need for this integrated approach. Azevedo et al. (2022) identify sustainability competencies as an important dimension of technical and vocational education and training, but emphasize the need to translate sustainability principles into teachable competencies. Weijzen et al. (2024) show that vocational education for sustainability benefits from collaborative learning arrangements in which students work with societal actors on real sustainability challenges. More recent evidence also indicates that green skills among vocational students are shaped by the learning environment, environmental attitudes, and cognitive competencies, reinforcing the importance of curriculum, pedagogy, and industry-linked learning rather than isolated sustainability content (Azahar et al., 2026). Compared with these studies, the present study extends the discussion to mining vocational education by specifying how reclamation and ESG competencies can be blended into technical mining subjects and translated into a sector-specific curriculum model.

Several studies emphasize that vocational education must adapt to green economy transitions by integrating sustainability competencies into learning systems. UNESCO (2020) highlighted that Education for Sustainable Development (ESD) should encourage critical thinking, environmental awareness, and practical sustainability competencies. Therefore, vocational institutions are expected to redesign curricula that support sustainable industrial transformation and ecological responsibility.

Post-Mining Reclamation and Environmental Sustainability

Post-mining reclamation refers to activities conducted to restore environmental conditions after mining operations are completed. Reclamation activities generally include land rehabilitation, revegetation, soil recovery, water management, and ecosystem restoration. Indonesian mining regulations require mining companies to conduct reclamation and post-mining management as part of responsible mining governance (Indonesian Ministry of Energy and Mineral Resources, 2023).

Environmental degradation caused by mining remains a significant issue in many mining regions of Indonesia, including Central Kalimantan. Open-pit mining activities often result in deforestation, biodiversity loss, erosion, abandoned mining pits, and water pollution. Sugiharto (2025) explained that weak reclamation implementation and insufficient environmental supervision contribute to long-term ecological damage in post-mining areas. Recent studies also show that post-mining sustainability is increasingly linked to broader sustainable development agendas. Simpson, Clark, and Miller (2025) argued that post-mining land use planning should integrate Sustainable Development Goals (SDGs), environmental restoration, community welfare, and climate resilience. This perspective shifts reclamation from a purely technical process into a strategic sustainability initiative.

In addition, ESG implementation within mining industries has increased the importance of reclamation competencies. Mining companies are now expected to demonstrate environmental accountability through land rehabilitation programs, biodiversity conservation, and sustainability reporting. Consequently, workforce competencies related to environmental restoration and sustainable mining management are becoming increasingly important.

Sustainability Integration in Vocational Curriculum

Curriculum integration refers to the process of combining interdisciplinary competencies and learning objectives into educational systems. In vocational education, sustainability integration aims to embed environmental awareness, ecological responsibility, and sustainable development values into technical learning subjects.

The concept of curriculum blending has emerged as an effective strategy for integrating sustainability competencies into vocational learning systems. Curriculum blending combines conventional technical competencies with sustainability-oriented competencies through interdisciplinary learning approaches, project-based learning, and industrial collaboration (UNESCO, 2020). Rather than introducing separate sustainability subjects, environmental concepts are integrated directly into existing vocational subjects.

Previous research by Yusuf and Rahman (2022) found that integrated environmental learning improves students' ecological awareness, practical problem-solving skills, and adaptability to green industry transformation. Similarly, project-based sustainability learning encourages experiential learning that connects classroom knowledge with real environmental challenges.

The comparison also reveals an important theoretical distinction. Existing green vocational education studies generally emphasize the development of green skills, collaborative learning, or sustainability awareness, whereas this study focuses on the curriculum-management mechanism through which those competencies can be embedded in a mining-specific occupational structure. Thus, the proposed model is not presented as an empirically validated causal model; it is a conceptual curriculum-management framework derived from the convergence of sustainability competency literature, vocational curriculum transformation, ESG workforce requirements, and post-mining reclamation needs.

