Assessment of Modern Training Innovations for Supervisors and Trainers in the South African Mining Sector

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As the mining industry modernises, skills development needs to be a priority. The aim of this paper was to develop guidelines that consider the assessment of modern training solutions for supervisors and trainers in modern mining. A literature review was conducted on best-practice criteria for the evaluation of modern mining upskilling and reskilling solutions. A draft evaluation matrix was developed based on the literature review insights and incorporated 48 best-practice criteria for the assessment of training solutions. The assessment instrument was applied to training curriculums for supervisors and trainers of two participant entities. Data gathering included assessments of the training solutions, and an industry panel review process. Strengths, weaknesses, opportunities, threats, and gap analyses were undertaken. Key insights were revealed for the respective training solutions. Recommendations included continuous review and improvement of the curriculum for alignment to mining modernisation skills needs, including consideration of modern training methodologies and facilitation; revised content and assessments; skills and training required for modernisation; tracking of graduates and learner feedback; better alignment with modernisation objectives and industry skills needs, increased focus on safety and risk assessment and control; and more immersive learning experiences. While sample training innovations were selected for evaluation, the recommendations remain relevant for training entities looking to align to their curriculum to mining modernisation skills needs and industry skills demands for modernisation.

Keywords: Training Curriculum, Training Evaluation, Modernisation, Reskilling, Upskilling

INTRODUCTION

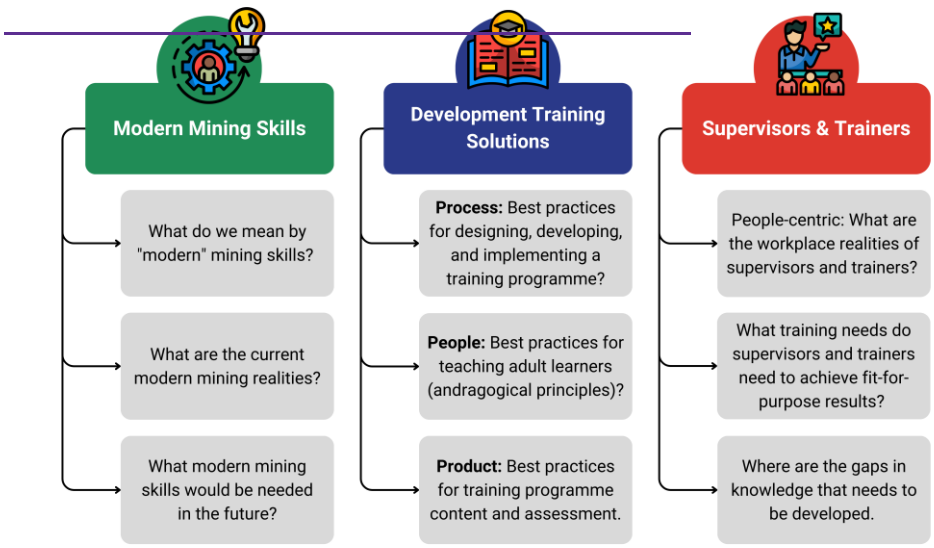
The Successful Application of Technologies Centred Around People (SATCAP) programme of the Mandela Mining Precinct focuses on understanding the impacts of mining modernisation on people in the minerals sector, and intends to support the mining industry's environmental, social and governance agenda. To this end, relevant projects have been commissioned with an emphasis on jobs, skills and people-centric modernisation. This paper provides a summary of the findings from the SATCAP Work Package (WP) 2.1 project in the 2024 financial year. The aim of the project was to develop a guideline for the South African mining industry through assessments of upskilling and reskilling training innovations to drive modern mining skills development for supervisors and trainers. This project is linked to SATCAP WP 2.2 which also focuses on skills development innovations, but has an outward

focus on community members, therefore there are differences in the criteria used and the assessed solutions. However, because of the linkage, there is substantial overlap between this paper and the SATCAP WP 2.1 paper, titled 'Assessment of waste management and renewables-related training innovations towards mining sustainability.'

