Mining 4.0: Investing in Human Operators

Vale

WBCSD Future of Work case study

Table of Contents

Summary

In an effort to increase productivity of its mining operations, Brazilian mining giant Vale has assembled a team of experts from diverse fields and expanded its focus from investing in machines but also valuing and developing the people at the core of its business - the human operators of excavators.

Vale's *High Performance Operators Program* (POAD by its acronym in Portuguese)[1] starts by recognizing the operator as the main piece of the productivity puzzle. In doing so, Vale searched and mapped several characteristics and key-factors that might impact the worker's performance on a individual level. To do so, it establishes four areas of action cores, each of which apply tools from different fields of science to deliver specific objectives, while their interaction results in the holistic development of each individual operator.

The POAD Program is part of Vale's initiatives for sustainable development. It is based on the concept that there is no sustainable development without the valorization of the worker and the full development and enhancement of his or her abilities. Through the methods employed in the project there is an improvement of the workers' physical and mental health and of their cognitive abilities. Fostering work based on innovation, experimentation, collaboration and implementing new ideas is crucial to this development. In Vale's words "We understand, therefore, that the benefit for the company is inseparable from the benefit for the employees."

Key figures

- Monthly average productivity increased by 9%

Company background

Operating for more than 70 years in the extractives mining industry, Vale employs more than 80'000 people, increasing to 130,000 if outsourced team members are included. Headquartered in Brazil, the company is the worldwide leader in iron ore and the second largest producer of nickel, with operations in more than 30 countries on five continents.

---

[1] In Portuguese: Programa de Operadores de Alto Desempenho (POAD)

Future of Work challenge

Over the last decade, the mining industry has witnessed a steady decrease in productivity, reaching an estimated 28% decline since 2004. This decline was driven by several factors, including labor inefficiencies, high capital expenditures, and increasing complexity of mining operations (going deeper and into more remote locations) while investments in innovations remain low.[2]

Reversing this trend is of crucial for future economic growth, and is equally important for mining companies to grow sustainably and sustain and improve workers' wages over time.

Some of the workforce-related concerns in the mining industry include high turnover and an ageing workforce, and unexperienced or inadequately trained workers. Digitalization and process automation are expected to have a significant impact on the workforce, be it in a positive (e.g. improved safety; tech-based augmentation of human performance) or negative way (e.g. job discplacements).[3]

Business case

To address declining productivity, mining companies across the world have adopted similar strategies, with short-term results being achieved mainly through cost-cutting and investing in machines, process automation and the integration of digital technologies.

Another strategy to improve productivity is based on improving the performance of the human components in the mining processes. This is done by investing in the skills and capabilities of workers, as well as their mental and physical health and wellbeing.

This human-centered approach – adopted by Vale – is particularly attractive for business, as it addresses productivity growth on the basis of a

long-term strategy, and aligns the company's business success and sustainability strategy. But it also addresses labor-related challenges that many companies are facing: From Vale's perspective, this means attracting and retaining new talent, as well as adapting its business model to suit and make future generations of employess feel engaged in the company. As for the employees that already work for the company, the challenge is to (re)train them so that they acquire new skills and can adapt to new ways of working.

Innovation, a key to modernize operations, improve business performance and position it for new opportunities, is also a key element in this approach, as it finds on the one hand new ways of leveraging technology to augment human performance, and on the other, to improve safety, sustainability, productivity and financial return.

"There is no sustainable development without the valorization of the worker and the full development and enhancement of his or her abilities."

Vale's solution

The *Eliezer Batista Complex* S11D, located in the Carajás Mining Complex in Brazil is a milestone in Vale's history and a worldwide reference in the concept of mining operations. This complex will be the first of its kind among iron ore mines, as it replaces trucks to mine ore and move waste with crushers and conveyor belts.

This 'In-Pit Crushing and Conveyor System', or 'truck-less system' features conveyor belts strategically positioned throughout the mining process. This technological innovation, driven by an effort to increase productivity, in turn drives

---

[2] See McKinsey & Company (2015) and EY (2017)
[3] Deloitte (2018) and EY (2017a)

significant changes in the demand for work on the mining site. Examples of now redundant work activities are operating the rope shovel or driving trucks, since those two elements of the process are eliminated.

Therefore, one of the main focuses of the S11D Complex is associated with the performance of these professionals, who are expected to achieve an average productivity of 8,000t/h, which are unprecedented values in the mining industry for this type of equipment.

In 2017 Vale started establishing the *High Performance Operators Program* (POAD)[4], a training program to increase the productivity of the human operators in large excavators by addressing physical, psychological, cognitive and technical aspects.

The objective of the POAD is to increase individual operators' productivity to 8,000 t/h, which equals to doubling the hourly productivity of the operating system.

The only way to reach this high prodcutivity performance is – very much like in developing top athletes – achieved through a better understanding and individualized mapping of the characteristics and variables that impact the worker's performance, and acknowledging that each individual is unique.