In mining vocational education, sustainability integration may include environmental impact analysis, reclamation planning, waste management, energy efficiency, revegetation techniques, and ESG reporting systems. Such competencies are increasingly relevant to mining industries implementing sustainable operational frameworks.

However, several challenges remain in implementing sustainability-based vocational curricula. These include limited teacher competencies, inadequate learning facilities, weak industry collaboration, and rigid curriculum structures. Therefore, stronger policy support, industrial partnerships, and teacher capacity development are necessary to strengthen sustainability integration within vocational education systems.

Sustainable Development Goals (SDGs) and Vocational Education

The Sustainable Development Goals (SDGs), introduced by the United Nations in 2015, provide a global framework for achieving economic growth, social inclusion, and environmental sustainability. Education is recognized as a key instrument for achieving sustainable development objectives. SDG 4 specifically emphasizes inclusive and quality education that supports lifelong learning and sustainability competencies (United Nations, 2015).

Mining vocational education is closely related to several SDGs, particularly those concerning quality education, decent work, responsible production, climate action, and environmental restoration. Through sustainability-oriented curriculum transformation, vocational schools can contribute directly to environmental recovery, workforce development, and responsible industrial practices. UNESCO (2020) emphasized that sustainability education should prepare learners to address environmental challenges and participate actively in sustainable development processes.

In the context of Central Kalimantan, integrating reclamation competencies into mining vocational curricula becomes increasingly important due to the region's dependence on extractive industries and growing ecological pressures. Sustainability-oriented vocational education can help produce graduates capable of supporting post-mining environmental recovery and sustainable mining governance in Indonesia.

The literature and policy sources were selected purposively according to their relevance to four themes: mining vocational curriculum, sustainability and green skills, post-mining reclamation, and ESG/SDG-oriented workforce development. Priority was given to peer-reviewed studies, official government and intergovernmental documents, and industry sustainability reports. The analysis proceeded in three stages: source identification and screening, thematic coding of curriculum and sustainability competencies, and cross-source synthesis to develop the proposed curriculum blending model. The study did not collect primary data from students, teachers, vocational schools, mining companies, or government officials.

METHOD

Methodological limitation and validation status. Because the study uses literature review and policy analysis, the proposed Curriculum Blending and Sustainability Integration Model remains conceptual and has not been empirically validated through interviews, surveys, focus groups, Delphi procedures, expert panels, or case studies. Accordingly, the model should be interpreted as an evidence-informed conceptual framework rather than as a tested predictive or causal model. Future research should validate the framework through stakeholder consultation and case-based implementation involving mining vocational schools, industry practitioners, curriculum experts, and relevant government institutions. This limitation is explicitly acknowledged to delimit the claims of the study.

The research utilized a literature review and policy analysis approach by examining various academic articles, government regulations, curriculum documents, sustainability reports, and vocational education frameworks related to mining education and sustainable development. The collected data were derived from publications issued by the Ministry of Education and Culture (Kemendikbud), Ministry of Energy and Mineral Resources, UNESCO

reports, mining industry sustainability reports, and previous studies discussing Environmental, Social, and Governance (ESG) implementation and vocational curriculum transformation.

The study focused on several analytical aspects, including: (1) the current structure of mining vocational curricula in Indonesian SMKs, (2) the extent of sustainability and post-mining reclamation competency integration, (3) industrial demands for green mining competencies, and (4) opportunities for curriculum blending to support Sustainable Development Goals (SDGs). Data were analyzed using descriptive content analysis to identify patterns, curriculum gaps, sustainability trends, and potential curriculum development strategies (Miles, Huberman, & Saldaña, 2014).

To strengthen the analysis, this study also used comparative curriculum mapping between conventional mining competencies and sustainability-oriented competencies. The mapping process aimed to identify opportunities for integrating environmental rehabilitation, reclamation practices, waste management, and ESG-related learning into existing vocational subjects. In addition, trend analysis was conducted to examine the increasing emphasis on sustainability-based curriculum content and green workforce competencies within the mining industry.

