SAMERDI SATCAP21 WP3 - CLOSE-OUT SUMMARY REPORT: VIRTUAL REALITY MINERS SOLUTION

Name of Programme	**SATCAP**	
Programme Manager	**Sherin Ramparsad**	
Work-package	**Number**	**Title**
	3	**Virtual Reality Solution for the Upskilling of Miners**
Service Provider(s)	**Enterprises University of Pretoria** **CSIR** **WinWin International**	
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1. PROJECT OVERVIEW

The study has been commissioned by the Mandela Mining Precinct, through the Successful Application of Technology Centred Around People (SATCAP) programme, to Enterprises University of Pretoria (EUP), in collaboration with CSIR and WinWin International (WWI). OEMs played a pivotal role in the project.

SATCAP focusses on the effects, impacts and challenges of mining modernisation on people in the mining sector. For 2021, SATCAP projects considered skills development to support a modern workforce for modern mining.

For 2021, as the Successful Application of Technology Centred Around People (SATCAP) programme has a skills-related focus, the work packages (WP) are related to immersive learning experiences to support modern training for modern mining. The aim is to investigate engaging learning contexts that are virtually and physically interactive, allowing for learners to be immersed in the learning experience.

This project aimed to investigate and exhibit a modern training methodology that supports the upskilling/reskilling of Miners, which is needed to support healthy and safe production.

The objectives of the research are as follows:

- *Objective 1:* Source and demonstrate a virtual reality (VR) training module/solution, from relevant industry - preferred training suppliers and/or original equipment manufacturers (OEMs), to enable Miners in Gold (Au) and Platinum Group Metals (PGM) conventional and modernising mines, with upskilling, for healthy and safe production.
- *Objective 2:* Make recommendations, regarding the VR training module/solution for Miners' upskilling for potential industry uptake.

2. METHODOLOGY

A mixed methods approach was adopted for this work package. The objectives of the study were achieved by conducting a literature review, data gathering through reviews of an existing solution, interviews and surveys, development of a training module, and validation with industry through a SATCAP exhibit/workshop.

As the research design was exploratory, industry expert engagements were emphasised in the methodology. The research team undertook various engagement sessions with OEMs and industry experts to arrive at the findings and recommendations. There were various site visits undertaken where the solutions were tested. Setup of the solution was also done at the University of Johannesburg (UJ) and various setup videos were done for industry and student access. Traditional methods were investigated, and a comparison made with potential VR solutions.

LITERATURE REVIEW AND DATA GATHERING

Data gathering included a desk top literature review. The literature review discusses VR training in various industries including the mining industry, as well as the implications thereof. The literature review was prepared by an HDSA student that was included into the project team for capacity building and personal development.

Data gathering was done on Au and PGM sites, for gaining understanding of and for obtaining of inputs from both conventional and modernised mines. Survey questions were distributed to training managers and facilitators. These stakeholders are seen as the subject matter experts within the field of education and training in the mining sector.

Additionally, there were workshops held with OEMs and solution providers to get a thorough understanding of the current as well as potential upskilling solutions.

REVIEWS AND VALIDATION

Reviews and validation sessions were conducted with representatives from various stakeholder groups, i.e. organised labour, OEMs, regulators, solution providers, Minerals Council, Mine Health and Safety Council, SETAs, MEMSA, and mining operations.

The stakeholders requested clarity on the benefits of introducing such technology to the sector. Benefits were discussed which amongst others included that VR training allows for a blended approach to training and development of Miners. VR training is done within a safe environment that can be controlled by the facilitator. It allows for virtual practise so that potential risks and consequences are identified and rectified. VR training also becomes more attractive to a younger work force. Additionally, the technology offers gamification which contributes to upskilling in a more interactive, stimulating environment. The findings and recommendations are discussed in more detail in the next section.

3. FINDINGS AND RECOMMENDATIONS

The following table summarises the major **findings** of the study.