Skills development needs to be a priority as the mining industry continues to change and modernise. The modernisation of mines introduces new ways for mine supervisors and trainers to conduct activities. Although the role of supervisors is viewed as critical, there is a missing link between strategy and the implementation of innovative solutions; the sustainability of the sector is dependent on requisite skills development. Relevant skills development will provide employees with the skills required for modern mining and post-mining, thereby enabling modernisation. Furthermore, many of the same skills, especially much-needed digital skills and their application, are relevant for other sectors, including construction, manufacturing and agriculture, and may allow for job options post-mine closure.

REVIEW OF LITERATURE

A literature review was conducted to obtain a deeper understanding of the modern mining skills needed for supervisors and trainers, and to identify best-practice criteria that can be used to assess existing modern mining skills development training solutions. Figure 1 illustrates the core focus areas.



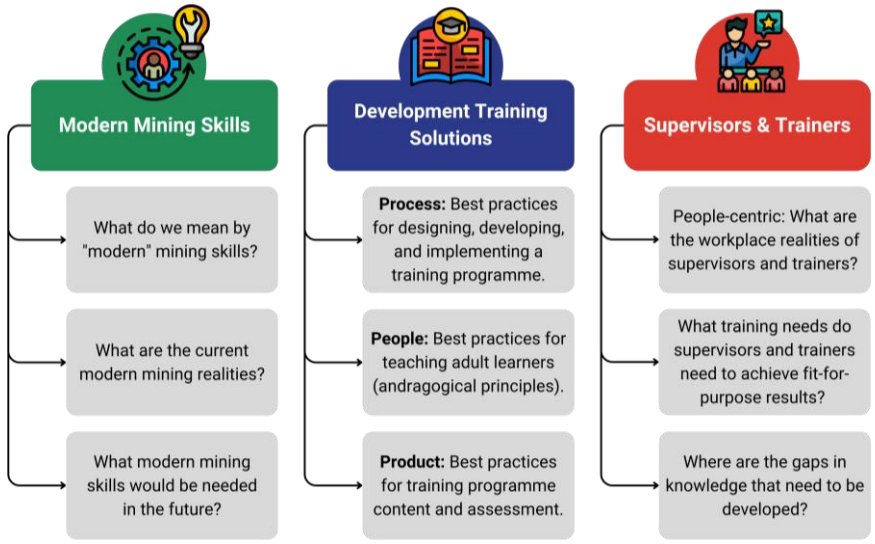


Figure 1. Literature review core focus areas.

Modern mining skills development for supervisors and trainers

Modernisation in mining – defined as the shift from traditional methods to advanced technologies and practices – requires evolving skills for all workers, including supervisors and trainers, to effectively adapt and lead in increasingly complex operations (Global Mining Guidelines Group, 2019). The adoption of technology to conduct mining activities (for example, through mechanisation) has, in some cases, replaced manual tasks. Furthermore, the implementation of automation, which constitutes digital and autonomous mining technologies, reshapes the roles and skills of the workforce (Fraser, 2017; Jacobs and Webber Youngman, 2017). The training content for supervisors and trainers must be adapted to ensure successful implementation of various technologies. Mine supervisors and trainers should generally understand that legal, operational, health and safety, environmental, communication, and logistical changes are introduced by these technologies (Hattingh *et al.*, 2010; Global Mining Guidelines Group, 2019; Lynas and Horberry, 2011; Willis *et al*., 2004). It is therefore critical that mine supervisors and trainers are given the relevant training for the diverse array of competencies necessary for the effective operation and management of advanced mining technologies and processes. The skills include digital literacy and technology proficiency; immersive learning and virtual reality (VR) training; advanced technical skills; health and safety management; gamified and mobile micro-learning; educational technology solutions; cross-industry collaboration and innovation; and adaptability and lifelong learning (Minerals Council South Africa, 2024).