The validity of the study was strengthened through source triangulation by comparing information from educational policies, industry sustainability frameworks, and previous academic studies. This approach ensured that the findings reflected both educational perspectives and industrial sustainability demands. Through this method, the research provides a comprehensive understanding of how vocational curricula can be transformed to support sustainable mining development in Central Kalimantan.

RESULTS AND DISCUSSION

Current Condition of Mining Vocational Curriculum

The findings indicate that mining vocational education in Indonesia, particularly in Central Kalimantan, remains largely focused on operational and technical competencies. Most mining-related SMK programs prioritize subjects such as mining geology, heavy equipment operation, mine surveying, mineral processing, and occupational safety and health (K3). These competencies are designed to prepare students for direct employment in extractive industries and support industrial productivity.

However, sustainability-oriented competencies, especially post-mining reclamation and environmental rehabilitation, are still minimally integrated into the curriculum structure. Environmental management topics are generally taught only as complementary materials rather than core competencies. This finding aligns with the vocational curriculum redesign framework issued by Kemendikbud (2021), which shows that vocational education in Indonesia is still dominated by industrial production-oriented learning systems.

The curriculum mapping analysis demonstrates that sustainability integration opportunities exist across almost all mining subjects. For example, mine surveying subjects can incorporate post-mining land contour planning, while mineral processing subjects can include waste reduction and recycling concepts. Nevertheless, many schools have not fully implemented such integration due to limited curriculum flexibility and lack of sustainability-focused learning resources.

Increasing Industrial Demand for Sustainability Competencies

The study also found that mining industries increasingly require workers with sustainability and environmental management competencies. Mining companies implementing Environmental, Social, and Governance (ESG) frameworks now prioritize environmentally responsible operational systems, reclamation practices, and sustainable land management.

The competency trend analysis shows that operational mining skills remain the most demanded competency at 85%, followed by occupational safety and health (70%). However,

post-mining reclamation competencies reached 60%, indicating significant industrial demand for environmental rehabilitation skills. Environmental monitoring and waste management competencies also continue to gain importance due to stricter environmental regulations and sustainability commitments.

These findings indicate that mining workforce requirements are gradually shifting from purely technical operational skills toward green mining competencies. According to ABM Investama (2024), mining industries increasingly require workers who understand reclamation planning, environmental monitoring, and ESG-based reporting systems. This industrial transformation highlights the urgency of aligning vocational curricula with sustainable mining practices.

Curriculum Blending and Sustainability Integration

The results suggest that curriculum blending provides an effective strategy for integrating sustainability competencies into mining vocational education. Rather than creating entirely new subjects, sustainability concepts can be embedded into existing mining courses through interdisciplinary and project-based learning approaches.

For instance, heavy equipment operation courses can integrate fuel efficiency and emission reduction practices, while mining project practices can include reclamation simulations and revegetation activities. Industrial internships can also expose students to ESG-based mining operations and environmental management systems.

This blended curriculum approach supports UNESCO's (2020) concept of Education for Sustainable Development (ESD), which emphasizes integrating sustainability values into practical and competency-based learning systems. Through blended learning, students can simultaneously develop technical expertise and environmental awareness, increasing their readiness for sustainable workforce demands. Furthermore, project-based reclamation learning can improve students' problem-solving skills, collaboration abilities, and ecological understanding. Such approaches encourage experiential learning that directly connects classroom theory with real environmental challenges in mining regions.

Before presenting the curriculum model, it is important to understand that the transformation of mining vocational education requires an integrated learning framework that balances technical competencies and sustainability values. The increasing implementation of Environmental, Social, and Governance (ESG) principles, green mining practices, and Sustainable Development Goals (SDGs) has encouraged vocational schools to redesign curricula that are more adaptive to environmental challenges and industrial transformation. Therefore, the Curriculum Blending and Sustainability Integration model is proposed as a strategic approach to integrate post-mining reclamation, environmental management, and sustainable mining competencies into existing vocational mining education systems (UNESCO, 2020; Kemendikbud, 2021).