Area within research objectives	Outcome
Skills challenges	The skills challenges are not necessarily only the technical knowledge of Miners but would also include broader themes such as problem solving, reporting, communication, and fault finding.
Current methodologies	Current methodologies are focused on ILT and classroom-based interventions. The current methods rely on the expertise and experience of the facilitator. There is a greater adoption of new technologies in the sector, but these are often described as “nice to haves” instead of serious contributors to training and operational success. Subject matter experts, such as the OEMs, are often excluded from the training and development process. The current on-the-job training initiatives are still seen as being effective. Current methodologies can be supported with VR technologies.
New methodologies	The theme of blended learning repeats during the study. Feedback provided by the participants indicated that VR technology can be a genuine contributor to understanding the theoretical portion of training. In essence it is putting theory into practice within a controlled environment. VR technology can be expensive and post implementation systems support is often required. New methodologies also rely on some form of digital literacy. The need for digital literacy is in part addressed by the inclusion of clear instructions during the orientation phase of the VR training process. There remains the need for human intervention and guidance during the use of VR technology. It is evident

	that VR technology currently does not replace the ILT methodology completely.
Contribution to health and safety	The finding is that there should be an increase in the safety practices of miners. This is due to the assessment practices put in place during VR interaction. These safety practices then become part of the individual's way of work. Furthermore, the miner can visually experience the impacts of not following safety protocols, which increases the awareness. VR does allow miners to practise their skills before entering a work site, which directly contributes to higher skills and indirectly contributes to safer operations. Training is also conducted in a controlled environment and the trainers believed the VR environment can create sufficient foundational knowledge of learners prior to underground engagement. VR and AI can also run simulations of blasts within a safe environment.
IT systems and requirements	The technology is standalone and cannot automatically be plugged into a current LMS. The setup of the technology is often specialised, and support of the provider is required. Newer mobile technology is becoming easier to use, but there is clarity required on how implementation is fully handed over to the training department. There are limited providers of this specific technology in South Africa, which could make procurement difficult. Programming of the specific parameters (i.e., stope height different between Au and PGM) still needs to be programmed by the specialist providing the system. The operating system is licensed, and this creates dependency on the provider.
Implementation	Some of the systems (i.e., mobile VR headset unit) is relatively easy to implement. Technology such as the VR wall and stope face is not easily implemented. Physical space requirements need to be considered. The strategy that the company takes towards technology adoption is also to be considered. Conventional mining is not necessarily geared to the adoption of new technologies. First setup at initiation stage requires specialised skills and support services are required post implementation.
Regulators of the training environment	Currently simulations are not a preferred of assessment from the regulators (i.e., SETA and QCTO). VR is still technology that is still seen as an additional assessment tool to see whether a miner can operate certain machinery or within a specific parameter. Clear standards by the regulators to the inclusion of VR into learning material could not be found during the time of the study.
Cost of technology	The implementation of VR solutions for training is expensive. The technology is continuously being developed and improved and this has an impact on the costing. Aspects such as licensing, software updates, technical systems support, and influence of changing technology should be considered. The projection is that the technology will become less expensive over time as there is greater uptake in the market. Once duplication of systems is possible there will be a lowering in costs for VR solutions.
Applicability to Au and PGM	The technologies are currently being used and further developed on both Au and PGM commodity sites. The VR environment can be customised specific to the commodity (as can be seen in the VR stope) or specific to the operation. The VR technology is also developed around machinery that is currently being used for both commodities. It needs to be noted that the technology can be customised to most environments due to the environment being created within the parameters of the client. VR technology can be copied and pasted to a large extent, but the final customisation would depend on the client. New training methodologies have been successfully introduced to the Coal sector and the study could find no clear indication that it could not be adapted to Au and PGM sites. The only consideration would be connectivity of the VR sets if used underground in the mock-up environment.
Conventional vs Modernised	There has been little difference identified between the needs of conventional and modernised mines when it comes to the training of miners. Modernised