Effective training for mining supervisors and trainers must address behavioural skills, digital literacy, and safety culture to support technological advancements (Haywood, 2022; Mape, 2020). Some of the key focus areas include encouraging safety awareness; enhancing digital literacy and acumen for effective training and supervision on, and use of new equipment; proficiency in innovative training methods like gamification and VR, and knowledge of the Mine Health and Safety Act (MHSA) (Moodley, 2018). Supervisors must adapt to automation, the internet of things, and artificial intelligence mentor teams, and leverage modern technologies to enhance productivity and efficiency (Gleeson, 2023; Rawden, 2024). Existing skills training in South Africa appears to emphasise management, leadership, and technical mining competencies, with less focus on modernisation technologies and their operational effects (MQA, 2024).

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Reskilling and upskilling are critical for modernising the mining workforce, allowing mines to adapt current employees rather than relying on external hires (Makonese, 2024). Upskilling enhances existing skills, while reskilling equips workers for new roles in modernised environments (Cloud Assess, 2024). Reskilling includes foundational training in new technologies, transitioning roles, and readiness evaluation (Cloud Assess, 2024). A collaborative blueprint involving education institutions, mining companies, and technology providers ensures a future-ready workforce (Ling, 2022; Makonese, 2024). Effective reskilling programs identify trends, skills gaps, and delivery methods, engage stakeholders, and incorporate feedback to improve success (Cloud Assess, 2024). Modern training methods found to be effective include blended learning (70-20-10 model); Learner Management Systems for content delivery and tracking; interactive and gamified methodologies, immersive VR, and simulators; internal training or seminars; and bridging programs to develop science, technology, engineering and mathematics skills for adults (Haywood, 2022; Mape, 2020; Moodley, 2018). Retraining also plays a key role in adapting employees to new job responsibilities due to technological advancements (Cloud Assess, 2024).

In summary, findings from the literature review indicated that any curriculum changes or enhancements to enable modernisation should consider the following, amongst other factors:

- Legal requirements/compliance changes
- New or updated manuals, operating procedures
- New safety, health and environmental hazards and mitigation measures
- Reviews of performance measures and on-job assessments
- Leadership development and coaching
- Effective ways of communication and engagement
- Changes in equipment/machinery/hardware maintenance processes
- Changes in logistics (transport of materials needed for daily shift activities)
- Changes and advancements in technologies
- Training and skills development (digital, technical, safety and health, technology proficiency)
- Modern training methodologies; and
- Change management.

Best-practice criteria
In the literature review, important frameworks with which to create best-practice criteria to evaluate training were also identified.

The foundational framework used was the ISO Standard for Competence Management and People Development (cf. International Organization for Standardization, 2019:v). The ISO standard, with the Plan-Do-Check-Act (PDCA) cycle, serves as a recognised guideline for good quality management. The PDCA cycle includes the process to plan for competence development, aligns the requirements from a business or institutional perspective, and provides guidance for implementation and continuous improvement.

The ISO PDCA Cycle was enhanced using an instructional design framework called the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Florida State University, 2024), to provide extra depth to what is needed when developing a training programme. A Training Needs Analysis forms part of the first step of the PDCA cycle and ADDIE and refers to a systematic process to assess individuals' current knowledge, skills and application against the competence criteria as set by the business or institution.

The third framework used to enhance the PDCA cycle was the Kirkpatrick and Phillips model. This framework aligns with the Check step, as it provides a guideline by which to assess the learner experience and learning within the competence approach. This model is an internationally recognised tool for evaluating and analysing the results of educational, training and learning programmes with a learner-centric approach. It consists of five levels of evaluation: Reaction, Learning, Behaviour, Results, and Return on Investment (ROI) for an amplified business or institutional perspective (Ashofteh and

Orangian, 2021; Kirkpatrick and Kirkpatrick, 2013; Phillips, 1998).

