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Editorial Commentary

Thinking globally and acting locally. Can research and science help?

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"Learning is an ornament in prosperity, a refuge in adversity, and a provision in old age."
— Aristotle

This issue of the Journal starts volume 3, an occasion to pause, give thanks, and reflect on the past year or so.

Two major events in recent times have shed a true meaning to the saying "think globally, act locally". The Covid-19 pandemic and the Russia-Ukraine war underscored that we exist in a globalizing and "boundaryless" economy. There has been no escaping of the ripple-effects of these two events. The result has been heightened unemployment across all industrial sectors, particularly worsened in vulnerable sectors such as tourism and hospitality. The informal sector has also particularly been hit. Food insecurity has increased, and inflation has picked across the globe. Economic growth has stalled, and standards of living have plummeted in the past three years.

Countries have acted differently - a true realization of acting locally - to tame the effects on the economy and population. Developed countries acted much faster, while developing countries acted laggards. In laggard countries, policies have lacked evidence.

Attributed to Scots town planner and social activist Patrick Geddes (1915), and popularized in the 1970s (Heaps, 2010), the catch term ***think global-act local*** has evolved. It has been used in various contexts, including planning, environment, education, and towards business strategies. Thinking globally and acting locally, in its simplest form, is a commitment to personal change. It is a liberating journey of small, deliberate changes to dismantle inconsistencies that exist (Barash, 2002; Groom 2012). This acting is not only at country level, but also applies at a community sphere. For example, geographic proximity and local networks influence diverse practices at a local level, and it not uncommon for organizations to act differently in different settings.

Having a long-term vision to offset the impacts of globalization is important for a country. But how much of these locally tailored solutions can be informed by research and science? This call for local action is increasing been made in the case of mitigating for the impacts of climate change. The emphasis has been that global warming requires local solutions. The options are many: Make buildings tighter, maximize passive solar applications, substitute higher-efficiency appliances and motors, encourage telecommunications instead of physical meeting, among others. This problem can be eradicated easily through the introduction of many county-wide regulations, such as tax breaks on households that recycle, readily-available recycling bins and trashcans among many.

Africa too needs local solutions for global challenges. One can not overemphasize the power of local solutions to address global challenges. And so, in the Namibian context, we argue that local solutions should be informed through active research and scientific inquiry. However, just like everywhere around the world, local efforts to protect our planet are too often underfunded and overlooked.

Nevertheless, we must not tire. There is need to develop a knowledge hub, we require a critical mass of experts, there is need to get others inspired by reaching out, that knowledge must be shared or disseminated through civic participation in advancing scientific and research discovery to support the country's development.

Perhaps we can start from the basics. Our education system. Effective partnership in basic education and for local solutions is necessary. Mothowanaga and Gladwin, in this issue, puts a question that we should rethink the curriculum implementation. Using a secondary school history curriculum, as a case study, they have demonstrated that a top-down approach to curriculum implementation may cause challenges, but rather they argue that preparedness of teachers and learners is equally important. Readiness assessments of school environment, teachers and learners in particular should not be missed. In another study, Amunime, Boer and Haipinge explored whether Facebook has the potential to support learning and mastery of Physical Science content to improve learners' academic performance on the topic of stoichiometry at Grade 12 level. Using a quasi-experimental design, findings showed Facebook may improve student performance when used as a learning support tool.

Equally critical are local innovations. As presented by Mundia et al., in this issue, grassroots innovation provides significant opportunities to develop creative solutions to address challenges of developing economies, like Namibia, where the majority of the people live under difficult economic conditions. They emphasized that existing bottlenecks that inhibit accelerated growth of grassroot innovations would require mitigating the existing legislation governing Science, Technology and Innovation (STI) in Namibia, as well as linking grassroots innovation to techno-entrepreneurship.

And there is more. Two articles, in this issue, have global themes. Markus Hitila and Sylvanus Onjefu's "Radiological Risk Assessment of Technologically Enhanced Naturally Occurring Radioactive Materials in coal wastes from Van Eck Coal-Fired thermal Power Plant, Namibia" demonstrate the need for environmental monitoring of air pollution - a thing that has come to the fore due to fossil burning. And indeed Namibian government must act locally to safeguard the lives of many within its borders. The other article by Horn, Shimwafeni, and Mulima writing on "True potatoes seeds (TPS) as an alternative method for potato production in Namibia", sheds light on potato food production - a major theme to support food security in a rapidly urbanizing Namibia. They present the case of how potato, which plays a great role in the human diet all over the world for the achievement of food security programmes, can be adapted to different environmental conditions, such as arid Namibia, as well as increase its yielding capacity.

The issue is complete with seven articles.

Special thanks to the editorial board members and the reviewers. Thank you for many hours invested in the review of manuscripts providing critical insight to authors and editors. You improved the published science.

Enjoy reading.

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Original Research Article

True potatoes seeds (TPS) as an alternative method for potato production in Namibia

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ABSTRACT

Potato plays a great role in the human diet all over the world for the achievement of food security programs due to its popularity and ability to adapt to different environmental conditions as well as its yielding capacity. Production of potatoes in Namibia however is far less than in other countries due to constraints such as the unavailability of growing materials in the form of true potato seeds (TPS) or seed tubers. This situation is not only denying the opportunity for local farmers to produce potato crops but also limiting the opportunity for Agrobusiness and crop diversification in the country. Without a formal potato seed system, farmers will continue making use of varieties of unknown origin as no improved varieties are available to the majority of the farmers. Lack of awareness about the use of improved technology and practices has also impeded the adoption of potato technologies in Namibia. This review is aimed at summarizing challenges and constraints to potato Production and value chain in Namibia, and to provide baseline information on the potato for current and aspiring producers in Namibia or similar agro-ecologies in Sub-Saharan Africa (SSA).

1. Introduction

The Irish potato (*Solanum tuberosum L.*) is the world's fourth largest food crop after wheat, rice, and maize. It is regarded as an important source of food, employment, and income generation in developing countries (FAO, 2008). The tubers are high in carbohydrates, protein, and vitamins, especially vitamin C (FAO, 2008). It is reported that global calories supply depends only on twelve (12) domesticated plant species, eight of which are cereals (barley, maize, millet, rice, rye, sorghum, sugar cane, and wheat) while four are in the tubers category (cassava, potato, sweet potato & yam) (Robiansyah et al., 2014).

Potato world production stood at 381 million tons (Mt) produced annually (Zhang et al., 2017). Cultivation of Solanaceae potato is reported to have originated in the Andes of northern Bolivia and southern Peru and may date back 7 000 to 8 000 years ago (Allemann et al., 2004). China is reported to be the largest potato producer worldwide in terms of either volume or area where it once served as the "lifesaving potato" and through its contribution to the reproduction and prosperity of the Chinese nation (Zhang et al., 2017). According to Allemann et al. (2004), the crop was introduced into Europe between 1570 and 1590, and from there spread to North America and later to the rest of the world. According to Zhang et al. (2017), Potato grows well in high-altitude areas with extremely cold climates. Potato crop production is widely based on the use of tubers as an asexual reproduction method or tuber pieces with eyes (nodes) from which plants emerge (Alpers and Jansky, 2019; Jansky et al., 2016). Subsistence and smallholder farmers in dry countries like Namibia depend mainly on four staple food crops which are pearl millet, sorghum, cowpea, and maize (Embashu and Nantanga, 2019; McDonagh and Hillyer, 2003). Potato farmers in Namibia use potato tubers (ware) which originates from neighboring South Africa for seeds.

The use of potato tubers as seeds is regarded as an easy way of potato propagation by some people however, this practice is also accompanied by many disadvantages (Khandaker et al., 2011). Potato tubers are meant for food and not for propagation purposes, therefore using it for propagating materials is not only wastage of food that could feed the population or enter into the market, but also posing danger to the soil as they could contain soil-

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borne pathogen carriers (Almekinders et al., 2009; Muthoni et al., 2013). Damaged seed tuber which are often of poor quality could also lead to seed degeneration and hence low yields (Muthoni et al., 2013). As a result, the Ministry of Agriculture, Water and Land Reform in Namibia has put strict measures against potato tuber seeds importation, to curb the transmission of cross boarder crop diseases as stipulated under Section 11 of the Agricultural Pest Act 1973 (Act 3 of 1973).

Therefore, this paper aims to explore possibility and alternative ways to potato production in Namibia and to provide information on the crop production in other countries. In light of the above background, the objective of this review is to summarize challenges and constraints to potato Production and value chain in Namibia. To provide baseline information on potato for current and aspiring agronomists and producers in Namibia or similar agro-ecologies in Sub-Saharan Africa (SSA). The information on potato production and consumption is crucial to the agricultural sector and to the local farmers who may wish to venture into potato production.

2. Importance of potato as a food crop

Potato is the fourth most important food crop in the world after wheat, rice, and maize due to its great yield production and high nutritive value (Geohive, 2013). In addition, the potato crop is one of the economic important crops across the globe with successful large-scale production, high consumption, and affordability with easy availability in the open market (Zaheer and Akhtar, 2016). Furthermore, potatoes are very important to the human diet because it provides basic nutrients such as carbohydrates, dietary fiber, several vitamins, and minerals such as potassium, magnesium, iron (Zaheer and Akhtar, 2016; Zhang et al., 2017). Potato are made up of high nutritional value, with abundant in carbohydrate, protein, and contains various minerals, vitamins and dietary fiber (Chung et al. 2016). Particularly, it is rich in vitamin B and vitamin C which are not sufficient in cereals. Potato grows easy in most soils and thus can adapt tobe grown almost everywhere as an affordable source of food.

According to Zaheer and Akhtar (2016), potatoes was reported to have saved many families from hunger especially in Europe and China during the famines in the early 1770s. Haverkort and Struik (2015) reported that most of the potato crop was only grown in the developed world until 50 years ago and not much was happening in developing countries. However, developing countries nowadays produce more potatoes than developed countries (Devaux *et* al., 2021, Haverkort and Struik, 2015). Therefore potato plays an important role in human health through consumption, while in China, potato consumption was associated with lowering risk of type 2 diabetes in the Shanghai women's (Zhang et al., 2017).

3. Status of Potato production and Production constraints in Namibia

Namibia consumes fresh potato with the average demand of 3800 tons per month creating a production gap of 50% potato needs (Potato News Today, 2020). According to the USAID, 2015 report, potato marketing and value chains are well organized globally. In southern Africa, potato industry is well developed with large processing industries such as starch extraction (Allemann et al., 2004). Potato industry in Namibia is based on household consumption and to a lesser extend processing. At the moment, potato is consumed in the form of fresh tuber in Namibia and is favoured for its delicious salad served at weddings or processed into fried potato chips (French fries) and backed wedges as in China (Zhang et al., 2017). According to NewEra Reporter (2007), potato production in Namibia showed an increase in 2007 due to its higher demand and profitability in recent years. The increase in potato production in developing countries such as China and India was because of increased demand and was made possible by the introduction of modern seed technology, fertilizers and fungicides (Haverkort and Struik, 2015). Unlike other developing countries, the importation of potato tubers was increased significantly due to limited local production as outlined in the Namibian Agronomic Board (NAB) reports of 2017/2018. Importation of food items cause increase in commodity prices, a situation which is not only likely to have disproportionately affected low-income households, who have higher relative shares of food expenditure, but also on urban households who rely more on cash purchases for consumption (Emongor and Kirsten, 2009; Levine, 2012). According to Gebru et al. (2017), low access to and high prices of seed tubers of improved potato varieties (>0.25 USD kg^{-1} seed tubers) and scarcity of information on good fertilizer management practices for producing the potato has led to limited potato production in Ethiopia. According to Levine (2012), the Ethiopian rural low-income households dependent on subsistence agriculture which in most times negatively affected by climate change and as a result, these households could not get much share from their hard work as they are dependent on cash purchases for a large share of their consumption.

Potato production in Namibia is at low level hence most of it is being imported into the country. Potatoes from South Africa feed the neighbouring countries which includes Namibia, Angola and Botswana (Franke et al., 2011). Namibia has a few numbers of commercial potato producers which are found around Tsumeb, Otavi, Outjo, Groot Fontein, Otjiwarongo,

Mariental, along the Orange River, and the Hochfeld area (NAB reports of 2017/2018). It is reported that ware potatoes tubers imported from South Africa finds its way into the Namibian economy and used as seeds and for human consumption (Franke et al., 2011). Besides, in the informal seed potato system, seed tubers produced usually as part of ware are stored under poor conditions making it unfit as seeds (Hirpa et al., 2010). Without a formal potato seed system, farmers will continue making use of varieties of unknown origin as no improved varieties available to the majority of the farmers (Hirpa et al., 2010). Lack of awareness about the use of improved technology and practices has also impeded adoption of potato technologies in Namibia. The Namibian Agronomic Board (NAB) reports of 2017/2018 financial year, further reported that potato have been the most traded horticultural fresh produce in Namibia with 39% recorded during 2018. The consumption of potatoes was at 31,498 metric tons in Namibia (NAB) reports of 2017/2018). This exceeded the country's production capacity during 2017/2018 season. Subsequently, 23,655 metric tons of potato were imported while only 7,844 metric tons were produced locally (NAB annual report 2017/2018). Despite the demand for potato tubers and seeds for production, potato propagation materials remain unavailable in Namibia. While in South Africa, potato is grown on approximately 50 thousand hectares with a yield close to 2 million tons per annum (Franke et al., 2011).

