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Mine-of-the-future: How is Africa prepared from a mineral and mining engineering education perspective?

P.O. Oshokoya[a,*], M.N.M. Tetteh[b,1]

[a] University of the Witwatersrand, Faculty of Engineering and Built environment, School of Mining Engineering, South Africa
[b] Faculty of Engineering and Built Environment, School of Mining Engineering, Wits Mining Institute, South Africa

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ABSTRACT

The mining industry continues to be a major source of employment despite challenges faced by mining engineering graduates to get employment. The issue of skills shortage continues to be a major concern and it is perceived as a real threat to the future of mining. Although the industry has undergone several changes in terms technological advancements, it is further envisioned that the future-mine will rely on a highly skilled skeleton labour force with the ability to perform several tasks through automated and remote-controlled operations and monitoring. The industry is expected to be knowledge-driven through a database model that receives and sends information (environmental, mining production and mineral processing) to enable proactive decisions to be made from both operational and control room perspectives. The four main key focus areas of the mine-of-the-future have been identified as operating practices and technology; talent and leadership; partnership with key stakeholders; and governance. A significant question that arises is the preparedness of mining engineering education in Africa to address the vision of the mine-of-the-future in relation to these four focus areas.

This paper explores mining engineering programs run in selected countries across four sub-regions in Africa (South Africa, Namibia, Morocco, Ghana and Tanzania). The selection of these countries was based on the criteria including percentage contribution of the country's mineral sector to its GDP; percentage share of the country's mineral exports in its total export; The rank of country's production/supply of mineral commodities in the world; political stability and resource governance index measurement. The universities chosen from each of these countries were based on the Cybermetrics Lab-CSIC university ranking system. Mining engineering programs from these countries were compared with mining engineering programs in two international countries (Canada and Australia).

The paper demonstrates a need for an improvement in mining engineering education in Africa to meet the vision of the future-mine.

1. Introduction

The mining engineering profession has been an active contributor to the world economy, in terms of giving employment to millions around the world and supplying various products to a world, which is heavily dependent on technology. The profession is well known for issues concerned with safety, profitability, social and environmental responsibility and sustainability. These issues affect the sector's ability to meet the demands of various parties including investors, citizens and governments.

The mining industry like many other industries has gone through various phases of enhancement with regards to mining equipment and technologies for mineral production and processing. Guirco et al. (2009) predicted further challenges to the industry due to deposits getting deeper and usually at low grades, higher energy costs, as well as increased environmental limitations. Although change is inevitable, several organisations and individuals have expressed their opinions on their visions of the future-mine. One thing that is common to all the visions of the future-mine is the fact that the mine-of-the-future will have fewer people working in them, highly skilled personnel operating sophisticated systems that are able to do several tasks at the same time. Future-mines will certainly be automated, with remotely controlled equipment and monitoring.

The objective of this paper is to analyse mining engineering

* Corresponding author. Permanent address: University of the Witwatersrand, Faculty of Engineering and Built environment, School of Mining Engineering (Office number 330), 1 Jan Smuts Avenue, Braamfontein, 2000 Johannesburg, South Africa.
E-mail addresses: Tomi.Oshokoya@wits.ac.za (P.O. Oshokoya), Monica.Tetteh@students.wits.ac.za (M.N.M. Tetteh).
[1] University of the Witwatersrand School of Mining Engineering, Faculty of engineering and Built environment, School of Mining Engineering (Genmin Laboratory Office number 110), 1 Jan Smuts Avenue, Braamfontein 2000, Johannesburg South Africa.

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education in selected countries in Africa (Countries chosen from each of the sub-regions of North, South, West and East Africa excluding the central African region). These mining engineering programs are then compared with mining engineering programs run in two International countries (Canada and Australia). This paper seeks to address the preparedness of Africa towards the future-mine from a mining engineering education perspective.

The research method employed in this paper was to analyse mining engineering curriculum from the websites of universities, mining-related literature sources, as well as mining-related research facilities.

The next section highlights the principles and components of the future-mine.