The importance of following a systems approach was also identified when developing the best-practice evaluation matrix. Factors to consider when setting evaluation criteria include the learning environment, learner readiness, teacher orientation, learning contents, and if learning is fit for purpose (contextual relevance). The demand for specific competence requirements from a business and social perspective should always inform how evaluation criteria are set – in this case, the modern mining skills necessary for supervisors and trainers. If these demands and requirements are not considered, the learning programme will be less effective.

METHODS

The project followed a design and assessment process that considered the evaluation of modern training solutions for trainers and supervisors. A mixed methods approach was taken to achieve the project objectives. Figure 2 shows the project process flow and activities.

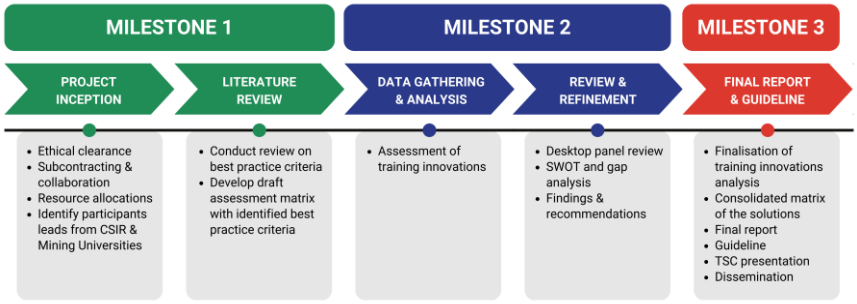

Figure 2. Process flow of project activities.

A literature review was conducted on upskilling and reskilling best-practice criteria for the development of modern mining skills, to support the development of a training innovations assessment tool. A draft evaluation matrix which incorporated best-practice criteria for the assessment of training solutions was developed. The criteria were aligned with the PDCA model, and the ADDIE instructional design framework, and were categorised into the three sub-areas of people, process, and product. Input relating to the design and application of the best-practice criteria as an assessment tool was also obtained from an industry review panel, providing credibility to the evaluation matrix and subsequent evaluation process. The review panel members were selected based on their expertise in the mining industry and skills-related subjects and included individuals from the SATCAP Technical Steering Committee, Minerals Council South Africa (MCSA), Mining Qualifications Authority (MQA), and mining companies. The initial evaluation matrix developed had 76 best-practice criteria, but this was later refined to a streamlined 48-criteria version.

Engagements were held with training provider entities, and the assessment instrument was applied to selected training solutions for trainers and supervisors. Two training providers were identified for participation and included a state-owned entity and a mining university. Purposive sampling was used to select the participating training providers, based on their knowledge and expertise in providing training to supervisors and/or trainers. The data gathering was undertaken in an interview format, either virtually or in-person. The best-practice criteria matrix was used to guide interviews with the training providers related to the selected training offerings. Further data gathering included an industry panel review process to obtain expert input into the analysis of the assessed training curricula. The application of the evaluation matrix provided insight into the respective strengths, weaknesses, opportunities and threats (SWOT) of the training solutions for supervisors and trainers, and recommendations towards closing the gaps or taking advantage of opportunities. The findings would

enable training providers to adjust their curricula to meet industry skills demands for sustainable modern mining. Ethics exemption was received for the project from the CSIR Research Ethics Committee.

RESULTS AND DISCUSSION

Assessment tool

Based on insights from the literature review, an assessment tool in the form of an evaluation matrix was developed to evaluate the training programmes for supervisors and trainers. The best-practice criteria included a planning and delivery approach, work integrated learning, instructional design principles, and the integration of learning (process, people, and product). The evaluation of the training solutions in terms of PDCA methodology considers:

- **Plan:** Industry needs and skills gaps, and curriculum design
- **Do:** Curriculum relevance, and curriculum delivery
- **Check:** Evaluation/review; and
- **Act:** Continuous improvement, and future foresight.