According to the Potatoes outlook South Africa report 2021, the average potato yield in 1998 was 30.4 tonnes per hectare, in 2018 the average potato yield was recorded at 46.5 tonnes per hectare and by 2028, yields close to 50 tonnes per hectare has been anticipated. Potatoes can be grown year-round provided there is sufficient water for irrigation during off season, and the average days to maturity is about 120 days. The crop perform very well with minimum amount of water (4 mm d^{-1}) supplementation even when temperatures are high and rainfall low or when grown in the winter (Haverkort and Struik, 2015). The conditions in South Africa are similar to those of Namibia hence subsistence farmers could also take part in potato production, if TPS become available to them. At the moment, potential potato farmers are challenged with the unavailability of potato seeds in the country.

Production constrains of potato includes a number of diseases as well as insect pests reported as prone to South Africa. These includes diseases such as early blight, late blight, bacterial wilt, scab and virus (Allemann et al., 2004; Khandaker et al., 2011). Insect pests such as tuber moth and leaf miner are also listed among major production constraints. Potato is the first crop where breeding for resistance to diseases was initiated due to its susceptability to the late blight attack that led to the Irish potato famine in Europe (Martin et al., 2014; Zadoks, 2008). According to Zadoks (2008), the late blight resulted from importation of a new potato breeding material from the Americas into Belgium and it began to spread in 1844, causing destruction to potato crop in Ireland and triggered the 'Great hunger' across Europe. Following the disaster, the European governments responded quickly to the emergency and ordered both seed potatoes and potato seeds from abroad for experimentation and also to look into the matter and suggest methods of disease control (Zadoks, 2008).

4. Use of true potato seed (TPS) as a mean of propagation material

The alternative to potato tuber as propagating material is the true seed potato seed (TPS). TPS refers to the botanical seed that is harvested from a potato (Jansky et al., 2016). Sexual propagation via TPS offers many benefits over asexual propagation via tuber pieces. The use of TPS could offer various benefits over the tuber pieces used in current potato cropping systems. As compared to seed tubers, TPS could serve as seeds for potato production because dealing with TPS is less labour and capital-intensive, and it is suitable for small-scale farmers (Almekinders et al., 2009). This method uses the botanical seed produced by sexual reproduction that is formed inside fruits (Almekinders et al., 2009; Jamro et al., 2015). The method of using TPS started at the International Potato Center (CIP) where research into converting the potato from a vegetative clonal crop to a botanical seed crop was at forefront from 1977 to 2000 (Jansky et al., 2016). According to Muthoni *et al.,* (2014) the use of TPS is a way to maintaining good health standards of the early generation's material generated to produce seedlings and seedling tubers. In addition, TPS has many advantages over tuber seeds especially when it comes to storing and transporting tons of tubers versus very small quantity say grams of true seeds (Almekinders et al., 2009; Jamro et al., 2015). Farmers can achieve the same or better results by planting as few grams of TPS per hectare, compare to the one who usually use two tons of seed tubers to plant a hectare of potato crop to produce the same amount (Jamro et al., 2015).

5. Possible interventions to potato production in Namibia

Poor access to quality Seeds is generally considered a yield-limiting factor. Poor quality seeds are being required for the expression of the yielding ability of the crop without constraints. The use of botanical or true potato seed (TPS) was first introduced by the International Potato Center (CIP) together with their collaborating institutions (Allemann et al., 2004;

Almekinders et al., 2009). Under their collaborations, an intensive research programme was implemented for over a period of 25–30 years on the use of botanical seed of potato as an alternative way of growing a potato crop (Almekinders et al., 2009). The use of TTPS was seen as a stepping stone in the development of a new crop commodity chain, requiring research on breeding, seed production, agronomy and marketing aspects. The use of TPS was especially attractive for small-scale farmers in developing countries. The difference of using TPS as compared to using seed tubers meant in many respects the development of a new crop–commodity chain, requiring research on breeding, seed production, agronomy and marketing aspects (Almekinders et al., 2009). In addition, advantage of having TPS is the light weigh of the product which can be carried to any place without any problem, especially by small scale farmers who do not have access to farm machinery (Allemann et al., 2004; Muthoni et al., 2013). TPS also do not require cold storage and no virus diseases transmitted from one generation to another or soil-borne diseases from one field to another (Allemann et al., 2004; Muthoni et al., 2013). Following the use of TPS in five different country as pilot project by CIP, China reported an extensive use of TPS that increased the enthusiasm in CIP circles for the innovative of the technology around 1984 (Almekinders et al., 2009; Roy et al., 2005). The CIP first directors Dr. Richard Sawyer (first director) and Dr. Orville Page (director of research) commended that the use of true potato seed would have the advantage that small-scale farmers could eat or commercialise the tubers that he or she would otherwise had to store or buy for next planting season (Almekinders et al., 2009). This led to the slogan 'a handful of seed replaces 2 tonnes of tubers'. Despite the CIP effort, research on TPS as an alternative in developing countries did not yield reference to a feasible large-scale use of the botanical seed for ware potato production (Almekinders et al., 2009; Jansky et al., 2016). The technology needs to be implemented and should be promoted in most developing countries in order to increase potato product yields. Although TPS are favoured for low transmission of diseases, they are sometimes affected by infections such as late blight, bacterial wilt and virus transmitted by aphids (Muthoni et al., 2013; Roy et al., 2005). According to Roy et al. (2005), the spread of infections in TPS is attributed to contact with virus infected hands and leaves of infected plants. Therefore proper distribution channels of TPS with high yield, tolerance to diseases and less expensive way of distribution need to be put in place (Muthoni et al., 2013). In most countries where CIP experimentation and adoption by farmers took place, the technological advantages of using TPS were only translating in economic benefits as compared to tuber seed which are costly or not available (Almekinders et al., 2009). Since the economic performance of seed tubers is likely to continue to fluctuate, TPS is the only possible alternative available (Almekinders et al., 2009). Advantages associated with the use of ware potato or tuber as seeds are higher yield compare to TPS planted directly (Jansky et al., 2016). The disadvantages of propagating the crop using tubers are that the tubers have a short preservation time and the potential to accumulate systemic diseases when propagated vegetatively over field generations using TPS (Jansky et al., 2016). The possible way to bypass low yield from using direct seeding with TPS is to generate seed tubers from TPS, which are then planted as the commercial crop in the following year (Jansky et al., 2016). These seed tubers from TPS are nearly pathogen free and can guarantee a better hygienic status than locally produced ware potatoes imported from other countries in developing countries without the resources and technologies for the production of pathogen-free-certified clonal seed (Jansky et al., 2016).

6. Conclusion

It was found through this review that seed tubers used locally are deemed to be poor in health, unsuitable in physiological age, poor in genetic quality, impure, physically damaged and inappropriate in size. Since there is no formal seed system yet in Namibia, Emphasis should be placed on prioritizing the improving of potato seed quality by increasing awareness and skills of farmers involved in potato production. Alternatively, formal seed systems should prioritize improving the production capacity of quality seed by availing quality varieties in the form of TPS and tubers. Furthermore, quality control methods as well as improving farmer's awareness on the use of TPS as planting materials should be encouraged. Improving seed tuber quality of early generations and market access should be developed in Namibia. There is also a need to develop and improve overall the non-existing seed potato supply in Namibia. A seed certification system for farmers who can server as seed producer and distributors should be introduced, or a self-regulation and self-certification in the informal and formal cooperative seed potato systems should be create.

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Original Research Article

Exploring bottlenecks towards accelerating grassroots innovation in Namibia

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ABSTRACT

Grassroots innovation (GI) provides significant opportunities to develop creative solutions to address challenges of developing economies, like Namibia, where the majority of the people live under difficult economic conditions. Despite substantial research on grassroots innovation, there is still little understanding of the inputs required for its acceleration. This article explores; the existing legislation governing Science, Technology and Innovation (STI) in Namibia, concepts of grassroots innovation and techno-entrepreneurship as a premise for mitigating any bottlenecks towards accelerating GI in Namibia. The Honey Bee Network (HBN) approach was employed in ten (10) regions of Namibia, to scout for and document locally designed solutions and traditional knowledge. The HBN framework was specifically used to explore existing bottlenecks to grassroots ideas with the potential to be refined to impact communities in terms of providing solutions to consumer needs through enhanced productivity, sustainability and poverty reduction. The findings of the study revealed that while there were some good grassroots innovation ideas, there is a lack of policy support for these ideas to reach their commercial or non-commercial potential. It was concluded that there was a need for the services provided by technological business incubators in developing the marketing capabilities of grassroots innovators in Namibia. In light of the findings it is recommended that Namibia develops a National Innovation Strategy, with specific focus on acceleration of grassroots innovation, through establishment of regional makerspaces and provision of Technology Business Incubation (TBI), particularly in rural areas.

1. Introduction

Unemployment in Namibia remained relatively high at 33.4% by 2018. The youth (15-34 years) were the most affected, constituting 46% of the total unemployed population, of which 49% represented female youth (National Planning Commission, 2020). The impact of the current global economic crisis, coupled with the COVID-19 pandemic, demands new focus on issues of inequality and social inclusion. Innovation at grassroots level has been shown to respond to local problems, when there is active involvement of Non-Governmental Organisations (NGOs), formal sector, individuals in the informal sector and local people, collaborating with industry (Seyfang and Smith, 2007).

It is in this backdrop that this paper explored bottlenecks faced by Grassroots Innovators (GIs) in Namibia. The data for this analysis was obtained from a grassroots innovation (GI) mapping exercise, conducted by the Ministry of Higher Education, Technology and Innovation in ten (10) regions during the year 2018, using the Honey Bee Network (HBN) approach.

The paper is structured as follows; the section that follows provides the literature review on grassroots innovation as well as insights on the relevance of GIs for developing economies and Namibia in particular. The section also presents an overview of the legislation governing Science, Technology and Innovation (STI) in Namibia, pointing out identified policy gaps in relation to support to grassroots innovations. Then, the Honey Bee Network framework that was used in mapping the innovation bottlenecks, is explained at the end of the second section. Section 3 discusses the methodology of the study. Finally, section 4 presents the findings of the study while section 5 presents the conclusions and recommendations.

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2. Literature Review

Grassroots innovation is defined by many scholars as a network of activists of innovative product or process created at the bottom of the pyramid, usually due to necessity, hardship and challenges (Seyfang, 2006; Hosssian, 2016:15 Reinsberger *et al.*, 2015). GI is portrayed through varied dimensions such as: grassroots creativity, the grassroots movement or community-led innovations, traditional-knowledge based innovations, rural innovation, empathetic innovation, and informal innovation (Joshi, Challah and Ramanathan, 2015).

Joshi *et al.* (2015) also maintain that GI is primarily undertaken to solve local problems, empower local people and improve livelihoods and, these objectives differentiate GI from the other closely-associated innovations. According to Daniels (2015), STI policies in most African economies, do not yet target innovation at grassroots level. This view is supported by Lundvall (1992; Gupta, 2019), who argues that national innovation policies typically focus on supply-side interventions in the mainstream market. As a result, innovations at grassroots level arise as a reaction to local challenges, such as agricultural needs, food supply, social injustices and environmental needs, hence often remain unrecognised and unsupported by existing innovation policies.

The Honey Bee Network framework was adopted as the research approach of the study. The Honey Bee Network evolved in the late 80's, not only to correct the asymmetry of power and influence in the formal and informal sectors but also to create a more reciprocal, responsible and respectful relationship between them (Gupta *et al.*, 2016). It continues as a voluntary organisation working in the field of educational, technological, cultural and institutional innovations and promotes viable and sustainable traditional knowledge systems.

There are four main principles of the Honey Bee Network philosophy: (a) whatever is learnt from the people must be shared with them in a local language, with or without value addition, in order to enrich the collective understanding of the ways in which different individuals and groups have solved specific problems, (b) the cross-pollination of ideas across languages and other cultural barriers fertilizes the imagination of communities and encourages further experimentation, (c) both scouts and innovators should be acknowledged by name for their contributions, and (d) any benefit arising from the commercial or non-commercial dissemination of innovations should be shared with those who contributed knowledge or innovations in a fair and just manner, with or without value addition.

For the purpose of this study, the HBN was constituted by 4 staff members of the Directorate of Research and Innovation in the Ministry of Higher Education, Technology and Innovation, 1 staff member from the Namibia National Commission for UNESCO (United Nations Educational, Scientific and Cultural Organization), a development planner from the regional council of each region that was visited, technical and vocational education centres, research institutions, rural development centres, the governor of each region visited, identified community leaders, NGOs and industry representatives where applicable.

The findings of this study will hopefully inform policy makers about typical bottlenecks currently retraining grassroots innovation in Namibia. Hence contribute towards the development of a more inclusive policy landscape that facilitates stronger interactions between mainstream and grassroots innovation ecosystems and thus establish a supportive environment for incubation and commercialisation of grassroots innovation ideas.

3. Methodology

The study used a qualitative research design based on in-depth, semi-structured interviews as the means to explore the dilemmas experienced by the grassroots innovators that were visited in 10 regions of Namibia. An exploratory, partially-inductive research design was adopted given the lack of theoretical research examining this phenomenon. This research design is appropriate when it is not clear a priori what specific grassroots innovation bottlenecks exist (Hossain, 2016).

Purposive sampling was used in selecting 10 regions out of the fourteen (14) regions of Namibia. On the other hand, convenience sampling was used in selecting the grassroots innovation value chains and projects that were assessed using the Honey bee network (HBN) approach. The regions were selected on assumption that grassroots innovation activities were prominent because of high rural community population residing in the chosen regions, whereas the actual projects were visited on the basis of availability of the members at the time of the HBN's visit.