2. Principles of the Future-mine

In recent times, several authors (Schwekart, 2009; Klawitter et al., 2010; Gipps et al., 2011; Goldsmith, 2014) have expressed their views on the future of mining. Most of these views are embodied in the future-mine described by Yameogo and Suarez (2013), who envisioned the future-mine to be fully automated with various smart technologies, analytics and machines which are able to interact with the rock and the environment. This means that real time data about the quality and quantity of materials being mined as well as mining assets will be collected and reported through a communication system into a control room where proactive decisions regarding safety and production can be made. The CEO of Goldfields, Nick Holland, presented an overview of the Future-mine at the 120th Anniversary celebration of the University of the Witwatersrand's School of Mining engineering on 23rd of March 2017 and documented by C. Musingwini (Head of School, School of Mining engineering, University of the Witwatersrand[2]) on 17th of May 2017. Although managing uncertainty is one of mining's biggest risk factors, the mine-of-the-future as explained by Nick Holland (2017) will be sustainable, and add value to all its stakeholders. According Mr. Holland, the four main key areas of focus for the future-mine are operating practices and technology; talent and leadership; partnerships with key stakeholders; and governance. These focus areas can be perceived as building blocks and depicted in the Figure 2.1. The constituents of each block requires the adoption of the right talented and skilled labour force to handle the demands of the future-mine. This therefore requires mining engineering education to include twenty first century mining engineering skills, which will enable the mining engineer to possess the requisite skills to solve problems across all four key areas.

The development and utilization of various advanced technologies are essential in the future-mine. Whilst the shortage of skill in the mining industry is known worldwide, several mining stakeholders (Mining engineering universities, government, mining professional bodies, etc.) have tried to address this issue. Some reasons of skills shortage according to Mills (2012) was because the mining industry had failed in terms of its recruitment and training of mining professionals during difficult times.

Musingwini et al. (2012) further explained the need to continuously train mining skills to avoid any further skill shortage issues. Although Stacey et al. (2008) recognised the migration of mining skills from Australia and Canada to USA and technical skills migration from South Africa to Australia, Yamoego and Suarez (2013) expressed concern in the potential gap in the mining engineering education programs and the future-mine. It is therefore necessary to attract the requisite talents and equip them with skills that will enable them to operate the future-mine. One certainty is that the future-mine will definitely have minimum crew who are highly skilled in various aspects of automation, database management systems, data science and technology and social and environmental management skills. The next section gives a description of the various aspects, which are fundamental to the mine-of-the-future.

Figure 2.1. Focus areas for the future-mine (Adapted from Holland, 2017).

2.1. Components of the future-mine

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) located in Australia is a federal agency dedicated to scientific research in Australia. The research organisation has identified some key components that the future-mine will have. These include a database model that drives knowledge; control and evaluation system; sensors; communication systems; automated and remote control plant and mobile equipment; operation interface; and exploration, mining, processing and transportation system (Gipps et al., 2011). Each of these components are explained in Table 2.1.

The question of concern is whether the current mining engineering education systems across Africa are structured to meet the needs of all the components of the future-mine and their respective functions discussed in Table 2.1. The next section highlights the status of mining engineering education across selected countries from each of the sub-regions of Africa and two international countries. Courses taught in the Mining engineering Universities in each of these countries are analysed and compared against the four main key focus areas of the future-mine.

3. Current status of mining education across selected countries in Africa

In order to conduct a fruitful assessment of the readiness of the current mining education systems in Africa to prepare and equip students with necessary skills required by the Mine-of-the-future, several countries in four sub-regions of Africa had to be originally considered. A decision was made to narrow the selection of countries to at least one mineral-rich State from four sub-regions of Africa excluding the Central African sub-region. To a significant extent, the choice of countries for consideration was random and might not be totally representative of their respective regions. The idea of their consideration and/or selection was to use them as proxies for their respective regions and Africa in total, in order to obtain a general 'feel' of the status of mining engineering education in the continent.

3.1. Selection criteria

There are important factors that can facilitate the soundness and credibility of institutions (political, educational etc.) and investor-attractiveness of a country. With respect to mining education in particular, some of the factors that were considered as good enablers of such institutions/systems are as follows (non-exhaustive list):

1. Percentage contribution of the country's mineral sector to its GDP;
2. Percentage share of the country's mineral exports in its total exports;
3. The rank of country's production/supply of mineral commodities in the world;
4. Political stability; and

[2] University of the Witwatersrand is also referred to as Wits University.