The evaluation matrix has key focus areas with associated criteria for assessments, assessment questions, and assessment ratings. The revised matrix further includes a consolidated and heatmap summary view, that includes interviewee comments. The following is noted:

- The PDCA cycle serves as the base for the criteria
- Supporting models and approaches are included in each step of the PDCA cycle, to enhance the validity of the criteria and ensure that it is comprehensive and covers all necessary fields in terms of the process, people, and product of training interventions; and
- The evaluation matrix is informed by the skills needed and the best approach to develop the requisite modern knowledge, skills and application for the mining industry.

A snapshot of the best-practice criteria evaluation matrix is shown in Table 1, while a summary of the refined best-practice criteria is shown in Figure 3. This project guideline containing the evaluation matrix is available on the Mandela Mining Precinct website, for use by industry training entities. When applying the tool, it is important to consider that it should not be used as a tool for measuring the value of a training offering, given the context of mining modernisation; but rather used to highlight opportunities for improvements.

Table 1. Snapshot of the training assessment best-practice criteria evaluation matrix

ISO PDCA Phase:		PLAN				
ADDIE Step(s):		ANALYSIS				
Best-Practice Criteria		Evaluation Questions:	Assessment:			Recommended action to close the identified gap or change a weakness into a strength or take advantage of an opportunity to improve:
Identify industry needs & skills gaps			**NO** (Strong Weakness)	**Partially** (Weakness)	**YES** (Strength)	
PROCESS	**Evidence-based Training Needs Analysis**	Has an evidence-based Training Needs Analysis been conducted to identify the training requirements for mine supervisors and trainers?	No TNA done.	Yes, a TNA was done but subjective or not focussing on supervisors & trainers.	Yes, an evidence-based TNA was done for supervisors & trainers.	
	Multiple source data collection	Has comprehensive data been collected from multiple sources (e.g., surveys, interviews, performance reviews) to identify training needs?	No data was collected.	Yes, data was collected but not from multiple sources.	Yes, data was sourced from multiple sources.	

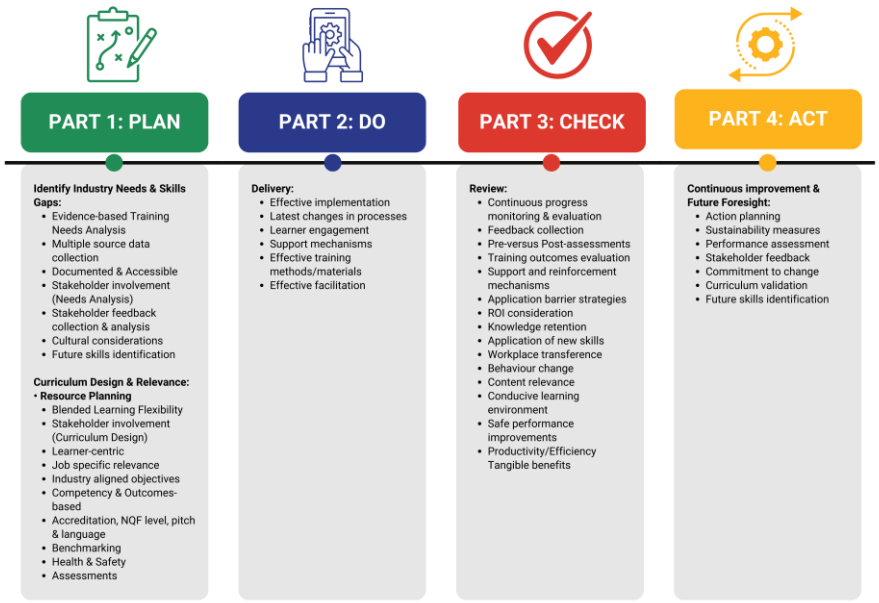

Figure 3. Summary of the refined best-practice criteria used for the training assessment.

Assessment results

Two training providers participated in this project (anonymised). Assessments were conducted for two training solutions offered by each provider. A summary of the training courses that were assessed is shown in Table 2.