Various grassroots entrepreneurs and innovators were asked to complete a needs assessment questionnaire. The HBN paid courtesy visits to the governors' offices in each respective region through which the regional leaders were briefed about the purpose of the grassroots innovation mapping, and reciprocally for the HBN to obtain an overview of the key innovative activities and projects in each region.

4. Findings and Results

4.1 Existing Grassroots Innovations

The study identified several existing innovations in Namibia. Potentially successful grassroots

technological innovations per region were identified, with a view of supporting them through the regional research institutions, vocational training centres, rural development centres or makerspaces. The following section discusses some of the grassroots innovation value chains and or projects that were mapped by the HBN, in the different regions.

4.1.1 Worm Silk Manufacturing Project

The project is run by five (5) women, using homemade technology. The project is hampered by lack of appropriate technology with the current spinning and weaving machines needing upgrading or replacement, as seen on Figure 1. The women have identified lucrative European markets, including exports and sales to Austrian markets.

Figure 1: The worm silk processing innovators using old technology.

4.1.2 Traditional Fence Manufacturing Project

The wire fence manufacturing project form the Hardap Region manufactures and sells wire fence to farmers and communities of the town of Mariental. The challenges faced by the project, is that it is using old technologies (see Figure 2), that results in uncompetitive pricing, hence reduced market demand, making its operations unsustainable.

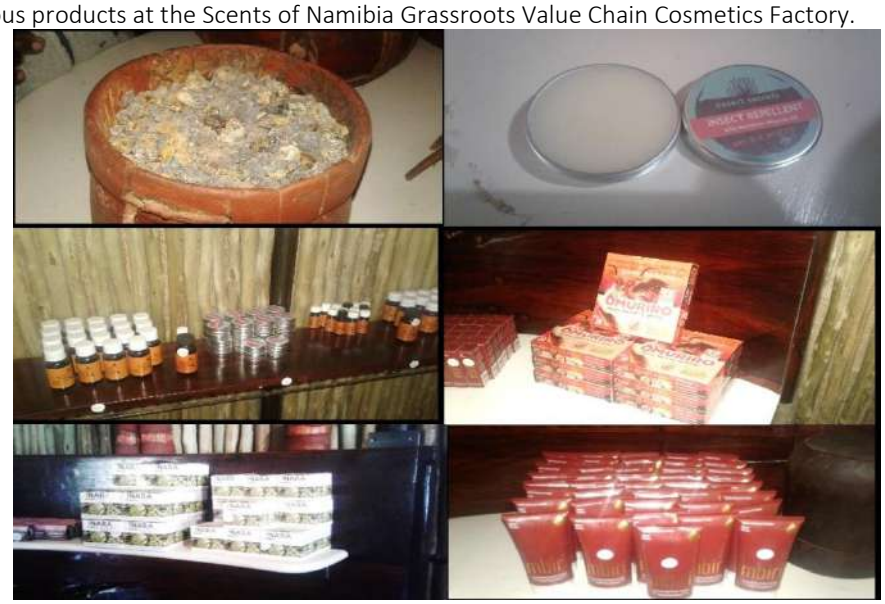
Figure 2: The traditional wire fence manufacturing technology.

4.1.3 Scents of Namibia Project

The Scents of Namibia project, is an oil processing facility situated in the outskirts of Opuwo town. The raw materials are sourced from members of the community who sell them to the facility. These raw materials are Commiphora resin and Mopane seeds.

The Commiphora resin has for years been used by Himba women (Himba is a nomadic tribe in Kunene region) to make their traditional perfume. The oil produced from the resin (Figure 3) is used to produce various cosmetic products. Similarly, the essential oil is extracted from the mopane seeds and used to make various cosmetic products. Other projects with a potential of generating income for the local communities is the traditional Himba powder, known for skin protection against the sun. The powder (see top right of figure 3) is not only used by Himbas but used by other indigenous Namibian tribes for instance Hereros and Wambos.

Figure 3: Various products at the Scents of Namibia Grassroots Value Chain Cosmetics Factory.



4.1.4 Lubata Community Bee Keeping Project

The project is run by community members living in the Lubata Community Forest of the Zambezi region, and produces organic honey, as seen in Figure 4. This project is supported by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), while the Ministry of Agriculture, Water and Forestry works closely with the beekeepers and assists the community members with the harvesting and selling of the honey. All the profits go to the communities. The team learnt that there is high demand for the locally produced honey and there is thus potential to expand the project to produce more honey. However, there is no value addition to the honey and parallel post-harvest bi-products, like wax, and the beekeepers have not explored the market for such by-products.

Figure 4: Honey extraction process using outdated technology.

4.2 Grassroots Innovation Challenges

At national level, Namibia has recognised the value of grassroots innovation in generating bottom–up solutions that respond to the needs of local communities and that have an immense potential for wealth creation. The study identified the absence of not having specific policy measures to guide government on how to promote grassroots innovation, to be a challenge at macro level. The other challenges the study found at micro level were lack of technology in business incubations for value addition and marketing strategies. Small scale farmers and entrepreneurs interviewed, indicated that they lack skills such as bookkeeping and proposal writing for bankable proposals as well as access to SME micro-financing schemes.

It is a well-known fact that at grassroots level, local communities suffer from inefficiency and low production capacity owing to lack of automation and shortage in the availability of skilled human resources (Singh, Maiyar and Bhowmick, 2020). Ultimately, grassroots innovation offers alternative technologies that meet the basic need of the grassroots communities at affordable prices. These innovations may not be of the highest quality but are cost efficient, affordable and frugal in terms of resource requirements, and have the potential to improve local productivity thereby contributing to regional development and social capital at the bottom of the pyramid (Joshi *et al*., 2015).

4.3 Possible Areas of Innovation

There is an indication that there is more and more interest in using grassroots innovation in combating poverty, providing employment, and increasing income. Empowering rural youth through Information Communication Technology (ICT) skills can enhance new innovations through development of locally relevant mobile applications. The challenges of outdated technologies could be addressed by establishing stronger networks between innovators and vocational training centres, rural development centres, makerspaces, universities and other research institutions. There is capacity for these institutions to collaborate in the design and fabrication of frugal technologies to accelerate production and value addition processes.

5. Conclusions and Recommendations

5.1 Conclusions

While there are a number of potential marketable grassroots innovations, these innovations are not documented. The absence of proper documentation hinders innovators from getting needed support. Remarkably, most regional councils do not have support programmes for small businesses and young entrepreneurs, and this could be one of the reasons they fail to grow.

The Ministry of Higher Education, Technology and Innovation has already facilitated the establishment of three (3) pilot makerspaces in Khomas two (2) and Oshikoto one (1) regions. The Ministry has also commenced with stakeholders' consultations for inputs towards the development of an inclusive National Innovation Strategy.

5.2 Recommendations

There is need for Namibia to develop a National Innovation Strategy to address the observed bottlenecks. To mediate the challenges of lack of or outdated technologies in grassroots value chain processes, the establishment of grassroots makerspaces, equipped with digital fabrication tools is recommended. Such tools could be deployed in regional makerspaces, ideally to be hosted at vocational training or rural development centres as may be appropriate. The makerspaces provide a suite of digital design and manufacturing technologies, including 3D-printers, web-based design tools, electronics kits, computerised welding equipment, laser and plasma cutters.

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Original Research Article

Rethinking the implementation of the revised history curriculum: teachers' and learners' preparedness in selected public secondary schools in Khomas region, Namibia

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ABSTRACT

The objective of the study is to determine the preparedness of both teachers and learners in implementing the revised History curriculum in secondary schools (grade 8-12) since the introduction of the revised curriculum in 2017. Jess, Carse, and Keay (2016) discovered that teachers must be prepared and trained in order to accomplish the objectives of a curriculum; the authors' attention was on the curriculum-development process and the educator's role. Teachers are familiar with classroom circumstances and may be able to identify gaps and implement changes and enhancements that will assist students in achieving the desired results. Furthermore, teachers must be able to provide developmentally appropriate learning challenges that are connected with curricular requirements. The focus of training and professional development must be on teaching students how to appropriately interpret the curriculum so that their needs are met through suitable instructional approaches. Allowing teachers main engagement in curriculum development and the process of alignment as it relates to identifying student needs and then instructing accordingly, as recommended by Jess et al. (2016), is one method to assist this situation. Learners are also a crucial component in curriculum implementation. While teachers are the ones who decide what happens in the classroom, it is the learners who decide what is actually communicated and adopted from the official curriculum. Unprepared teachers and learners are impediment to the effectively implementation of curriculum processes. The lack of preparedness among teachers, as well as their attitudes and morale, has a negative impact on the implementation of the curriculum therefore, proper training should be provided to teachers in order to prepare them in all aspects of the curriculum in order to enhance their ability to deliver and implement the curriculum effectively. The study recommends that teachers need have proper training before they implement the new or revised curriculum. It is also recommended that NIED in collaboration with the ministry of education be holding regular training and workshops for teachers and to have a follow-up system in place to ensure that the trainings are effective. This will aid teachers in understanding the varied expectations of the new curriculum as well as staying current or abreast to current curricular changes.

1. Introduction

There has been some criticism of the curriculum drafters' lack of consultation with instructors and the curriculum implementers (teachers as the most agent of curriculum implementation). There has been a high failure rate in Social sciences subjects specifically History and in particular, Khomas region since the introduction of the revised curriculum. History is one of the compulsory subjects in grade 8 and 9 and despites learners having done the introductory in these grades, they still fail it in grade 10-12. It is against this background that this study investigated perceived causes and problems of curriculum implementation in Khomas region, leading to poor results. This study sought to establish that if the curricula were properly implemented, there would be an improvement. When and if a curriculum is successfully implemented, it leads to improved results and thus there is a need for countries to make sure curriculum is implemented effectively after some changes or reforms. The educational system is being realigned to suit the demands of Namibia's

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Vision 2030, a long-term national goal (National Institute for Educational Development, 2013).

2. Reviews and the context of Namibian curriculum

The National Curriculum for Basic Education (2016) replaces the curriculum for basic education of 2010 to ensure the continuity of the foundation of the Namibian Basic education and "Education for all of 1993 that was found and put into practice by the ministry of education as from 1993. In addition to this, the government directives had tasked the directives from the ministry of education in 2011 to hold a conference in order to review the curriculum for basic education and address the challenges and the needs of the Namibian society.

The outcome of the conference includes the reviewing of the curriculum to the challenges and needs of the Namibian society, reducing the number of subjects in the junior secondary phase, expanding the subjects on higher level in the senior secondary phase, and reintroducing technical and vocational subjects in the school curriculum. As a result of the conference held by the ministry of education's directives in 2011, the following reviews or changes were made concerning the secondary phase of education.

Junior Secondary Grade 8 and 9

According to The National Curriculum for Basic Education (2016), the junior secondary phase extends the learners' knowledge and skills, strengthens their values and attitudes, and prepares them for continued studies. This phase provides learners with the opportunity to explore a wider range of subjects to enable them to make informed subject choices for future career opportunities. It is more challenging, and a greater body of knowledge is covered to develop a higher level of understanding and skills. The curriculum becomes more diversified and a degree of choice is introduced. In this phase, the medium of learning continues to be English and learners continue to take English and another language, Physical Science, Life Science, Geography, History and Mathematics.

In addition, learners take any two of the following elective pre-vocational subjects: Agricultural Science, Accounting, Office Practice, Entrepreneurship, Computer Studies, Design and Technology, Visual Arts, Integrated Performing Arts, Home Economics, Fashion and Fabrics, Hospitality, Technical Drawing, and Technical Studies A or B or C. Technical pre-vocational subjects will be offered in schools with both academic and pre-vocational streams. There will be a reading period and together with a reading period, the following support subjects are also offered in this phase: Arts, Life Skills, Physical Education, Religious and Moral Education, and information and communication. The junior secondary phase, which consists of Grade 8 and 9, will require learners to write junior secondary semi-external examinations at the end of Grade 9 which is similar to the previous Grade 10. This means the examination will be set and moderated nationally but marked in the regions by the subject teachers from the respective schools.

Senior Secondary: Grades 10-12

The senior secondary phase extends the learners' knowledge and skills, strengthens their values and attitudes, and prepares them for continued studies and young adult life. It is therefore during this phase that the 'learning to learn' skill area must be consolidated so that learners will continue in lifelong learning (The National Curriculum for Basic Education, 2016).

This phase is sub- divided into two parts, the Grades 10-11 and grade 12 NSSCAS

Grade 10-11

All learners take three promotional core subjects, three promotional elective subjects and four support subjects. Natural sciences are divided into the subjects Biology, Agricultural Science, Physics and Chemistry, and Social Sciences into the subjects Geography, History and Development Studies. Pre-vocational subjects include Accounting, Office Practice, Entrepreneurship, Business Studies, Economics, Computer Studies, Design and Technology, Art and Design, Integrated Performing Arts, Home Economics, Fashion and Fabrics, Hospitality, Health and Social Care, Woodwork, Metalwork and Welding, Building Studies, and Motor Mechanics. In addition, a reading period and the following support subjects are offered: Arts, Life Skills, Physical Education, and Information and Communication. Therefore, the junior secondary phase will consist of seven compulsory promotional subjects, elective subjects and support subject's national examination for the Namibian Senior Secondary Certificate Ordinary (NSSCO) level is written at the end of Grade 11. Grade 11 is the first exit point from basic education and some learners will start an independent young adult life, enter non-formal education, seek employment, or create their own employment. Learners will have an internationally recognised certificate which gives them access to further education and training, which includes tertiary education institutions with an NQF Level 3 entry requirement.