	mines have embraced the training methodology more easily, but this is influenced by the strategy of the company. Modernised mines tend to focus more on the inclusion of technology. Further to this, the systems investigated are customisable and thus the training methodology would be appropriate to both. A potential influence identified might be the recruitment standards between the conventional and modernised. Informally it was stated that modernised mines tend to recruit and select a higher educated individual. However, with the development of learning pathways within the SETA structure, this should not be such an influence.
Traditional vs VR Simulators	During engagements it was determined that traditional simulators are expensive to purchase and maintain. VR technology is becoming more accessible and affordable. VR simulators are progressing to provide Miners with a real "in-cab" feel, which traditional simulators are still able to do. There are OEMs that are working together the combine the best experience of each simulator.
Next Steps in VR	Solution providers are working towards VR becoming more realistic through incorporating real-world physics. An example is a hand drill being used in VR training, with real-time tracking on the movements of the drill. This would mean that a Miner would handle a real drill (e.g., weight and size) with a VR solution tracking the use, such as angle, height, depth, and pressure behind machine.
Influence of Commodity on VR	It was evident that the type of commodity does not have a major influence on the use of VR. The solutions provided are customisable, (i.e., adjusted for stope height at differing commodities) to the site specifications. Yet, the type of machinery used obviously has an impact due to the VR solution being based on the specific machine. VR solution providers are working to standardise the major variables around a specific type of machine.

The following table summarises the major **recommendations** from the study.

Area of Recommendation	Recommendation
Costing of technology	There needs to be a breakeven analysis done on the cost of the training vs the return of effective blasting. The respondents informally calculated that a 5% increase in drilling accuracy would translate in enough additional revenue to fund a fully modernised technical training centre. There was no evidence of this at the time of study. Costing of the technology is currently expensive, and it is necessary for OEMs and developers to look at how these costs can be lowered.
Local capabilities	There are local companies that are operating at international best practice. The expertise of these technologies is however limited to a few providers. The costs of locally developed and manufactured VR technologies are often high. There is lack of specialised skills specific to this type if technology, which also influences local procurement and prices. It is recommended that a broader local producer development strategy be investigated.
Skills challenges	There have been skills challenges identified in the study. These related mostly to the supporting skills such as communication, reporting and problem-solving. The inclusion of VR has provided a platform where miners can practice their skills to entering the work site. There might be a challenge in terms of digital literacy, but the systems that the project team has investigated are designed to be intuitively simple. The facilitators have also stated that the technology only enhances the learning process, and that digital literacy has not yet been identified as challenge to the educational process. A digital skills

	literacy development programme can be developed and administered through the relevant regulators.
Infrastructure	The current operations that the team visited were converted specifically for new technologies in the training of miners. The infrastructure was thus specifically adapted to ensure the technology could be used. This does come at a cost and is not realisable at all mining operations. Not all conventional operations are geared towards upgrading of their training centres for VR technology. The need for physical training space might become less as the mobility in the technology increases. It is recommended that training centres investigate how much of a VR approach will be used. Further to this there is also the need to look at connectivity in more remote sites. Solution providers outlined that certain of their VR solutions can be used offline and will upload the required data once an internet connection is available. The current technologies often require a dedicated physical area within a training centre. This infrastructure is not always available and would need to be built specifically for the aim of rolling out new training technologies. This is not always possible at all mining operations. The recommendation is for providers to further investigate the mobility of their solutions.
Blended Learning	Blended learning is a finding that repeats itself across the various sites visited, material reviewed and interview feedback. There is the recommendation to further investigate the correct blend percentages that would work. Blended learning also needs to be part of the strategy of training centres.
Systems Integration	Current providers do not always provide the means for their systems to be integrated with current mining systems. This does create dependency on providers and could add to the costing of the systems. It is recommended that providers investigate ways to increase integration with current systems. APIs could be a way information can be shared between the various platforms.
VR and AR Integration	There is a high potential for the integration between VR and AR. The technologies could complement each other and become a mobile solution for inspection and safe-making practices. A challenge is that there is large processing capacity required for incorporating both technologies in a mobile manner.
Traditional vs Modernised Simulators	There is the need to determine the cost for combining traditional simulators with VR simulators. Traditional fixed simulators have the benefit of providing a real feel in terms of being inside a cab, whereas VR simulators can be customised more to a specific environment and gives a 3D effect to the training. Combining the two technologies could be beneficial to creating a VR solution that has a real in-cab feel to it.

4. TRANSFER TO INDUSTRY

The following will be transferred to industry for potential use:

- A training module, with online learner guide. It includes access to an online portal - that may be used by learners and facilitators to support the learning process.