Data collection was conducted by applying the developed best-practice evaluation matrix, and these findings were used to conduct a SWOT analysis for each of the assessed training innovations. Key insights were revealed for the respective training innovations towards meeting the industry skills demands and training needs for trainers and supervisors. The process of assessment and the analysis of data enabled areas of strengths and areas for potential improvement to be highlighted. Review by

the industry panel also contributed to findings and recommendations. The primary objective of the panel review was to gain an understanding from an industry perspective and whether the training solutions that were considered were meeting and addressing the skills and training demands for a modernising landscape.

Table 2. Training assessments conducted

Trainer A	Trainer B
Training innovation A1 is an NQF level 8 Bachelor of Engineering (BEng) semester course aimed at undergraduates. The module is presented in English in a classroom-based setting and comprises three lectures and two tutorials per week. **Training innovation A2** is a short course that is open to mining industry representatives and provides the learner with a theoretical background on the topic of Geotechnical Engineering. The course is presented over five days and allows interaction between the facilitator and the students.	**Training innovation B1** is a Safety Awareness Training short course aimed at new and returning industry employees. The module is presented in English in a classroom-based setting and comprises eight hours (1 day) of instruction. **Training innovation B2** is also a 1-day / 8-hour Emergency Response short course that is open to mining industry representatives – preferably candidates with basic literacy and numeracy knowledge and a minimum of two years underground experience (advised).

A direct comparison of individual offerings was not advised but was considered insightful to identify common and recurring themes across all the assessments that were done, to highlight and even grade the major pain points (weaknesses and threats) and also the stand-out positive aspects (strengths and opportunities) that emerge. To this end, a semi-quantitative and partly subjective scoring system was applied to a consolidated matrix of the assessment results. For each positive response ('Yes'), a score of +2 was assigned. 'Partial weakness' responses were assigned a score of -1, while strong negative responses ('No') were assigned a score of -2. The scores were tallied to yield a cumulative score for the complete list of the 48 best-practice criteria. The grading approach that was applied based on the cumulative scores is shown in Table 3. The consolidated matrix (heatmap) of results is shown in Figure 4. As the results may primarily be of significance to the participant entities to remediate or enhance their curriculum, they are not discussed in detail in this paper. However, the results have relevance to training entities in need of aligning their curricula towards modernisation skills development efforts.

Table 3. Grading approach

MIN	MAX	RATING COLOUR	
-8	-3		A cummulative score of between -8 and -3 indicates the most concerning weaknesses
-2	0		A cummulative score of between -2 and 0 indicates less concerning, but arguably still important weaknesses
1	3		Cummulative scores of between 1 and 3 can be considered as neutral
4	8		Cummulative scores of between 4 and 8 can be viewed as prominent strengths