Grade 12 NSCASS

The main purpose of Grade 12 is to prepare learners for higher education. Much greater demands are made on the learners with regard to their cognitive, personal

and social development, specifically in terms of academic achievement. They must take greater responsibility for their own learning and consolidate good work ethics and practices (The National Curriculum for Basic Education, 2016). On completion of Grade 12, learners will have an internationally recognised certificate known as the Namibian Senior Secondary Certificate Advanced Subsidiary (NSSCAS) level which gives them access to higher education institutions with NQF level 4 entry requirements, or to the job market. Grade 12 learners take three to five promotional elective subjects and two support subjects. One of the elective subjects must be a language. At the end of Grade 12, learners take the NSSCAS level examination.

3. Review of the literature

3.1 Teacher's and learner's preparedness in History Curriculum implementation

According to Kombe (2017), understanding the two concepts teacher and preparation is required in order to completely comprehend teacher preparedness. A teacher is someone who assists others in gaining information, skills, or values, whereas preparation is the act or process of getting something or someone ready for something. As a result, teacher readiness is the act of preparing a teacher for a specific task (Oliver et al. 2021). To prepare a teacher, he or she must participate in a number of activities that will enable him or her to assist others in acquiring information and/or other skills. As a result, in order for teaching to be effective, a teacher must receive proper and extensive training to ensure that they are aware of when and how to use various teaching methods (Oliver et al. 2021).

Suyanto (2017) reported that school preparation for implementing the C13 curriculum was low in their study in Indonesia. First, ineffective training and socialization are to blame for the low readiness. Five-day training is insufficient to ensure that teachers, principals, and supervisors are familiar with the C13 curriculum's ideas and application. The scarcity of learners and teacher books also contributes to the schools' insufficient preparation to apply the C13. Curriculum implementation relies heavily on learning materials such as books (Suyanto, 2017).

Lack of pedagogical understanding on how to infuse the features of the curriculum in instruction was the biggest obstacle that prevented the implementation of the curriculum, in their research of Zimbabwe teachers (Zhuwale & Shumba, 2017). Handwe and Mpofu (2017) conducted a study on teacher preparedness to apply a newly established grade three curriculum in Zimbabwe, with the goal of examining primary school teachers' ability in developing lesson plans related to the new curriculum. The findings revealed that teachers' training was insufficient to meet their demands in terms of developing successful lesson plans. According to the findings, the Ministry of Education should implement short courses to bridge teachers' knowledge gaps on the curriculum. This means that when curricular changes necessitate alternative components of lesson plans, teachers must be instructed on how to create them.

Muleya and Mbewe (2018), on the other hand, found that teachers in Zambia were well-prepared to apply the 2013 updated Business Studies curriculum in their study. According to the survey, teachers were properly prepared in terms of subject combination, with 81% having a mix of Commerce, Office Management, and Principles of Accounts but no entrepreneurial component. The study found that, with the exception of a few head teachers, teachers were prepared for the implementation of the revised Business Studies curriculum, that teaching and learning resources, refresher courses, and CPD's were insufficient for effective implementation of the Business Studies curriculum. This made it easier for Zambia's Business Studies Curriculum to be implemented smoothly.

In contrast to the previous study, Oliver et al (2021) revealed that the goal was to determine secondary school teachers' readiness to execute the new Zambia Education Curriculum Framework of 2013 in the Kabwe District of Zambia's Central Province. The study found that even after the updated curriculum was commissioned in 2013, schools still lacked teaching tools with which to apply the revised curriculum. Furthermore, some teachers continued to use traditional teaching methods, making it difficult for them to fully comprehend the demands of the updated curriculum of 2013. Based on the findings, the study suggests that policymakers and implementers consult more frequently during the development and/or updating of curriculum.

In their study on teacher preparedness in the implementation of the integrated Business Studies curriculum in Kenyan public secondary schools (Jerotich, Kurgat, and Kimutai, 2017). According to the study, Business Studies teachers were trained in the old curriculum's orientation to teach Accounting, Economics, or Commerce as separate subjects, with the majority being trained to teach Economics rather than Business Studies as an integrated subject, and about a third of the teachers being untrained. According to the findings, they experienced numerous obstacles in implementing the Business Studies program, which resulted in the curriculum's failure. The lack of preparedness among teachers, as well as their attitudes and morale, has a negative impact on the implementation of the Business Studies curriculum in Kenya's secondary schools. Teachers Service Commission (TSC) should hire more professionally

prepared Business Studies teachers and hold more in-service training courses.

Sabola (2017) investigated how well Malawian teachers have been trained to implement a new elementary school curriculum. Due to a lack of training and materials to teach the new elementary school curriculum, this study discovered that the curriculum was only partially implemented in schools. Similarly, Paulo (2014) discovered that teacher training influences their ability to integrate competency-based curriculum in Tanzanian secondary schools. Pre-service instructors were not given appropriate training in new evaluation procedures or how to design lesson plans, as required by the CBC. As a result, they stuck to the old ways of teaching and testing.

In confirmation of Paulo's findings, Komba and Mwandanji (2015) found the same results in their Tanzanian investigation (2014). Their research found that the majority of the teachers who took part in the study had no idea what the competence-based curriculum's goals were. Furthermore, the majority of the assessed lesson plans (78 percent) did not match the characteristics of a competence-based lesson plan. Furthermore, the observed teachers' involvement of pupils in classroom activities was, on the whole, relatively low. Regular training for in-service teachers should be conducted, in order to enable them to gain up-to-date teaching abilities as necessary by the changes in school curricula.

In a study conducted in Nairobi, Kenya, Isaboke, Mweru and Wambiri (2021) discovered a statistically significant association between teachers' level of CBC training and their capacity to apply the curriculum in public pre-primary schools in Nairobi City County. The majority of public pre-primary school teachers had not received any training on how to execute the curriculum. Even those who had been trained lacked adequate knowledge and abilities in a variety of areas that were supposed to be included in the curriculum. As a result, it might be determined that the teachers were not sufficiently equipped to implement the curriculum, necessitating additional training.

4. Research methodologies

The study was qualitative in nature and employed an interpretivism paradigm and a case study research design. The study had drawn its population from circuit 2 of Khomas region. Only three schools out of 8 schools from Immanuel Shifidi cluster centre that are offering Social sciences field of study were selected to be part of the study. Purposeful sampling was used to select teachers who have implemented the revised History curriculum and also with 2 years and above experience in teaching the History subject. The participants consisted of 3 principals, 10 teachers and 8 learners. Data was collected using face to face interviews, non-participating observation and document analysis. Data collected was analysed using thematic analysis.

5. Findings and Discussion

5.1 Workshop

The study revealed that teachers were expected to attend workshops in order to prepare for the implementation of the updated history curriculum, but that the majority of them did not because just a few teachers were chosen to attend the workshop. In literature, Alsubaie (2016) indicated that in order to contribute to the formulation of curriculum, teachers require professional development training and workshops. Hence the ineffective implementation of the history curriculum emanates from lack of workshops.

5.2 Insufficient information on lessons plans

The study revealed that teachers were not adhering to the requirements outlined in the new curriculum's authorized lesson plan structure. In literature, the same was noted in a study conducted by Handwe and Mpofu (2017) examined primary school teachers' ability in developing lesson plans related to the new curriculum in Zimbabwe. The findings revealed that teachers' training was insufficient to meet their demands in terms of developing successful lesson plans. Similarly, Komba and Mwandanji (2015) in Tanzania reported that the majority of the assessed lesson plans (78 percent) did not match the characteristics of a competence-based lesson plan. This shows the unpreparedness of some teachers in the implementation of the revised curriculums, as a result this has a great effect on the outcomes of learners in the history subject. This also implies that when curricular changes necessitate alternative components of lesson plans, teachers must be instructed on how to create them.

5.3 Insufficient In-service training

The study revealed that participants in the study never received training on how to implement the updated history curriculum. Those who received training complained that there was not enough time for them to learn because the course was only a few days long. In literature, Sabola (2017) in Malawi discovered that due to a lack of training and materials to teach the new elementary school curriculum, the new curriculum was only partially implemented in schools. Isaboke et al. (2021) reported that the majority of public pre-primary school teachers had not received any training on how to execute the curriculum. Even those who had been trained lacked adequate knowledge and abilities in a

variety of areas that were supposed to be included in the curriculum. The results of Sabola (2017) and Isaboke et al. (2021) match the current study findings. Paulo (2014) discovered that teacher training influences their ability to integrate competency-based curriculum in Tanzanian secondary schools. Komba and Mwandanji (2015) suggested that regular training for in-service teachers should be conducted, in order to enable them to gain up-to-date teaching abilities as necessary by the changes in school curricula.

5.4 Use of old teaching methods

The study revealed some teachers have found it difficult to transition to the new curriculum, which requires different teaching methods. In literature, it was noted that in order for teaching to be effective, a teacher must receive proper and extensive training to ensure that they are aware of when and how to use various teaching methods (Oliver et al. 2021). As result the study findings revealed that teachers continued to use traditional teaching methods, making it difficult for them to fully comprehend the demands of the updated curriculum of 2013 (Oliver et al. 2021). In the same sentiment, Paulo (2014) in a study in Tanzania revealed that teachers were not given appropriate training in new evaluation procedures or how to design lesson plans, as required by the CBC. As a result, they stuck to the old ways of teaching and testing. The use of traditional methods in teaching has an effect on the curriculum implementation hence the need to adopt recommended teaching and assessment methods as proposed in the revised history curriculum for it to be effective.

6. Recommendations

Findings of the investigations made suggest that teachers should make an effort to collaborate with other history teachers in the Region. The collaboration forums are intended to aid them in sharing subject knowledge and assisting one another in teaching diverse historical themes and topics as this will help them in implementing the curriculum more effectively. The school administration should seek funding from various companies in Namibia to help create libraries, purchase textbooks for students, and teacher's books. They should not rely solely on the government, but rather seek out other options that will aid in the improvement of schools and the simple implementation of curriculums. Schools should implement staff development programs to provide teachers with the information and skills they need to teach successfully and meet the goals of the new curriculums. NIED should also hold regular training and workshops in various circuits and have a follow-up system in place to ensure that the trainings are effective. This will aid teachers in understanding the varied expectations of the new curriculum as well as staying current on curricular revisions. NIED should establish numerous committees for various disciplines that focus on the Khomas region as a whole while evaluating teachers' delivery of historical lessons. NIED should train all the subject advisory teachers for the implementation of the revised curriculum.

7. Conclusion

The use of specific resources offered in a curriculum to deliver education and assessment is referred to as curriculum implementation (Nevenglosky, Cale, Aguilar, 2018). As the most significant step of the curriculum development process, the implementation process necessitates the readiness of all stakeholders, particularly teachers (the most important agent), learners, and principals. When implementing curriculum, particularly newly revised curriculum, an educator must be able to assess it so that early problems can be identified. Determining what problems a teacher encounters during curriculum implementation can have a positive impact on curriculum success (Karakus 2021a). As a result, a teacher should be able to understand and implement curriculum effectively. The greater a teacher understands with curriculum, the more effectively she or he can develop, design, and administer it. If curriculum innovation compels teachers to assume new roles, Muleya and Mbewe (2018) claim that they typically lack confidence in their own expertise, identity, and classroom mastery. According to Kafu (2010), more training is needed for teachers to be able to deal with new obstacles in the implementation of new curriculum innovations. In order to contribute to the formulation of curriculum and implement curriculum effectively, teachers require professional development training and seminars. Findings for this study have revealed that teachers did not attend History workshops and thus this made them not be prepared for the implementations of the revised History curriculum. This had impacted the learning of learners as they lost the value of being taught by experienced teachers due to lack of in-service training. The study recommends that there must be available and ongoing support services, such as the provision of appropriate and adequate teaching/learning materials and the establishment of local centres where educational personnel can gather in seminars and workshops to discuss and enhance the new curricula. As long as the Government particularly the Ministry of Education is not meeting the teachers demands in having more workshops training of the teachers, the situation will deteriorate.

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Original Research Article

Radiological Risk Assessment of Technologically Enhanced Naturally Occurring Radioactive Materials in coal wastes from Van Eck Coal-Fired thermal Power Plant, Namibia.

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ABSTRACT

In this study, the concentrations of primordial radioactive nuclides ^{226}Ra, ^{232}Th, and ^{40}K and their potential for causing radiological health hazards were measured using coaxial high-purity germanium (HPGe) gamma detector in coal, bottom, and fly ashes collected from the 120 MW Van Eck thermal power plant, Windhoek, Namibia. The experimental results showed that for coal samples, the activities of ^{226}Ra, ^{232}Th, and ^{40}K were 20.22 ± 3.82 Bq/kg, 26.70 ± 5.90 Bq/kg, and 30.36 ± 6.36 Bq/kg, respectively. For the bottom ash layer samples, the activities of ^{226}Ra, ^{232}Th, and ^{40}K were 88.89 ± 11.91 Bq/kg, 113.28 ± 15.44 Bq/kg, and 97.84 ± 16.55 Bq/kg, respectively whereas for the fly ash the values are 59.18 ± 4.55 Bq/kg, 77.00 ± 5.89 Bq/kg and 77.17 ± 7.30 Bq/kg, respectively. The activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K were all enhanced in the bottom and fly ash relative to coal samples. However, the estimated radiological health hazards and the concentration of the various samples from the selected location were within the permissible limits provided for human safety and environmental protection.