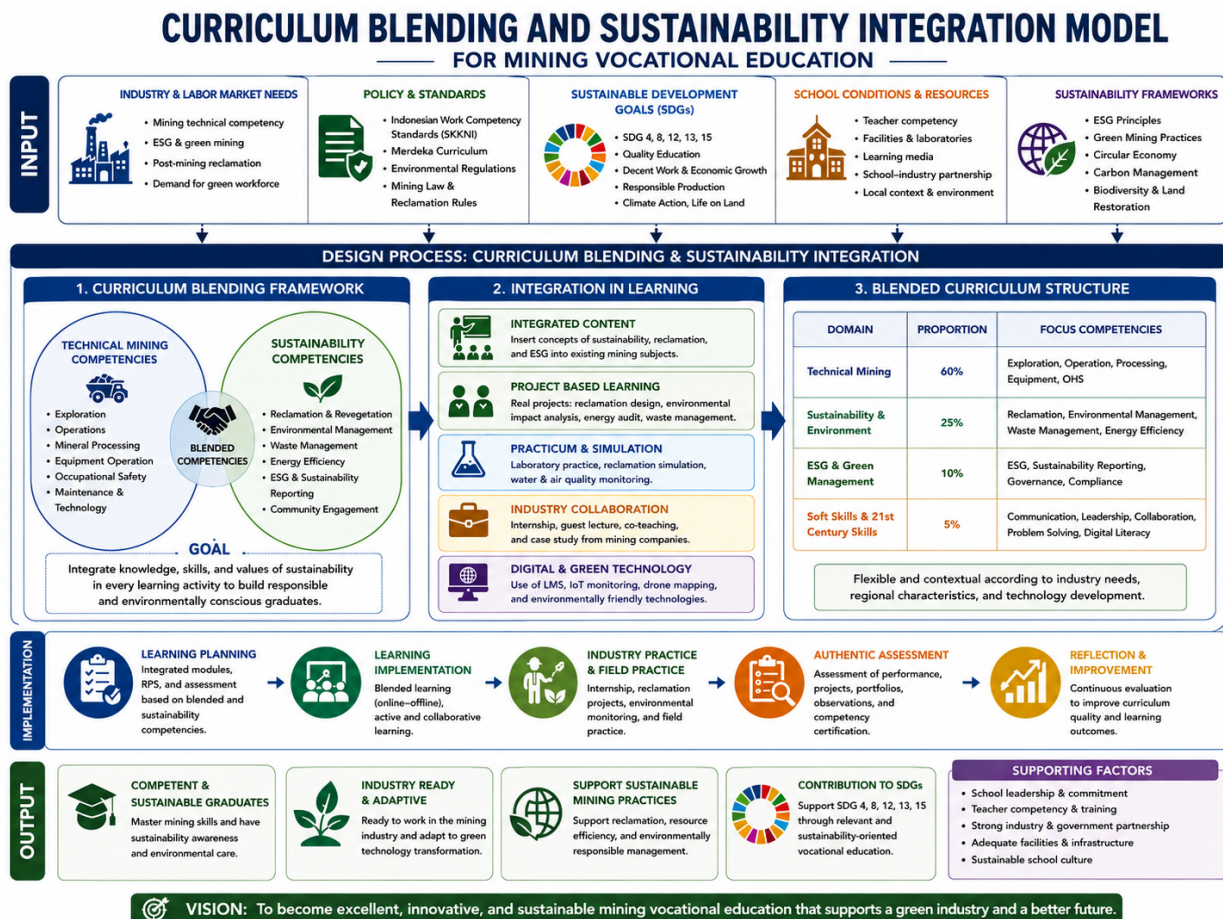


Figure 3. Curriculum Blending and Sustainability Integration Model in Mining Vocational Education

The figure above illustrates a conceptual framework for integrating sustainability competencies into mining vocational curricula through a blended curriculum approach. The model begins with several input components, including industrial workforce demands, national curriculum policies, SDGs principles, ESG frameworks, and the availability of school resources. These components become the foundation for curriculum transformation in vocational mining education.