Additionally, the human productivity in any business is directly or indirectly affected by innumerable factors internal and/ or external to the work environment, making it paramount to include professionals from different areas of study to better understand the workers and which factors have an influence on the execution of work activities with greater safety and better performance.

Therefore, the POAD brings together and integrates experts from different backgrounds and knowledge fields: engineers, researchers, physicians, neuroscientists, psychologists, computer scientists and statisticians, with proven experience in their respective areas of expertise. These experts are grouped into four cores that, combined, make up the POAD:

Technical, Clinical & Physical, Psychosocial and Cognitive. Together with Vale, institutions such as the Vale Technological Institute (VTI), the Federal University of Pará, the Federal University of Ouro Preto and the Catholic University of Minas Gerais are directly involved in these cores.

Each action core uses different tools and interventions that contribute to specific objectives while their interaction results in the holistic development of individual operators.
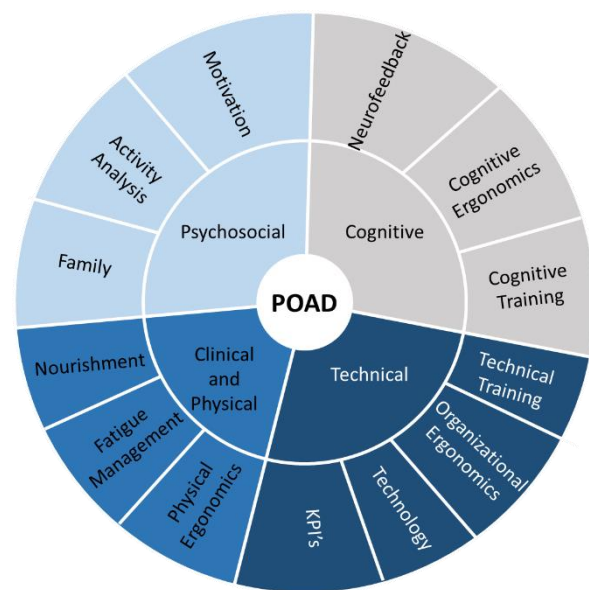

Figure 1 he four core intervention areas of VALE's High Performance Operators Program

The Technical Core (TC) is composed of the Training and Operational Control teams of the Eliezer Batista Complex. Both teams work hand in hand. The first is responsible for all the theoretical and practical training stages of the operators, as well as for carrying out the continuous evaluation in the field, and guiding and perfecting them when necessary. The entire training stage is customized per individual, based on each operator's main skills gaps. This is only possible due to a detailed control generated from operational diagnostics elaborated by the Operational Control area. These diagnoses are developed based on information from a simulator that replicates with

---

[4] In Portuguese: Programa de Operadores de Alto Desempenho (POAD)

high similarity the excavator operation and a Fleet Management System, which generates information on a detailed level that allows to identify the loss of performance on the scale of seconds. The role of the TC is also to develop technological solutions that allow to improve the performance of the operators and reduce their workload. An example of optimization achieved by the first core, is the use of an excavation simulator itself, as training time is reduced by 50%.

The Cognitive Core (CC) consists of experienced researchers with background in areas such as engineering, computer science, and neuroscience, hence responding to the need for a multidisciplinary approach. The scientists in the CC search for physiological markers that might characterize specific cognitive abilities that are relevant in the workplace. The tool used to probe these abilities is the electroencephalogram (EEG), that measures fluctuations of the brain activity while the worker is resting or active. The primary goal of the CC approach can be summarized in two phases.

- Identifying cognitive abilities that are related to the work environment;
- Develop cognitive skills, improving decision making, working memory and accuracy.

To achieve these goals we first collect EEG data during the resting period as well as during the working period to characterize the cognitive state (e.g., attention and work memory) using the EEG mapping of brain waves. The following step comprises the cognitive training using state-of-the-art methods to modulate the brain waves recorded in the first phase. To extract the relevant information from EEG, we use artificial intelligence algorithms developed by the CC researchers. In this way, the CC research line branches out in methods identified with industry 4.0, with the difference that the focus here is the human being. Vale's overall employee strategy is mirrored by this cutting-edge approach to productivity: By providing employees an environment connected to open digital practices regarding innovation, experimentation,

collaboration and implementation of ideas, the benefits are numerous for them as individuals and for the company as a whole.

Figure 2 Mining operator using a training simulator, while his brain activity is monitored to assess cognitive skills and identify stress factors. Source: Vale

The Psychosocial Core (PC) applies qualitative methodologies, through techniques that call on the subjects to reflect, analyze and improve their own work activity. At the same time, in order to meet demands related to families and a mapping of the psychological profile of the operators, instruments such as psychological tests, questionnaires and semi-structured interviews were used. As for the analysis of the activity, the PC used tools linked to a theoretical discipline called *Activity Clinic*, among them: "Examining the Look-alike" and "Simple and Cross Self-Confrontation". Both allow the workers to move from their usual point of view and see their activity from a reflective perspective, thus creating the possibility of a co-analysis of the operation. This reflection and change of perspective results in new knowledge about the activity and the meaning attached to it, enabling

the development of strategies and actions aimed at improving work performance, transforming the work situations, and emphasizing health promotion and protection.