1. Introduction

Coal residues and waste produced by the combustion of the coal contain naturally occurring radionuclides such as ^{238}U, ^{226}Ra, ^{232}Th, and ^{40}K which can be dispersed into the environment through the combustion processes [1]. The mobilization and dispersion of these radioactive materials into the atmosphere and human environment have been associated with significant human health challenges [2]. In recent decades, there has been a growing awareness by professionals on the impact of thermal power plants which use, for various applications, raw materials such as lignite, bituminous coal, and high ash and S-bearing coals naturally rich in uranium, thorium, or radium [3].

In this study, the focus was on the Van Eck Power Plant that produces electricity based on the combustion of bituminous coal. In most instances, the mechanism used in the combustion of coal will enhance the concentration of long-lived radionuclides in the raw material which is termed as Technologically Enhanced Naturally Occurring Radioactive Materials (TENORMs). These combustion processes generate large amounts of solid residues in the form of fly and bottom ashes [4]. Considering the rapid industrialisations, the Van Eck coal-fired power plant will continue to play an important role in the medium-term energy requirement of Namibia which serves as part of a diverse energy mix to ensure the security of supply, reducing the over-dependence on imports and mitigating the diverse impacts on the balance of payment. However, the management of waste generated presents a major challenge for both the power plant and the surrounding environment [5]. Particularly, fly ash particles, entrained up the stack in the flue gas stream, have a greater tendency to absorb trace elements such as natural radionuclides during combustion owing to their relatively small size and large surface area [6, 7].

According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the combustion of coal in a coal-fired power plant can lead

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to an increased concentration of natural radionuclides in the environment through the pathways of ash deposition of non-combustible elements with enrichments factor of 5–10 times the average concentrations of the primordial radionuclides (^{40}K, ^{238}U and ^{232}Th) [8, 9]. However, with changes in environmental consciousness throughout the world, there is also a growing tendency of utilizing industrial by-products such as fly ash. The storage of waste resulting from the combustion of coal in thermal power plants can potentially lead to significant environmental and human health problems. Therefore, utilization of ashes as a secondary raw material such as an additive in concrete construction, and road construction, and asphalt's mixture has clear environmental and economic advantages [10].

However, coal-powered plants (CPPs) that produce TENORMs during their operation should be investigated from the radiological point of view as an additional radiation source. Moreover, for the utilization of these residues, it is of importance to evaluate the physical parameters, chemical composition, and radiological features of these materials. Therefore, monitoring of technologically naturally occurring radioactive materials is an important aspect from a human health and environment protection perspective. This study provides the much-needed data on, enrichment, and radiological characteristics associated with the utilization of waste as secondary raw materials.

2. Material and Methods

2.1 Sampling

The study focused on the Van Eck Coal-fired Thermal Power Plant located in the northern industrial area in Windhoek, Namibia, and is part of an extensive industrial area (heavy and light industry). The plant comprises four generating units with a combined output of 120-Megawatt (MW) per annum. The power plant uses approximately 650 kg of bituminous coal per MWh of electricity generated. The coal used is imported from neighbouring countries Botswana and South Africa based on product costs. The power station has been in operation since the early seventies and is a sub-critical thermal power plant.

2.2 Sample preparation and analysis

In this study, all samples were measured with high-purity germanium (HPGe) detector for the determination of the activities of ^{226}Ra (^{238}U), ^{232}Th, and ^{40}K. About 1000 g of coal, fly, and bottom ash samples were collected from a heap of coal waste where they are stored temporarily within the plant area using purposive random sampling. A total of fifty-four (54) samples comprising of eighteen Coal (numbered C-01 to C-18), eighteen bottom ash samples (numbered CA-01 to CA-18) and fly ash samples (numbered FA-01 to FA-18) were collected and kept in cleaned and numbered polyethylene bags. All collected samples were air-dried at ambient temperature in the laboratory for seventy-two (72) hours to ensure moisture-free samples.

2.3 Gamma-ray Spectrometry

The samples were oven-dried at 80 degrees Celsius for 12 hours to attain constant weight. The dried coal and bottom ash samples were thoroughly pulverised, sieved, and homogenised. About 600 ± 0.001 g of the homogenised samples were carefully packed in well-labelled 500 ml Marinelli beakers. To achieve secular equilibrium in the ^{238}U series (between ^{226}Ra and its daughters) and the ^{232}Th series (between ^{228}Th and its daughters), the samples were sealed hermetically to avoid (^{222}Rn and ^{220}Rn) emanation. The sealed samples were then stored for about +30 days (the equivalent of 7 half-live of ^{222}Rn) for ^{226}Ra and ^{222}Rn and its short-lived gamma-emitting decay products, ^{214}Bi and ^{214}Pb before being measured by gamma-ray spectrometry [11, 12].

The radioactivity in the collected samples was measured using a coaxial (62.80 X 64.80 mm) Canberra gamma-ray spectrometer HPGe detector Model No. GC4520 SN 10882 with 45% relative efficiency and resolution of 2.00 KeV (FWHM) at 1.33 MeV peak of Co-60 and 1.200 keV (FWHM) at 122 keV. The gamma spectrometry system was calibrated for energy and efficiency using a multi-nuclide calibration standard with an initial activity of 40 kBq homogeneously distributed in silicone matrix, which was supplied by Eckert & Ziegler Nuclitec GmbH, Germany, SN. AM 5599 and validated using IAEA NORMs reference material RGK-1, RGTh-1, and RGU-1. A computer-based Multichannel Analyser (MCA) Genie 2000 software from Canberra, Australia was used for data acquisition and analysis of gamma spectra. The samples were counted for 43200 s in a reproducible sample detector geometry and the configuration, and geometry was maintained throughout the analysis.

The 295.22 keV, 351.93 keV for ^{214}Pb and 609.32 keV, 1120.29 keV and 1764.49 keV for ^{214}Bi gamma lines were used in the assessment of activity concentration of ^{226}Ra, while 911.21 keV for ^{228}Ac, 968.97 keV and 238.63 keV for ^{212}Pb were used for ^{232}Th. The single 1460 keV Gamma-line of ^{40}K was used in its content evaluation.

The activity concentration of individual radionuclides in all samples investigated was calculated using the following analytical expression [13].

$$A(Bqkg^{-1}) = \frac{N}{\epsilon_\gamma P_\gamma T_s M} \ldots\ldots\ldots\ldots\ldots\ldots .1$$

where A is the specific activity in Bq/kg of each radionuclide in the sample, N is the net peak count rate of the resulting photo-peak, ε_γ is the detector efficiency of the specific gamma-ray, P_γ is the gamma emission probability of the corresponding gamma energy, T_s is the counting time of the sample and M is the sample mass in kg.

The error associated with every activity calculation was computed by the standard deviation equation derived from the uncertainty budget. The equal counting time for both background and sample was chosen to minimize the uncertainty in the net counts,

$$\Delta A = A\sqrt{(\frac{\Delta N}{N})^2 + (\frac{\Delta \varepsilon_\gamma}{\varepsilon_\gamma})^2 + (\frac{\Delta P_\gamma}{P_\gamma})^2 + (\frac{\Delta M}{M})^2 + (\frac{\Delta T_s}{T_s})^2} \dots\dots\dots 2$$

where ΔA is the uncertainty of the sample measured and ΔN, Δεγ, ΔPγ, ΔM, and ΔTs are the uncertainties of the net count rate, efficiency, gamma emission probability, sample weight, and counting time respectively.

2.4 Radiological assessment of bottom and fly ash as secondary raw material in construction industries

The radiological equivalence activity concentration (Ra_{eq}), the absorbed gamma dose rate (DR), annual gonadal effective dose equivalent (AGDE), annual effective dose equivalent (AEDE), activity utilization index (AUI), external hazard index (H_{ex}), internal hazard index (H_{in}), representative gamma index (I_γ) and excess lifetime cancer risk (ELCR) were computed using the following equations, respectively.

2.4.1 Radium equivalent activity (Ra_{eq})

Ra_{eq} defined based on the assumption that 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th, and 4810 Bq/kg of ^{40}K produce the same gamma-ray dose is calculated as follow:

$$Ra_{eq}(Bqkg^{-1}) = A_{Ra} + 1.43A_{Th} + 0.077A_K \dots\dots\dots 3$$

The Ra_{eq} is also used as the screening tool for radioactivity evaluation of construction materials.

2.4.2 External hazard index (H_{ex})

The quantification of the incurred radiation hazard due to external exposure to gamma-ray from the environmental sample was assessed by the external hazard index as follow:

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \dots\dots\dots\dots\dots 4$$

2.4.3 Internal hazard index (H_{in})

The radiation hazard administered to the respiratory organs from radon and its short-lived radionuclides was quantified by assessing the internal hazard index (H_{in}) as given by [14]

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \dots\dots\dots 5$$

2.4.4 Representative gamma index (I_γ)

The gamma radiation hazard due to the respective concentration of the investigated natural radionuclides was assessed by the representative gamma index. The index serves as a screening parameter for the material of possible radiation health challenges.

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \leq 1 \dots\dots\dots 6$$

2.4.5 Activity utilization index (AUI)

The natural radionuclides activity utilization index (AUI) was used to express the dose rate in the air from different combinations of the three primordial radionuclides in the studied sample. The appropriate factor to the measured specific activity of the respective nuclides was applied and the AUI was calculated from the equation [15, 16]

$$AUI = \left[\frac{A_{Ra}}{50\ Bqkg^{-1}}\right] f_u + \left[\frac{A_{Th}}{50 Bqkg^{-1}}\right] f_{Th} + \left[\frac{A_K}{500 Bqkq^{-1}}\right] f_K \dots\dots 7$$

where A_{Ra}, A_{Th}, and A_K are the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K respectively and f_u (0.041), f_{Th} (0.604), and f_K (0.462) are the respective fractional contribution from the actual activities of these radionuclides to the total gamma radiation dose rate in air.

2.5 Radiation doses

The radiation doses were calculated for total annual effective dose equivalent (AEDE), external outdoor absorbed gamma dose, and excess lifetime cancer risk (ELCR) from the radionuclides were calculated using Equations 8-10, respectively

2.5.1 Annual effective dose equivalent (AEDE)

The outdoor and indoor AEDE in mSv from the radioactivity content of the sample was calculated applying two conversion coefficients provided by UNCEAR (2000) as follow:

$$AEDE(mSvy^{-1}) = D_R(nGyhr^{-1}) \times 8760\frac{h}{y} \times \frac{10^{-6}}{10^{-9}}\frac{mGy}{Gy} \times 0.7 \times 0.2\frac{Sv}{Gy}$$

or

$$AEDE(mSvy^{-1}) = D_R \times 1.226 \times 10^{-3} \dots\dots\dots 8$$

The two conversions are the coefficient factor from absorbed dose in the air to an effective dose, given as 0.7Sv/Gy, and the outdoor occupancy factor of 0.2 based on the assumption that an individual spends on average of 80% of his time indoors.

2.5.2 Gamma absorbed dose rate (D_R)

The gamma absorbed dose rate 1 m above the air was computed as per the UNSCEAR report (2000) using the equation:

$$D_R(nGyh^{-1}) = 0.462A_{Ra} + 0.604A_{Th} + 0.0417A_K \ldots\ldots.9$$

2.5.3 Excess lifetime cancer risk (ELCR)

After the evaluation of the annual effective dose equivalent, excess lifetime cancer risk (ELCR) was estimated using the equation [13, 16]

$$ELCR = AEDE \times DL \times RF \ldots\ldots\ldots.10$$

where AEDE, DL, and RF are the annual effective dose equivalent, duration of life (70 years), and risk factor (0.05 Sv^{-1}) for stochastic effects in any given population respectively. Data obtained from this study were subjected to Pearson's correlation analysis using statistical software; the statistical package for social sciences (SPSS 22.0). This was necessary to understand and establish interdependency and mutual relationships that may exist among the measured radiological variables.

2.6 Enrichment factor

The enrichment factor (EF) defined as the ratio of activity concentration of the radionuclides [X] and ^{40}K in bottom ash or fly ash sample divided by the corresponding ratio of the feed coal sample was determined by the formula used by [16, 17] as follow

$$EF = \frac{([x]ash\ sample/40_K ash\ sample)}{([X]feed\ coal/40_k feed\ coal)} > 1 \ldots\ldots\ldots 11$$

This has the effect of normalizing the apparent enrichment resulting from the loss of carbon during the combustion process. The ^{40}K is used for the normalization process because its activity concentration remains constant in all types of fly ashes and is assumed to be a tracer for the aluminosilicate-dominated fly ash matrix.

3. Results and Discussion

3.1 Activity Concentration in Bq/kg of ^{226}Ra, ^{232}Th, and ^{40}K in Coal, Bottom ash and fly ash.

The statistical description of activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K, comprising the mean and standard deviation (SD) are presented in Figure 1 for the studied samples. Table 1 represents the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K for the present study compared to other similar work. From Figure 1 and Table 1, the mean activity concentration of 20.22 ± 3.82 Bq/kg for ^{226}Ra, 26.70 ± 5.90 Bq/kg for ^{232}Th, and 30.36 ± 6.36 Bq/kg for ^{40}K in coal samples were in accordance with the world average values and with studies of [4, 5, 9]. Meanwhile, in Table 2 the relatively enhanced activity concentration of 88.89 ± 11.91 Bq/kg for ^{226}Ra, 113.28 ± 15.44 Bq/kg for ^{232}Th and 97.84 ± 16.55 Bq/kg for ^{40}K in bottom ash, and 59.18 ± 4.55 Bq/kg for ^{226}Ra, 77.00 ± 5.89 Bq/kg for ^{232}Th, and 77.17 ± 7.30 Bq/kg for ^{40}K in fly ash samples were in agreement with studies of [9, 18].