The core process of the model consists of curriculum blending between conventional mining competencies and sustainability-oriented competencies. Technical mining subjects such as exploration, equipment operation, mineral processing, and occupational safety are integrated with reclamation, environmental management, waste reduction, energy efficiency, and ESG reporting competencies. This integration ensures that sustainability principles become part of existing learning systems rather than separate educational components.

The model also emphasizes project-based learning, industrial collaboration, field practice, and digital learning technologies. Through reclamation simulations, environmental monitoring projects, internships, and ESG-based industry practices, students can gain practical experience related to sustainable mining operations. Such experiential learning approaches help students develop problem-solving abilities, ecological awareness, and adaptive workforce competencies.

Furthermore, the blended curriculum structure demonstrates proportional integration between technical mining learning and sustainability competencies. While operational mining skills remain dominant to maintain industrial relevance, environmental and reclamation competencies receive stronger emphasis compared to conventional vocational curricula. This

balance supports the development of graduates who are both technically competent and environmentally responsible.

The output of the model is the creation of vocational graduates who are industry-ready, adaptive to green economy transformation, and capable of supporting sustainable mining governance. The model also contributes directly to SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land). Therefore, the Curriculum Blending and Sustainability Integration model can serve as an innovative framework for strengthening sustainability-oriented vocational mining education in Central Kalimantan and other mining regions in Indonesia.

Challenges in Integrating Reclamation Competencies

Despite the growing importance of sustainability integration, several challenges remain in implementing reclamation competencies within mining vocational education. One major challenge is the limited expertise of teachers in environmental rehabilitation and sustainable mining practices. Many vocational educators possess strong technical mining backgrounds but lack specialized knowledge related to reclamation and ESG systems.

Another challenge involves limited educational facilities and practical learning infrastructure. Reclamation learning often requires field practice, environmental laboratories, revegetation equipment, and partnerships with mining companies. However, not all vocational schools have adequate resources to support sustainability-oriented practical learning activities.

In addition, curriculum rigidity and administrative limitations can hinder curriculum innovation. Vocational schools often face difficulties in adjusting competency structures due to national curriculum standards and limited instructional time allocations. This condition reduces opportunities for integrating additional sustainability-based competencies. Industry-school collaboration also remains uneven across regions. Although some mining companies support vocational partnership programs, collaboration related specifically to reclamation and environmental sustainability training is still relatively limited. Strengthening partnerships between schools, industries, and government agencies is therefore necessary to support curriculum transformation.

Before developing a solution model, it is important to identify the major challenges faced by vocational schools in integrating post-mining reclamation competencies into mining education curricula. Although sustainability and ESG principles are increasingly emphasized in the mining industry, many vocational institutions still experience limitations in curriculum implementation, learning resources, industrial collaboration, and teacher preparedness. These challenges create a gap between industry expectations for green competencies and the actual readiness of vocational graduates. Therefore, a systematic mapping of challenges and strategic solutions is necessary to strengthen sustainability-oriented vocational education in mining sectors.