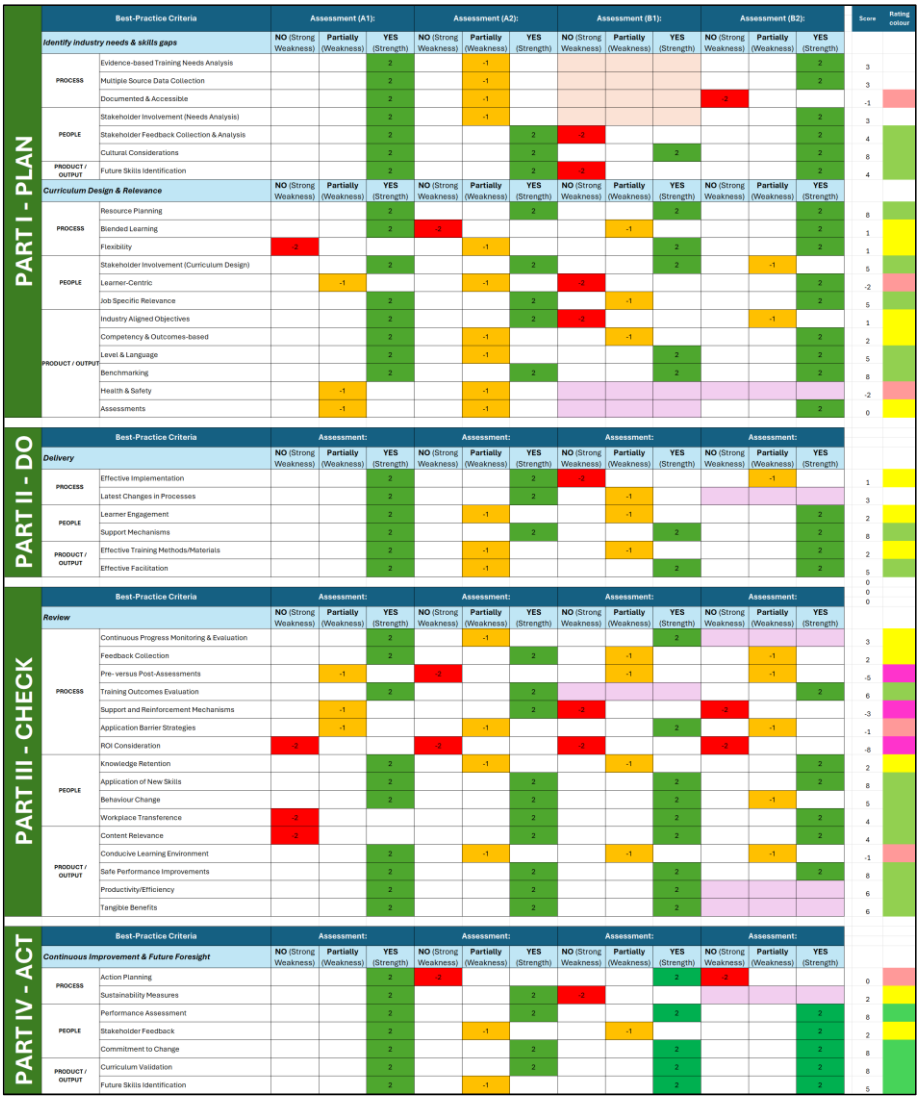

Figure 4. Consolidated matrix of assessment results.

CONCLUSION AND RECOMMENDATIONS

This project benefits both the mining industry and training providers. The value for the industry lies in the guidance that will enable them to identify training offerings that are aligned with best-practice training criteria, given the context of mining modernisation. Meanwhile, training providers can use the learnings from the project to design new and enhance existing offerings to remain at the cutting edge of providing training solutions for industry. Conclusions based on the assessment results are shown in Table 4.