Indeed, the study shows that the combustion of coal significantly enhances the activity concentration of the radionuclides of ^{226}Ra, ^{232}Th, and ^{40}K (Table 1). These variations in activity concentration could be attributed to the radionuclide's enrichment and volatilization before combustion due to ^{226}Ra and ^{232}Th which may have been in equilibrium in the feed coal samples. After combustion, the equilibrium state may be disturbed resulting in the disturbance of the degree of portioning of the radionuclides between the bottom and fly ash which is normally influenced by their volatility and geochemical association [19, 20].

These results further indicate the well-known pattern that uranium and its progenies are usually associated with the organic compound of coal, while thorium and its decay radionuclides together with potassium are associated with the inorganic material of coal [20]. The variations are also found in studies around the world Table 2. The activity concentration ranged from 97.3 Bq/kg (India) [21] to 1909 Bq/kg (Brazil) [19] for ^{226}Ra; from 32 Bq/kg (Turkey) [8] to 455 Bq/kg (Tanzania) [22] for ^{232}Th and 323 Bq/kg (Turkey) [8] to 3069 Bq/kg (Tanzania) [22] for ^{40}K.

Table 1: Activity concentrations (Bq/kg) of ^{226}Ra, ^{232}Th, and ^{40}K in coal with the world's average values and those of other published works

References	Coal		
	^{226}Ra	^{232}Th	^{40}K
[UNSCEAR 2008]	20	20	50
Present study	20.22	26.71	30.36
Nigeria [5]	34.18	18.18	70
Nigeria [18]	31.51	26.91	90.67
Botswana [9]	18.1	27.43	177.38
Kolo [4]	8.0	7.0	27.4

Figure 1: Mean activity concentrations in the bottom and fly ash samples.

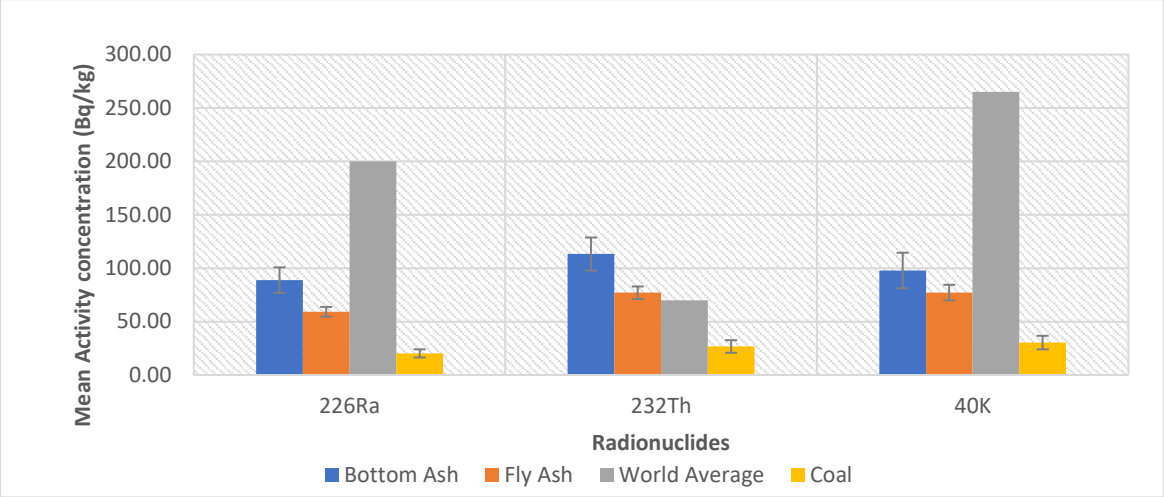


Table 2: Activity concentrations (Bq/kg) of ^{226}Ra, ^{232}Th, and ^{40}K in ashes with the world's average values and those of other published works

References	Ashes		
	^{226}Ra	^{232}Th	^{40}K
[UNSCEAR, 2008]	200	265	70
Present study	59.18	77.00	77.70
Brazil [19]	1909	58	650
Nigeria [18]	28.2	37.6	335
Botswana [9]	49.37	64.54	40.08
India [21]	97.3	107.5	315.8
Tanzania [22]	448	455	3069
Turkey [8]	815	32	323

3.2 Radiological Assessment of Bottom and Fly ash

The utilization of ashes as a secondary raw material or supplementary materials in the production of construction materials either for building or as aggregate in concrete can result in external gamma exposure to members of the public due to the presence of natural radionuclides. The radiological assessment was estimated based on human health and environmental protection perspective. Radium equivalent activity Ra_{eq} and gamma representative index I_γ were used as the screening parameters. The average activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K were used to estimate the radiological hazards. The results obtained are shown in Table 3.

The estimated values of Ra_{eq} ranged from 175.23 Bq/kg to 258.42 Bq/kg and are presented in Table 3. The average values obtained were within the world precautionary limit of 370 Bq/kg. The elevated activity concentration observed in ashes samples resulted in an estimated mean absorbed dose rate 1 m above the ground exceeding the recommended world average value of (60 nGy/y) (Figure 1). However, their corresponding total annual effective dose equivalent of 0.14 mSv/y and 0.09 mSv/y were within the public's annual effective dose rate threshold of 1 mSv/y and 20 mSv/y recommended for occupational exposure. The estimated values for AUI, H_{ex}, H_{in}, and $I_{\gamma r}$ were all comparable to the world average value of unity. In addition, the estimated lifetime cancer risk was relatively within the world safety limit of 0.05 for low-level radiation limit by the International Commission on Radiation Protection (ICRP).

The study found that the radiological indices of Ra_{eq}, I_γ, H_{in}, and H_{ex} were generally high for bottom ash than for fly ash samples. These relatively high values of Ra_{eq}, I_γ, H_{in} and H_{ex} could be attributed to the fact that when coal is combusted, most of the non-combustible material, which includes the natural radionuclides, remained, and concentrates in the bottom and fly ash thereby enhancing the Ra_{eq}, I_γ, H_{in} and H_{ex} values [17,20, 23].

3.3 Statistical analysis

Based on the data set of the activity concentrations and estimated radiation hazard indices for the studied samples, a correlation matrix was calculated and presented in Table 4-6. The results showed that there is a strong positive correlation of ($r \geq +0.66$) with radiation hazard indices and with ^{226}Ra, ^{232}Th, and ^{40}K activity for coal and fly ash samples. These results demonstrate the presence of radiation in coal and fly ash at the Van Eck power plant which is homogeneously distributed among the primordial radionuclides of ^{226}Ra, ^{232}Th, and ^{40}K. It can, therefore, be inferred that ^{226}Ra, ^{232}Th, and ^{40}K are the major contributors to radiation emissions in fly ash from Van Eck Power Plant. However, the existence of a positive correlation between ^{226}Ra, ^{232}Th, and ^{40}K may be independent of the nature of radium and thorium decay series origin. A very weak positive degree of association was observed in the bottom ash sample between $^{40}K/^{226}Ra$ (r=0.26), $^{40}K/^{232}Th$ (r=0.30), and ^{40}K ($0.37<r<0.32$) activity with all the radiation hazard indices. These results indicate that the gamma-ray emissions in bottom ash are predominantly due to the activity of ^{226}Ra and ^{232}Th activity.

Table 3: Estimated radiological hazards

Parameters	Ra_{eq} (Bq/kg)	DR (nGy/h)	AEDE (mSv/y)	AUI	H_{ex}	H_{in}	I_γ	ELCR (10^{-3})
Bottom Ash	258.42	113.60	0.14	1.53	0.70	0.94	1.79	0.48
Coal	60.55	26.75	0.03	0.37	0.16	0.22	0.42	0.11
Fly Ash	175.23	77.09	0.09	1.05	0.47	0.63	1.22	0.33
World Average	370	60	1 & 20	≤ 1	≤ 1	≤ 1	≤ 1	

Note: The ELCR world safety limit for low-level radiation is [0.05]

Table 4: Correlation relationship (95 % confidence level) of measured variables for coal samples from Van Eck power plant.

	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	DR	AEDE	AGDE	AUI	H_{ex}	H_{in}	I_γ	ELCR
^{226}Ra	1.00											
^{232}Th	0.89	1.00										
^{40}K	0.91	0.83	1.00									
Ra_{eq}	0.95	0.99	0.88	1.00								
DR	0.95	0.99	0.89	1.00	1.00							
AEDE	0.95	0.99	0.89	1.00	1.00	1.00						
AGDE	0.95	0.99	0.89	1.00	1.00	1.00	1.00					
AUI	0.91	1.00	0.86	0.99	0.99	0.99	0.99	1.00				
H_{ex}	0.95	0.99	0.89	1.00	1.00	1.00	1.00	0.99	1.00			
H_{in}	0.97	0.97	0.90	1.00	1.00	1.00	1.00	0.98	1.00	1.00		
I_γ	0.95	0.99	0.89	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	
ELCR	0.95	0.99	0.89	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00

Table 5: Correlation relationship (95 % confidence level) of measured variables for fly ash samples from Van Eck power plant.

	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	DR	AEDE	AGDE	AUI	H_{ex}	H_{in}	I_γ	ELCR
^{226}Ra	1.00											
^{232}Th	0.61	1.00										
^{40}K	0.68	0.76	1.00									
Ra_{eq}	0.83	0.95	0.82	1.00								
DR	0.84	0.95	0.83	1.00	1.00							
AEDE	0.84	0.95	0.83	1.00	1.00	1.00						
AGDE	0.83	0.95	0.83	1.00	1.00	1.00	1.00					
AUI	0.66	1.00	0.80	0.97	0.96	0.96	0.97	1.00				
H_{ex}	0.83	0.95	0.82	1.00	1.00	1.00	1.00	0.97	1.00			
H_{in}	0.90	0.89	0.81	0.99	0.99	0.99	0.99	0.92	0.99	1.00		
I_γ	0.82	0.95	0.83	1.00	1.00	1.00	1.00	0.97	1.00	0.99	1.00	
ELCR	0.84	0.95	0.83	1.00	1.00	1.00	1.00	0.96	1.00	0.99	1.00	1.00

Table 6: Correlation relationships (95 % confidence level) of measured variables for bottom ash samples from Van Eck power plant.

	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	DR	AEDE	AGDE	AUI	H_{ex}	H_{in}	I_γ	ELCR
^{226}Ra	1.00											
^{232}Th	0.85	1.00										
^{40}K	0.26	0.30	1.00									
Ra_{eq}	0.93	0.98	0.33	1.00								
DR	0.94	0.98	0.34	1.00	1.00							
AEDE	0.94	0.98	0.34	1.00	1.00	1.00						
AGDE	0.94	0.98	0.34	1.00	1.00	1.00	1.00					
AUI	0.86	1.00	0.37	0.99	0.98	0.98	0.99	1.00				
H_{ex}	0.93	0.98	0.33	1.00	1.00	1.00	1.00	0.99	1.00			
H_{in}	0.96	0.96	0.32	1.00	1.00	1.00	1.00	0.97	1.00	1.00		
I_γ	0.93	0.98	0.34	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00	
ELCR	0.94	0.98	0.34	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00

3.4 Radionuclide Partitioning in Bottom (BA) and Fly ash (FA)

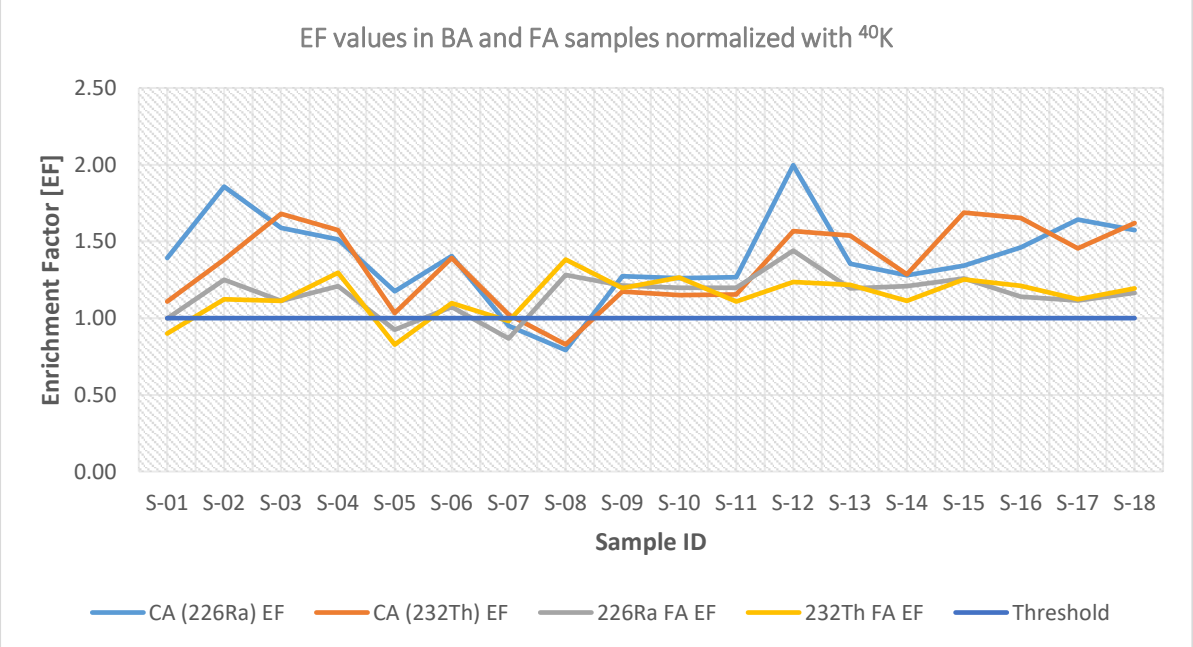
The degree of radionuclides partitioning between the bottom and fly ash due to the difference in physical and chemical characteristics and their association with the alumino-silicate in coal were determined by estimating the enrichment factor and activity concentration comparison of bottom ash and fly ash samples [24, 25].