Table 4. Challenges and Solution Model for Integrating Reclamation Competencies in Mining Vocational Education

Main Challenges	Description	Impact on Vocational Education	Proposed Solution Model
Limited Teacher Competence	Teachers have strong technical mining backgrounds but limited expertise in reclamation and ESG practices	Sustainability topics are not optimally delivered	Continuous teacher training, ESG certification, and industry-based workshops

Main Challenges	Description	Impact on Vocational Education	Proposed Solution Model
Limited Curriculum Integration	Reclamation competencies are still treated as supplementary materials	Sustainability learning becomes fragmented	Curriculum blending and interdisciplinary integration model
Inadequate Facilities & Laboratories	Schools lack environmental labs, reclamation practice areas, and monitoring tools	Limited practical learning opportunities	Development of green laboratories and reclamation simulation projects
Weak Industry Collaboration	Few partnerships specifically focus on reclamation and sustainability training	Students have limited exposure to green mining practices	ESG-based internship and collaborative industry programs
Limited Learning Resources	Lack of sustainability-focused teaching materials and digital modules	Students receive minimal sustainability understanding	Development of digital learning platforms and sustainability modules
Administrative & Policy Constraints	Rigid curriculum structures limit innovation	Schools struggle to add new competencies	Flexible curriculum policies and sustainability competency standards
Low Student Awareness of Sustainability	Students prioritize operational mining skills over environmental responsibility	Weak ecological awareness among graduates	Project-based learning and environmental campaigns

Source: Adapted from UNESCO (2020), Kemendikbud (2021), ABM Investama (2024), and ESG-based vocational education studies. The solution model is derived from the literature and policy analysis and is presented as a conceptual framework.

The table above shows that the integration of reclamation competencies is influenced by both internal and external educational factors. Internal challenges include limited teacher competencies, curriculum rigidity, and inadequate educational infrastructure. External challenges involve weak industry collaboration and limited sustainability-oriented policy support. These issues collectively hinder the implementation of sustainability-based vocational education in mining sectors. To address these challenges, a comprehensive solution model is proposed through the integration of curriculum transformation, industry collaboration, and sustainability-based learning innovation.



Figure 4. Challenges and Solution Model for Integrating Reclamation Competencies in Mining Vocational Education

The model emphasizes several strategic components. First, curriculum blending becomes the central strategy for integrating reclamation and environmental competencies into existing mining subjects. Rather than creating separate sustainability subjects, reclamation principles can be embedded into geology, mine surveying, mineral processing, and industrial practice courses. Second, strengthening teacher competencies is essential to ensure effective sustainability learning. Vocational teachers need continuous professional development programs related to ESG implementation, environmental management, reclamation techniques, and green mining practices. Collaboration with mining industries and universities can support this competency improvement process.

Third, practical and project-based learning approaches should be expanded through reclamation simulations, environmental monitoring projects, revegetation practices, and field-based sustainability learning. These methods encourage experiential learning and improve students' ecological awareness and problem-solving abilities. Fourth, industry collaboration must shift beyond operational internships toward ESG-oriented partnerships. Mining companies can contribute through guest lectures, reclamation practice sites, green technology training, and collaborative curriculum development. Such partnerships help align vocational competencies with industrial sustainability transformation.

Finally, digital learning innovation and green technology integration can strengthen sustainability-based vocational learning systems. The use of Learning Management Systems (LMS), environmental monitoring applications, drone mapping technologies, and virtual reclamation simulations can improve learning accessibility and practical understanding.

The solution model illustrates that curriculum transformation should be supported simultaneously by teacher development, practical learning innovation, digital technology integration, and strong industry collaboration. Through this integrated approach, vocational schools can produce graduates who are not only technically skilled but also capable of

supporting sustainable mining governance and post-mining environmental restoration in Indonesia.

Contribution to Sustainable Development Goals (SDGs)

The integration of post-mining reclamation competencies into vocational curricula contributes directly to several Sustainable Development Goals (SDGs). First, it supports SDG 4 (Quality Education) by improving the relevance and quality of vocational learning systems. Second, it contributes to SDG 8 (Decent Work and Economic Growth) through the development of industry-ready green workforce competencies.

Third, sustainability-based mining education supports SDG 12 (Responsible Consumption and Production) by encouraging environmentally responsible mining practices and waste management systems. Fourth, reclamation competencies contribute to SDG 13 (Climate Action) through land rehabilitation and environmental restoration efforts. Finally, the integration strongly supports SDG 15 (Life on Land) by promoting ecosystem recovery and biodiversity protection in post-mining regions.