The Clinical and Physical Core (CPC) has its methodology embedded in the application of protocols based on previous studies on fatigue, while also taking into consideration socioeconomic, cultural, nutritional (anthropometric), clinical (cardiometabolic) and physical conditions already seen in other Vale mines. This allows the CPC to classify the risk of workers, and develop ways to reduce and prevent the identified risk factors. Ultimately, this has the objective of improving the operators' quality of life, and an expected positive impact on their work performance.

"Despite the growing trend of automation, the improvement of processes depends on an individualized understanding of the people who work for the company."

Results

Vale started implementing the POAD at the end of 2017, and it is as of today, still in progress. However, the initial stage of data collection, shows that the first results already had an impact on the productivity of Vale's operations.

The monthly average productivity increased by 9%, reaching a value of 7,700 t/h and hence got close to the established target value of 8,000t/h.

As this is a qualitative and still ongoing research, the results of the Psychosocial Core will be built based on a continuous scientific confrontation between the researchers' knowledge, on the one hand, and the practical knowledge of the workers, on the other. The psychological tests point to a variation of the levels of attention of the workers of around 30,18% in relation to the average of the population, which serves as reference to the instrument. This reinforces the importance of the use of simulators and other training strategies.

To date, the following categories of analysis and intervention have been listed: the collective dimension of the activity; the human-machine relationship; physical and psychosocial demands of work; risks, safety and production; recognition of operators' work, and finally, its participation in the technical decisions with concrete impacts in the organization of work.

Challenges

Research projects involving human resources are not very common among technical companies such as Vale. The buy-in and authorization of an operator-centered project required a very open-minded top management, who believed in the potential of the POAD.

Once the program was approved, another challenge was engaging the workforce about the inclusive nature of the approach proposed by all cores. It was often observed that the workers perceived the research as a way to select the best among them rather than to include and develop those performing below average and helping them achieve their full potential.

Another challenge was the geographical distance of the researchers from the sites where they develop their routine activities. This limited the process of data collection to restricted time-windows.

Vale understands the fact that future changes in how people work must be compensated for by preparing them and connecting them to a dynamic and competitive business world that itself is also volatile, uncertain, complex and ambiguous. The future of work impacts how people relate to each other, how they work (more collaboration, less hierarchy, more holocracy, less silos and more diversity) and how they learn and take decisions. Planning and building contingencies for these developments is an ongoing process.

Key success factors

The openness of the company to innovation has been fundamental to the success of each step of the research. In addition, it is well known that innovation gives rise to more innovative initiatives thus creating a virtuous cycle and establishing a long-lasting culture of innovation.

The goal of the Vale Institute of Technology (VTI) is to promote the development of research projects in different areas, with an emphasis on sustainable development and mining. Our research projects are developed both by our research team and in partnership with Science and Technology institutions. Through VTI, Vale seeks to create options for the future, therefore, this work is fundamental for the development of programs such as POAD and to promote innovation within the company.

Moreover, the partnership with support areas such as Health and Safety and Human Resources has proven to be very valuable for the development of this type of research. The work of these teams supporting the continuity of the program has been fundamental mainly when it comes to different intervention processes, i.e. daily monitoring of the health conditions of the workers, the ergonomics of the workplace and the recognition of those colleagues who stood out in the program.

References & additional sources

Deloitte (2018): Tracking the trends 2018 - The top 10 issues shaping mining in the year ahead. https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/energy-resources/ca-en-ER-TTT2018_Jan_18_FINAL_Web_AODA.PDF (last accessed 12 Oct 2018)

EY (2017): Productivity in mining: A case for broad transformation. https://www.ey.com/Publication/vwLUAssets/EY-Productivity-in-mining/$FILE/EY-Productivity-in-mining.pdf (last accessed 12 Oct 2018)

EY (2017a): Productivity in mining - now comes the hard part: A global survey. https://www.ey.com/Publication/vwLUAssets/EY-productivity-in-mining-now-comes-the-hard-part/$FILE/EY-productivity-in-mining-now-comes-the-hard-part.pdf (last accessed 12 Oct 2018)

McKinsey&Company (2015): Productivity in mining operations: Reversing the downward trend, https://www.mckinsey.com/industries/metals-and-mining/our-insights/productivity-in-mining-operations-reversing-the-downward-trend (last accessed 12 Oct 2018)

Souza, Monteze, de Oliveira,et al (2015): Lifetime shift work exposure: association with anthropometry, body composition, blood pressure, glucose and heart rate variability. Occup Environ Med 72(3): 208–215.

Acknowledgements

**World Business Council
for Sustainable Development**

Maison de la Paix
Chemin Eugène-Rigot 2B
CP 2075, 1211 Geneva 1 Switzerland
www.wbcsd.org