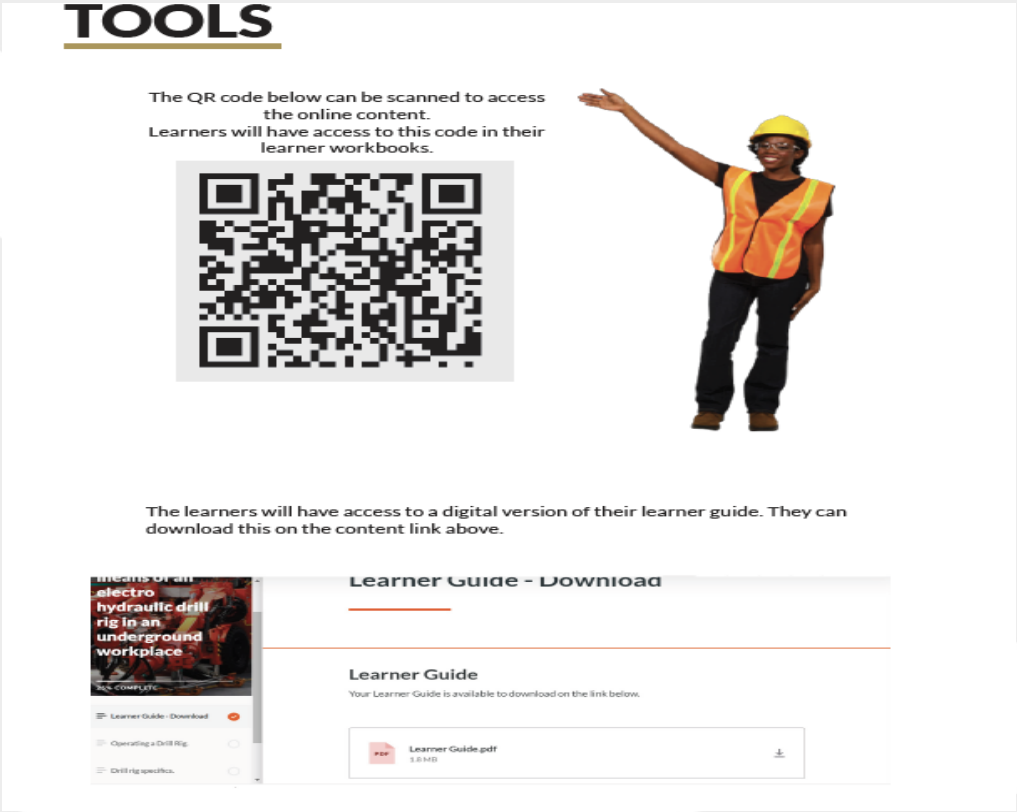
Training module

The training module for this project is based on the Manual for operating a drill rig. The module was based on current practices in the mining sector and is not commodity specific. The purpose of this training module is to give the learner the knowledge they need to operate a hydraulic drill rig. This knowledge will help the learners to become efficient in using this new technology before they operate it in a mine. This may also

assist to maximise workplace potential and safety through the correct application of the appropriate resources, and technology. Interaction with the module is through the use of QR codes as can be seen in the following figure.

QR Code for Manual

In addition, the manual provides links to online resources that assists the learner with working through the module. The figure in the following page is an extract from the Facilitator Guide with tools that can be used by the facilitator.