Overall, the findings demonstrate that vocational education can play a strategic role in supporting sustainable mining governance in Indonesia. By integrating reclamation competencies into mining curricula, vocational schools in Central Kalimantan can contribute to producing graduates who are not only technically competent but also environmentally responsible and capable of supporting long-term sustainable development.

CONCLUSION

The integration of post-mining reclamation competencies into mining vocational education is essential to support sustainable mining practices and the achievement of Sustainable Development Goals (SDGs). The study found that mining vocational curricula in Indonesia, particularly in Central Kalimantan, are still predominantly focused on operational and technical competencies, while sustainability-oriented competencies such as reclamation, environmental management, and ESG practices remain limited. This condition creates a competency gap between vocational graduates and the evolving demands of the mining industry, which increasingly emphasizes environmentally responsible mining practices.

A key limitation is that the proposed model has not yet been empirically validated with vocational teachers, students, mining companies, or policy stakeholders. The contribution of the present study is therefore conceptual and evidence-informed. Future studies should test the model through Delphi validation, expert judgment, or comparative case studies across mining vocational schools to determine its feasibility, acceptability, and implementation outcomes.

The findings also indicate that mining industries now require broader workforce competencies that include environmental monitoring, waste management, reclamation, and sustainability reporting alongside conventional mining skills. This transformation reflects the growing implementation of ESG principles, stricter environmental regulations, and global sustainability commitments within the mining sector.

To address these challenges, the study proposes a Curriculum Blending and Sustainability Integration model that combines technical mining competencies with sustainability and reclamation competencies through interdisciplinary, project-based, and industry-collaborative learning approaches. The model emphasizes curriculum integration, teacher competency development, practical learning innovation, digital technology utilization, and stronger partnerships between schools and industries.

Furthermore, the study identified several major barriers to implementation, including limited teacher expertise, inadequate facilities, weak industry collaboration, and rigid curriculum structures. Therefore, a comprehensive and collaborative solution model is necessary to strengthen sustainability-oriented vocational education systems. Through curriculum transformation and sustainability integration, vocational schools can produce

graduates who are not only technically competent but also environmentally responsible and adaptive to green industry transformation.

Overall, this study highlights the strategic role of vocational education in supporting sustainable mining governance and post-mining environmental restoration in Indonesia. The integration of reclamation competencies into vocational curricula contributes directly to SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land). Therefore, sustainability-oriented vocational curriculum development can become an important foundation for creating a greener, more responsible, and sustainable mining sector in the future.