3.4.1 Enrichment factor (EF)

The analysis showed an EF value > 1 which indicates enrichment in the ash's samples relative to feed coal. The EF values variations among the ash samples were considered the same with little differences. Generally, the EF in the FA samples is higher than the EF in BA samples however, in this study bottom ash EF values were moderately higher than those of Fly ash.

The results for ^{226}Ra in bottom ash samples further appear to indicate an increased activity concentration in the bottom ash rather than the finer fly ash as most literature suggests [25, 26] whose observation suggest that uranium and its progenies have the greatest small particle enrichment among elements that were neither lithophiles nor chalcophiles (elements associated with sulphide minerals).

Figure 3: Comparison of EFs of ^{226}Ra (^{238}U series) and ^{232}Th in the bottom and fly ash samples.

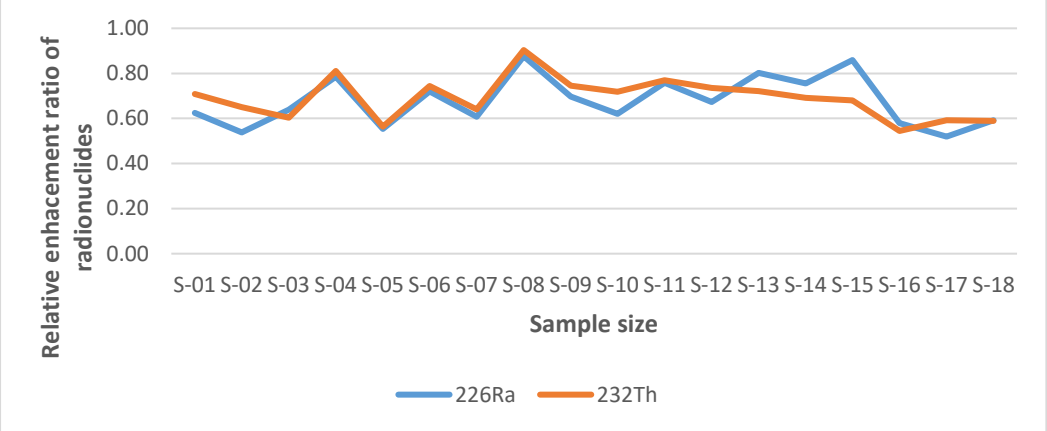


3.4.2 Relative Enhancement of Radionuclides Based on AC_{FA}/AC_{BA} Values

All the samples have activity concentration in fly ash relative to bottom ash of less than one for all the radionuclides of ^{226}Ra, ^{232}Th, and ^{40}K with the mean values of 0.68, 0.69, and 0.80 respectively Figure 4. Based on the AC_{FA}/AC_{BA} values in Figure 4, ^{226}Ra and ^{232}Th were found to be evenly partitioned and distributed between bottom ash and fly ash although they differ in their volatility with ^{226}Ra reported to be more volatile than ^{232}Th.

The relative enhancement of ^{40}K is less than one in all the collected samples which confirms its behaviour classification as readily incorporated into bottom ash and are normally partitioned between the two common waste products of combustion [17]. However, according to [6] an increase in the furnace temperature of the power plant can decrease the enhancement in bottom ash resulting in an increased enhancement in the fly ash relative to the bottom ash of the plant.

Figure 4: Relative enhancement of radionuclide activity in fly ash samples.



4. Conclusion

This study evaluated the radiological hazards associated with the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K in coal and coal combustion residues generated at Van Eck Coal-Fired power plant when used as secondary raw materials in construction industries. The results show that coal and ashes of Van Eck Power plant present high mean activity concentrations ^{226}Ra, ^{232}Th, and ^{40}K when compared to Morupule Power Station in Botswana and below that of Brazil, India, and Tanzania. However, the activity concentrations values obtained in this study, agree with other reported findings of reviewed literature in this work. As was expected, the activity of the three radionuclides was higher in the ashes samples than in the parent coal. This is because the activity concentrations accumulate when the coal is burned. The same observations were reported in coal and ashes samples reported elsewhere [9, 18, 19, 21, 22]. The statistical analysis demonstrates the presence of radiological hazards homogeneously distributed among the primordial radionuclides of ^{226}Ra, ^{232}Th, and ^{40}K in coal and fly ash, whereas for the bottom ash the radiological hazards are predominantly due to ^{226}Ra and ^{232}Th. Hence, continuous radiological screening and monitoring of the ashes utilized as a secondary raw material by other industries for any purpose whatsoever is recommended to keep the possible radiation hazards as low as reasonably achievable (ALARA). The study has provided the much-needed data on technologically enhanced naturally occurring radionuclides concentration in ashes fractions arising from Van Eck coal-fired power plant in Namibia. The results obtained in this study can serve as a baseline for further radiological studies of Van Eck Power Plant and as valuable data for the plant management and regulatory authority in waste management, drafting of policies, emission control regulations, and future developments.

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Original Research Article

Implementation of the new public procurement Act no. 15, 2015: a case study of the local authorities (municipalities) in Namibia

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ABSTRACT

This paper articulates the implementation of new Public Procurement Act (No.15, 2015) in the Local Authorities (municipalities) in Namibia. This paper explores the concept of implementation with specific focus on how the decisions and plans based on the new procurement process were executed in practice within the Local Authorities in Namibia. Quantitative questionnaires were used and the numerical data obtained was analysed and presented in the form of numbers and statistics. The major findings of this paper show that the implementation process was not successful as the municipalities and its employees were not ready for the implementation of the new Public Procurement Act (No.15, 2015). The need for proper planning prior implementation was emphasized. It was found that key factors such as leadership and management aspects, communication, training of employees should be considered before implementation. This research adds great value as it addresses the need for a proper communication of the new system and leadership development to drive and manage the implementation process. The research also contributes to the body of existing knowledge as it alludes to people, as the most intangible components of readiness and when they are not ready, the results of implementation would be negative. Recommendations were made as outcomes of conclusions drawn from the data gathered during the research and are considered to have potential for improved and successful implementation of the new Public Procurement Act within the municipalities in Namibia.

1. Introduction

Namibia has a fragile economic environment and has had the longest run of consecutive recessions since 2015. The Namibian leaders were exposed for their weakness, notably poor planning and execution. However, there is still a strong believe that these misfortunes can be turned around with better policy implementation. Therefore, the leadership and managerial qualities of those in charge of the municipalities in Namibia were put to test by the implementation of the new Public Procurement Act No.15, 2015. Implementation of the new act in municipalities was imperative to root out all corruptive and unfair practices in procurement of goods and services in order to optimize operational efficiency, which could also contribute towards growth in the economy of the country. The municipalities were established through the Local Authorities Act, No.23, 1992 to provide effective and efficient basic services to the clients as well as procurement of goods and services. Hence, the implementation of the new Procurement act in the Local Authorities was aimed at addressing the concerns with procurement and corruption in allocation of supply tenders, as well as procurement outputs, outcomes, processes, inputs, planning, stakeholders' satisfaction, and improvement of procurement service delivery at the municipality.

The new Public Procurement Act, No.15, 2015 was very crucial to ensure that the procurement guidelines and regulations are followed in each procurement process of goods and services and to eradicate corruptive practices fraught with procurement processes. Thus, the emphasis was on the principles of sound service delivery, and the application of the concept of procurement performance excellence throughout the entire municipalities. The main focus of this article is based on the notion that a systematic and thorough workplace diagnosis and documentation will

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provide the true basis for improving procurement performance at the organisational, process, and worker levels. Hence, the diagnostic approach, in the context of this study, refers to the problem defining method that takes into account the systemic nature of the municipalities (Armstrong, 2014) in terms of implementing the new Public Procurement Act (No.15, 2015). Furthermore, this research addresses the problem statement and also answer the research questions provided. The intention is that the research would lead to the development of an implementation model or plan for the new Public Procurement Act (No.15, 2015), which is appropriate for the municipalities (local authorities) in Namibia, with greater emphasis on employee buy-in and proper communication of the implementation process. Thus, this article will also contribute towards the theoretical understanding of the readiness of municipalities and its employees for the implementation. It is envisaged that the findings of this research will assist the local authorities tremendously to successfully implement the new Public procurement Act No.15, 2015 by considering various factors needed or to be in place before implementing the new procurement act and to ensure that the organisations are ready for the implementation. Successful implementation of the new Public Procurement Act, 2015 will promote integrity, accountability, competitive supply, effectiveness, efficiency, responsiveness, informed decision-making, legality and integration in the procurement of assets, works and services. Most importantly, the new Public Procurement Act (2015) put emphasis on the effective application of and compliance with some guidelines, regulations and directives.

Prior the implementation of the new Public Procurement Act No.15, 2015, all the local authorities (municipalities) in Namibia procured goods and services according to the Local Authorities Tender Board Regulations establish under the Local Authorities Act No.23, 1992. The Local Authorities Tender Board was solely responsible for the procurement of goods and services for a local authority council, for the arrangement of letting or hiring of anything or the acquisition or granting of any right on behalf of a local authority council. The Local Tender Board was also responsible for inviting tenders, enter into agreements, and also determine the manner in which such tender must be submitted (Local Authorities Act, No.23, 1992). This system did not operate effectively as it was more open to corruptive practices. As a response to this situation and to ensure more efficiency and effectiveness in procurement processes, the Ministry of Finance establish the new Public Procurement Act (No15, 2015), which includes procurement guidelines and regulations to be applied by all the State Owned Enterprises or the public sector. Therefore, and in compliance to these guidelines and regulations, the municipalities could strive to improve efficiency and effectiveness in the procurement process within the organization, which could more dramatically lead to changing the fundamental way in which the procurement process is done.

Considering the current trends in the procurement process of goods and services in Namibia, the research intends to unearth certain strategies and pre-conditions for successful implementation by seeking answers on the following research questions:

- Do the employees have the necessary skills and competencies to implement the new Public Procurement Act (No.15, 2015)?
- What are the challenges faced by the employees and employer during the implementation the new Public Procurement Act (No.15, 2015)?
- What are the most contemporary approaches and strategies for successful implementation?

The answering of these questions requires a holistic investigation into the implementation of the Public Procurement Act (No.15, 2015). Hence, the core research question is whether the municipalities are ready for the implementation of new Public Procurement Act No.15, 2015 and the key mechanisms in place to ensure successful implementation of the new act.

2. Research methodology

2.1 Research design

The research design for this article is based on the logical sequence that connects the empirical data to the paper's research question, and ultimately, to its conclusions. Hence, in considering an appropriate design and methodology, a quantitative approach best fit the aims of this research. A number of variables and constructs were identified and operationalise, and the research was done in a number of stages. The first stage deals with an intensive literature review; secondly, a quantitative study questionnaire, based on the research questions and problem, were developed to ensure that the research problem and questions are answered. The third stage is based on the administration of the questionnaire in the wider sample, under controlled circumstances. It means that this research is quantitative in nature because the focus is also on the numerical data for analysis of a sample of which the results were inferred from a larger population, and the findings are generalizable. Thus, the research is based on studies that describe events and studies aimed at discovering inferences or causal relationships, which is the essence of quantitative research design. The quantitative method was applied and involve the objective measurement of data

(Msweli, 2011). The population of this study consisted of the current 94 employees in charge with procurement of goods and services at three Local Authorities namely Windhoek Municipality, Usakos Municipality and Karibib Town Municipality. 5 people were selected from the internal Procurement Committee; 5 people from the Bid Evaluation Committee; and 6 people from the other departments who are also dealing with procurement matters as indicated in Table.1. These people are representing various departments such as Human Resources, Transportation, Infrastructure, Economic Development. Hence, the total number of people sampled or selected are 42 in total, which is a small representative number of the total population, which is studied. It means that in determining the size of the sample (n), the researcher first considered the size of the population. In general, it holds that the smaller the total population, the relatively larger the sample should be to ensure satisfactory results.

Table 1: Sample of the participants

	Job Title	Number	Department
1	Manager/Supervisor	2	Finance
2	Sourcing Specialist (Buyers)	12	Finance
3	Senior Storeman/Storeman	12	Finance Transportation
4	Officer Procurement/Tender Administration	6	Finance Infrastructure Economic Development
5	Members of the Procurement Committee	5	Finance Human Resources Transportation Economic Development
6	Members of the Bid Evaluation Committee	5	Finance HR Transportation Economic Development
Total:		**42**	**5**

The desired sample size does not only depend on the size of the population but also on the variance of the variables. As a general rule the larger the variance of the variable, the larger the sample, which is required (Msweli, 2011). Probability sampling method was applied, which means that there was a probability that any element or a person in the population was included in the sample. Then simple random sampling was also employed to ensure that all employees stand equal chance of being selected to avoid sample bias and to ensure that the results are reliable enough to be generalized (Creswell, 2013).

2.2 Data collection instrument

The researcher used questionnaires to collect the data from the respondents. The questions were mainly based on the research question and/or problem in order to help test the research hypothesis. The questionnaire consisted of five sections, based on personal particulars (questions 1.1 -1.7), organizational readiness for implementation (questions 2.1 – 2.5), implementation planning (questions 3.1 – 3.6), leadership and management of implementation (4.1 – 4.4) as well as best practices in implementation (questions 5.1 – 5.4).