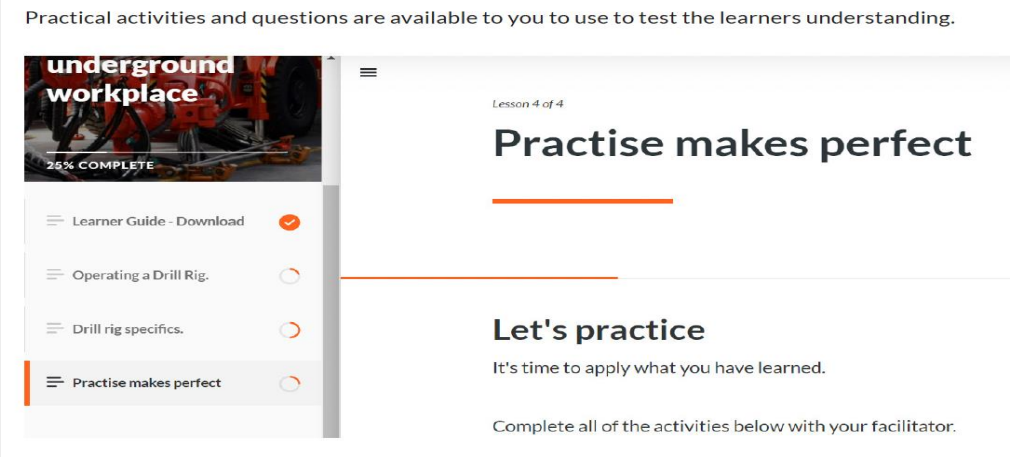


Learner Online Tools

The link will take the learner and facilitator to an online portal where learning can be tracked towards module completion. There are supporting sample extracts from videos, for the learner to use which will outline the use of the machine and how the VR technology works.

Training slides

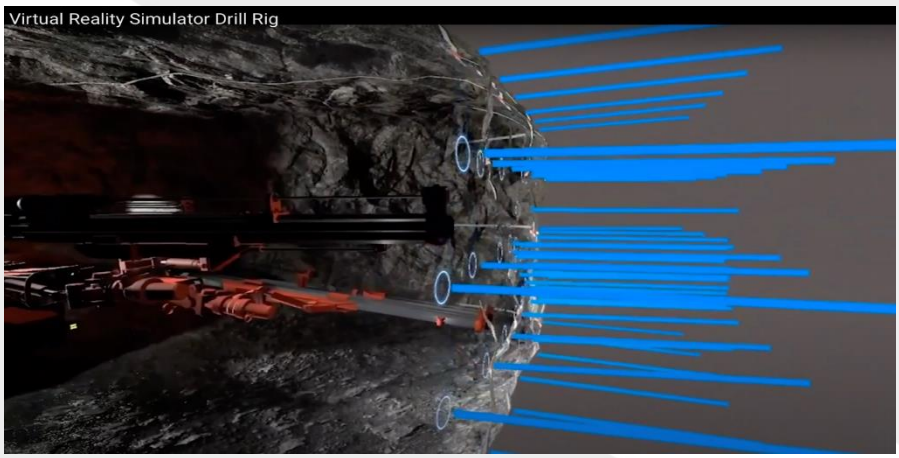
Traditional slide presentations are not used within this technology. There is however an online portal that can be used by learners and facilitators to support the learning process - through a formative assessment process. The next figure illustrates and example of the online practise section which is available.



Online Practise

A sample of the RDO training programme is available at:
https://rise.articulate.com/share/GYimbWvamoLW7Wnlt_qedKBWloTylLcy#/

Explanation videos on VR technology



In addition, a VR Wall and Drill Rig VR solution has been setup at UJ for industry access/demonstration. Licensing considerations apply, however the licensing for the equipment is valid until 30 November 2022. To note, should mining companies want to implement the solution on their mines, IP and licensing considerations will apply.

CONCLUSIONS

It is evident from the study that when it comes to digital training, a 'one size fits all' approach cannot be adopted. Mines are at varying maturity stages of modernisation. Findings identified were:

- Mines are using VR training methods to some extent;
- Mines cannot consider an 'one-size fits all' approach regrading VR training, as their contexts differ, and this suggests that a blended approach to training is preferred by mines;
- Classroom learning, on-job and on-shaft learning remains important;
- VR training may be used meaningfully for refresher training when back from leave, or for remote and self-learning more readily;
- Factors like literacy levels, ageing or a younger workforce, pitch and level of training needs consideration in terms of the approach around digital training;
- Mines have infrastructure differences, therefore Wi-Fi and other infrastructure needs for digital training will need the specific mine's consideration;
- Financial obligations for digital training needs consideration by mines. Licensing costs etc. will have an impact;
- VR training may not always allow for physical factors to be taken into account, like the weight of the drill and therefore VR training should be complemented with other training methods;
- A blended learning approach is preferred by mines and may be used by mines. Blended learning is a combination of offline (face-to-face, traditional learning) and online learning in a way that the one compliments the other.