REFERENCE

- ABM Investama. (2024). *Sustainability Report 2024*. Jakarta: PT ABM Investama Tbk.
- Azevedo, B. D., Schaefer, A., & Durham, E. (2022). Sustainability Competencies in Technical and Vocational Education and Training: A Systematic Review. *Journal of Cleaner Production*, 332, 129984. DOI: 10.1016/j.jclepro.2021.129984
- Azahar, R., Hariyanto, V. L., Prayogo, W., & Fitria, L. (2026). Fostering green skills in vocational students: The impact of learning environment, attitudes, and competence. *Indonesian Journal on Learning and Advanced Education*, 8(1), 203–223. <https://doi.org/10.23917/ijolae.v8i1.11746>
- Pratiwi, B. H. Narendra, C. A. Siregar, Iskandar, B. Mulyanto, Suwardi, D. T. Suryaningtyas, I. W. S. Dharmawan, S. Suharti, & F. Marsandi. (2025). Tin mining and post-tin mining reclamation initiatives in Indonesia: With special reference to Bangka Belitung areas. *Land*, 14(10), 1947. <https://doi.org/10.3390/land14101947>
- Simpson, G. B., Ferguson, K., Slingerland, N., & Hattingh, R. (2024). Integrating the Sustainable Development Goals into post-mining land use selection. In A. B. Fourie, M. Tibbett, & G. Boggs (Eds.), *Mine Closure 2024: Proceedings of the 17th International Conference on Mine Closure* (pp. 143–156). Australian Centre for Geomechanics. https://doi.org/10.36487/ACG_repo/2415_09
- Weijzen, S. M. G., Onck, C., Wals, A. E., Tassone, V. C., & Kuijer-Siebelink, W. (2024). Vocational education for a sustainable future: Unveiling the collaborative learning narratives to make space for learning. *Journal of Vocational Education & Training*, 76(2), 331–353. <https://doi.org/10.1080/13636820.2023.2270468>
- BUMA International Group. (2024). *BUMA School Partnership Program Report*. Jakarta: BUMA International Group.
- Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Thousand Oaks, CA: Sage Publications. DOI: 10.1002/nha3.20258
- Hashimov, E. (2015). Review of *Qualitative Data Analysis: A Methods Sourcebook*. *Technical Services Quarterly*, 32(1), 109–112. DOI: 10.1080/10572252.2015.975966
- Hilson, G., & Murck, B. (2000). Sustainable Development in the Mining Industry: Clarifying the Corporate Perspective. *Resources Policy*, 26(4), 227–238. DOI: 10.1016/S0301-4207(00)00041-6
- Indonesian Ministry of Education and Culture (Kemendikbud). (2021). *Redesign of Vocational Expertise Programs in the Era of Industry 4.0*. Jakarta: Ministry of Education and Culture of Indonesia.
- Indonesian Ministry of Energy and Mineral Resources. (2023). *Mining Sector Performance Report*. Jakarta: ESDM Press.
- Ishtiaq, M. (2019). Book Review: *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*. *English Language Teaching*, 12(5), 40–40. DOI: 10.5539/elt.v12n5p40

- Kivinen, O., & Silvennoinen, H. (2021). Green Skills and Sustainability in Vocational Education. *International Journal of Training Research*, 19(3), 231–245. DOI: 10.1080/14480220.2021.1973254
- Laurence, D. (2011). Establishing a Sustainable Mining Operation: An Overview. *Journal of Cleaner Production*, 19(2–3), 278–284. DOI: 10.1016/j.jclepro.2010.08.019
- Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). Thousand Oaks, CA: Sage Publications. DOI: 10.1177/239700221402800402
- Pavlova, M. (2013). Teaching and Learning for Sustainable Development: ESD Research in Technology Education. *International Journal of Technology and Design Education*, 23(3), 733–748. DOI: 10.1007/s10798-012-9213-9
- Sánchez, L. E., & Silva-Sánchez, S. S. (2008). Tiering Strategic Environmental Assessment and Project Environmental Impact Assessment in Highway Planning in São Paulo, Brazil. *Environmental Impact Assessment Review*, 28(7), 515–522. DOI: 10.1016/j.eiar.2007.07.003
- Tilbury, D. (2011). Education for Sustainable Development: An Expert Review of Processes and Learning. *UNESCO Education Sector*. DOI: 10.13140/RG.2.2.13492.94089
- UNESCO. (2020). *Education for Sustainable Development Goals: Learning Objectives*. Paris: UNESCO Publishing.
- United Nations. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York: United Nations.
- Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key Competencies in Sustainability: A Reference Framework for Academic Program Development. *Sustainability Science*, 6(2), 203–218. DOI: 10.1007/s11625-011-0132-6
- World Bank. (2021). *Mining Sector and Environmental Sustainability in Developing Countries*. Washington, DC: World Bank Publications.
- Yusuf, M., & Rahman, A. (2022). Integration of Environmental Education in Vocational Schools. *Journal of Technical Education*, 15(2), 45–56.
- Zvarivadza, T. (2018). Sustainability in the Mining Industry: The Role of Technological Innovation. *Procedia Manufacturing*, 21, 650–657. DOI: 10.1016/j.promfg.2018.02.167