Table 4. Summary of assessment results

Most concerning weaknesses	Other perceived weaknesses
• ***Pre- vs Post-Assessments:*** generally, learners' skills were not assessed before and after the training to determine new skills/upskilling and reskilling needs; it is mostly done only at the end of the training. • ***Support and Reinforcement Mechanisms:*** it appears that there were often no mechanisms in place to support effective application on the job. • ***ROI Consideration:*** the concept of ROI does not generally feature for the training programmes that were assessed.	• ***Documented and Accessible:*** competence gap analysis results were not usually documented. • ***Learner-centric:*** training programmes are generally not tailored to meet the specific modernisation skills needs. • ***Health and Safety:*** the training offerings do not necessarily equip supervisors and trainers with hazard, risk assessment and control measure information of the modernisation technology. • ***Application Barrier Strategies:*** remedial/reinforcement strategies are not offered post upskilling/reskilling/new skills development. • ***Conducive Learning Environment:*** the training environment is not always considered to be conducive to learning (e.g., comfortable, well-equipped, with modern machines/technologies for learning). • ***Action Planning:*** it emerged that specific actions were not always planned or implemented to address gaps or areas for improvement.
Most prominent strengths	**Most prominent strengths**
• ***Cultural Considerations:*** cultural factors and diversity aspects were generally considered; sometimes part of accreditation visits, advisory board meetings or part of professional body's requirements and demands. • ***Resource Planning:*** the necessary internal, competent resources (e.g., budget, materials, faculty) were allocated for the training programmes. • ***Benchmarking:*** curricula were mostly aligned with OEMs' standards and operating manuals, best-practices as well as future skills requirements. • ***Support Mechanisms:*** support mechanisms were put in place to guide learners to relearn new behaviours and unlearn old behaviours during the training. • ***Training Outcomes Evaluation:*** training outcomes were evaluated against the predefined modernisation/technology use and upskilling/reskilling objectives. • ***Application of New Skills:*** learners were enabled to apply the skills gained from the training in their job or in the training of workers/communities.	• ***Productivity/Efficiency:*** the training contributed to increased efficiency due to improved skills to deliver training/ supervise in the modern mining landscape. • ***Tangible Benefits:*** the training offerings considered seem to yield benefits, such as improved safe production, a better skilled workforce, upskilled supervisors and trainers as a result of the training. • ***Stakeholder Involvement:*** key stakeholders (e.g., industry experts, trainers, supervisors) were mostly involved in setting the learning criteria for the training programme and its assessments; learning criteria were also sometimes aligned with company values. • ***Job-specific Relevance:*** the curricula were generally considered relevant to the job roles and responsibilities of supervisors and trainers to support and enable modernisation; for example, where fundamentals of mine safety is taught. • ***Level and Language:*** training was pitched at an appropriate level considering the educational level of participants and their language. • ***Effective Facilitation:*** the trainers generally had the necessary capacity, capability, qualifications and competence to deliver the modernisation content and address learner new skills needs; however, it should be noted that in some cases, technical roll-out and capacity constraints were observed. • ***Behaviour Change:*** it was mostly agreed that the reskilling/upskilling and new skills development allowed for observable behaviour changes of supervisor and trainers; it was commented however that it was difficult to observe change in behaviour in the workplace and that employers should be better positioned to observe this. • ***Future Skills Identification:*** the faculty skills and competence requirements were generally assessed, to give faculty the required capacity development to support future skills demands; for example, allowing for additional lecturing staff for delivery.

Considering the consolidated analysis presented above and recommendations that were made based on individual SWOT analyses, the following consolidated recommendations can be made for training providers that either want to improve an existing training offering (in the broad context of mining modernisation), or for those wanting to develop a new offering:

- Maintain and build on existing or identified strengths, and do continuous review and improvement as the landscape changes for updates around training methodologies, content, facilitation, assessment and learner feedback approach, modernisation skills and training needs
- Better align curriculum with modernisation objectives to meet industry skills demands
- Investigate initiatives to keep track of graduates to perform post-study validations
- Better align the assessment criteria with modernisation skills needs
- Better align the curriculum with modernisation objectives and stakeholder needs; to this end, professional bodies should be lobbied for input
- Include more focus on safety and risk assessment/control measures in line with the use of modern technologies
- Introduce more immersive learning experiences and afford opportunities for practice or practical exposure
- Continual improvement based on learner feedback
- Take advantage of opportunities created in the industry to stay on top of the latest modernisation strategies to continuously align and improve training interventions
- Investigate how linkages with industry and the Department of Mineral Resources and the Environment, can be leveraged to secure additional funding to support and sustain and even expand current offerings
- A key to continual improvement is through learner feedback
- Investigate post-training opportunities in collaboration with industry - for example, behaviour change feedback, on the job application and remedial/reinforcement strategies
- Investigate how the concept of ROI can be better quantified, introduced to learners, and related to training offerings; and
- Ensure that continuous improvement and future foresight measures are put in place – for example, through faculty skills and competence assessment and development.

A key consideration is that while sample training innovations were selected for evaluation, the findings and recommendations are relevant to training entities looking to align to their curriculum to mining modernisation skills demands and training needs.

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