2.3 Data collection procedure

Data collection process was quantitative in nature as the questionnaires were used to collect the relevant data on the research topic or problem and the research questions and also to evaluate the feelings and attitudes of the employees towards the implementation of the new Public Procurement Act No. 15, 2015 in the Local Authorities. The questionnaires were distributed to 42 employees in total to provide answers on the implementation of the new Public Procurement Act no. 15, 2015 at the Local Authorities in Namibia. The data was collected from 2 Managers/supervisors, 12 Sourcing Specialists (Buyers), 12 Senior Storeman/Storeman, 6 Officers dealing with procurement matters and tender administration, 5 members of the Procurement Committee, and 5 members of the Bid Evaluation Committee. The participants completed and returned all 42 questionnaires promptly. The researcher edit and check the data collected The data collected for completeness, consistency and reliability. The next

step was to involve coding the responses in the coding sheets by transcribing the data from questionnaire by assigning characters symbols (numerical symbols).

2.4 Data Analysis

The data collected was organized in such a way to assess and evaluate the findings and to arrive at some valid, reasonable and relevant conclusion (Sarantokos, 2011). The responses to the questions on the questionnaire were analysed using frequency tables, charts, and simple percentage method. The researcher also used quantitative data analysis techniques to analyse data collected for this study. The researcher inspected, cleaned, transformed and modelled the data collected to discover useful information for conclusions and to make recommendations. This process included classifying, coding, and tabulating information needed to perform quantitative analysis. It means that the raw data was ordered and organised so that useful information could be extracted from it.

The researcher used SPSS (Statistical Package for the Social Sciences) to analyse the quantitative data collected from the respondents. The data was converted into percentages and collated in the form of tables, graphs and figures to make the data presentation meaningful. It means that the researcher prepared and checked the data and input it into the computer. SPSS software was used because it helps the researcher to derive conclusions and predict the future easily with minimum statistical deviation. Dale (2010) argues that the implications of the results are fairly evident and are statistically valid. SPSS provides a thorough *data* management, because when it comes to organizing and managing your *data*, the *SPSS* software offers the user a lot of control.

2.5 ethical considerations

All participation was voluntary and participants could withdraw at any stage. The researchers did not ask for personal details and did not know the identity of respondents. This voluntary process did not infringe on the rights of any respondents.

3. Results

3.1 Respondent characteristics

Figure 1 represent the percentage distribution of the respondents by department where they work in and sex and it shows that the majority of the respondents are working in the Finance department (61.9%), followed by the Economic Planning department (14.3%). About 7 percent of the respondents are working in the Human Resource department. More female respondents (64.3%) are working in the Finance department compared to male respondents (61.9%). Furthermore, more female respondents (14.3%) are working in the Transportation department compared to male respondents (7.1%).

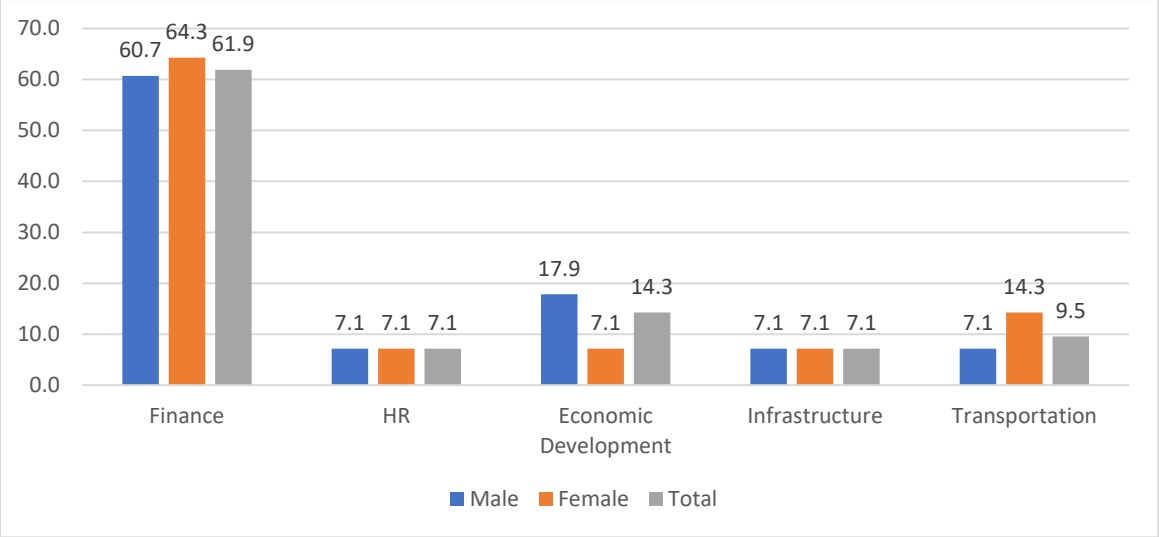

Figure 1: Respondents by department and sex

The majority of the respondents (59.5%) are employed in the procurement division, while only 7.1 percent of the respondents are employed in the Staffing and Remuneration division. More females (64.3%) compared to males (57.1%) are employed in the procurement division. More males compared to females are employed in the water and land delivery division, with 10.7 percent and 17.9 percent, respectively.

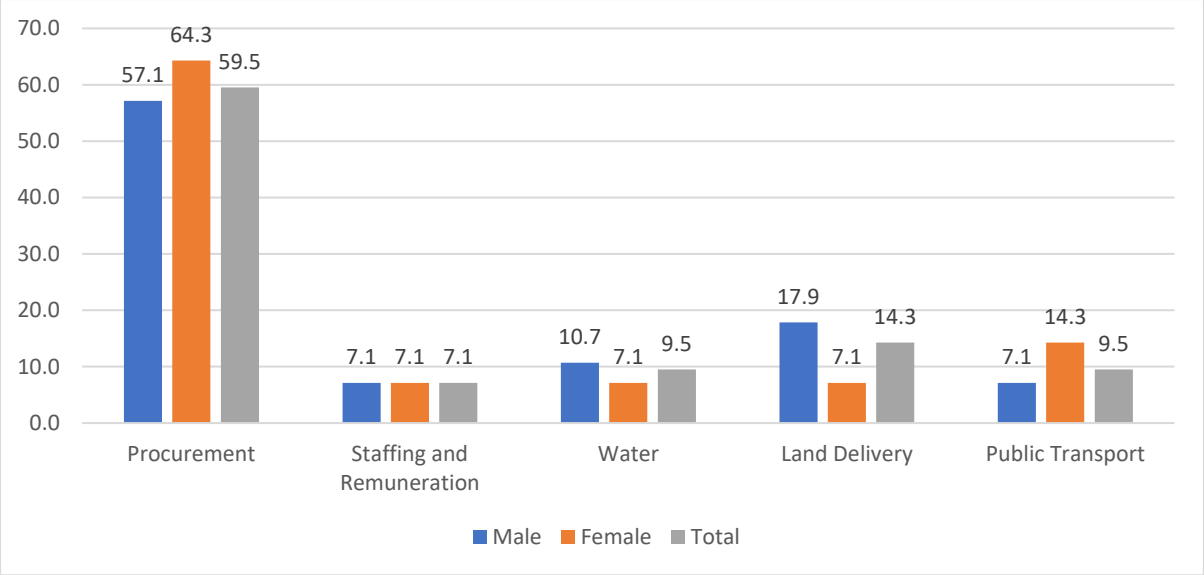

Figure 2: Respondents by division and sex

Figure 2 shows that 28.6 percent of the respondents reported that their job title is Senior Store man or Store man and Sourcing Specialist, whilst only 4.8 percent of the respondents reported that their job title is Manager or Supervisor.

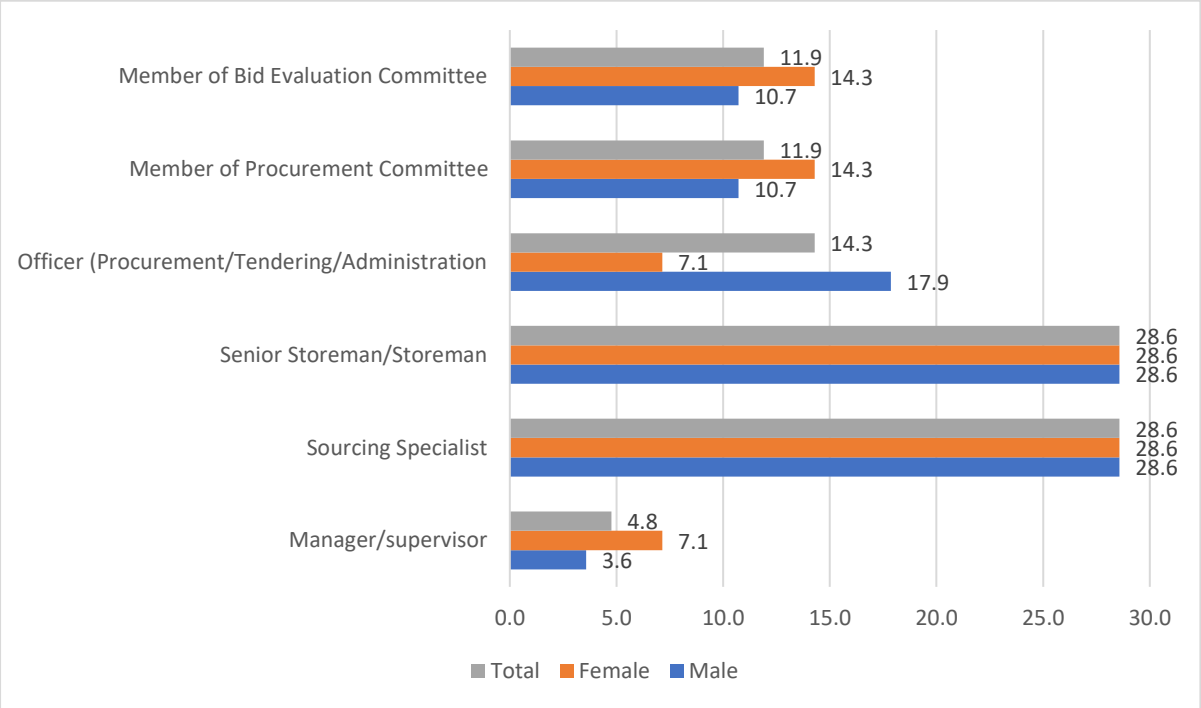

Figure 3: Respondents by job title and sex

Figure 4 shows that 38.1 percent of the respondents revealed that they are having a B-degree as the highest academic qualification, followed by grade 12 (35.7%). Equal proportions (35.7%) of female and male respondents are having grade 12 as the highest academic qualification. More females (28.6%) compared to males (17.9%) are having a diploma as the highest academic qualification.

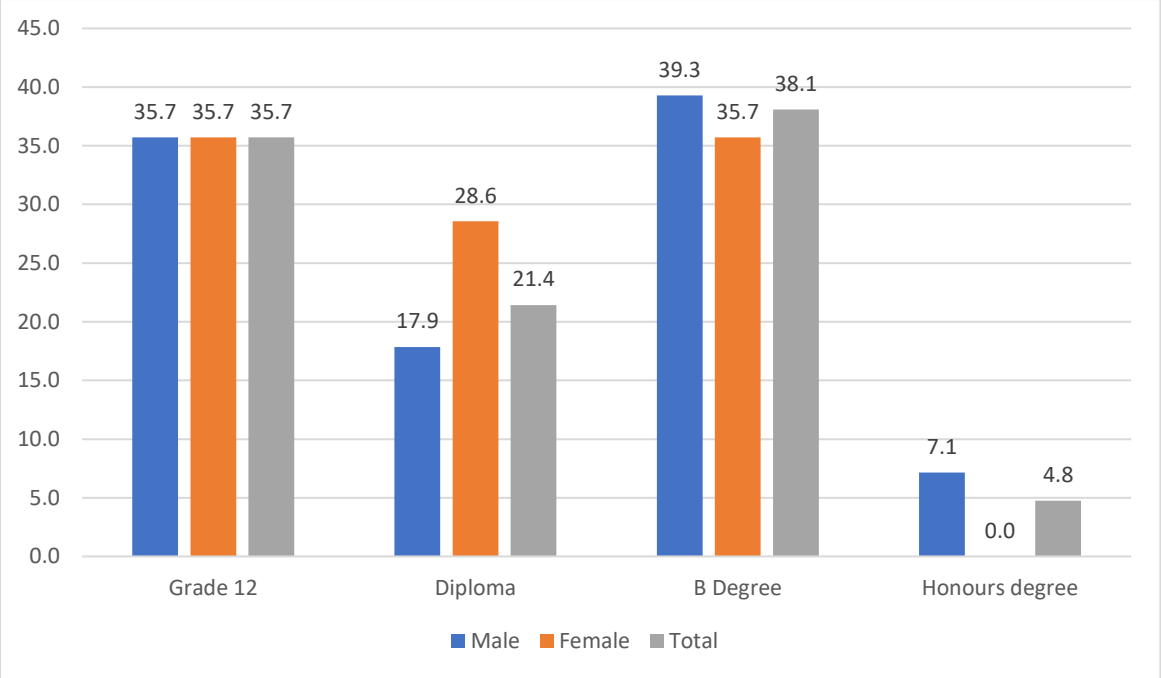

Figure 4: Respondents by academic qualification and sex

Figure 5 illustrates that a majority of the respondents, 42.9 percent reported that the worked 6-10 years at their organization., while only 4.8 percent of the respondents indicated that they worked one year and below at their organization. More female respondents (57.1%) compared with their male counterparts (35.7%) stated that the worked 6-10 years at their organization.

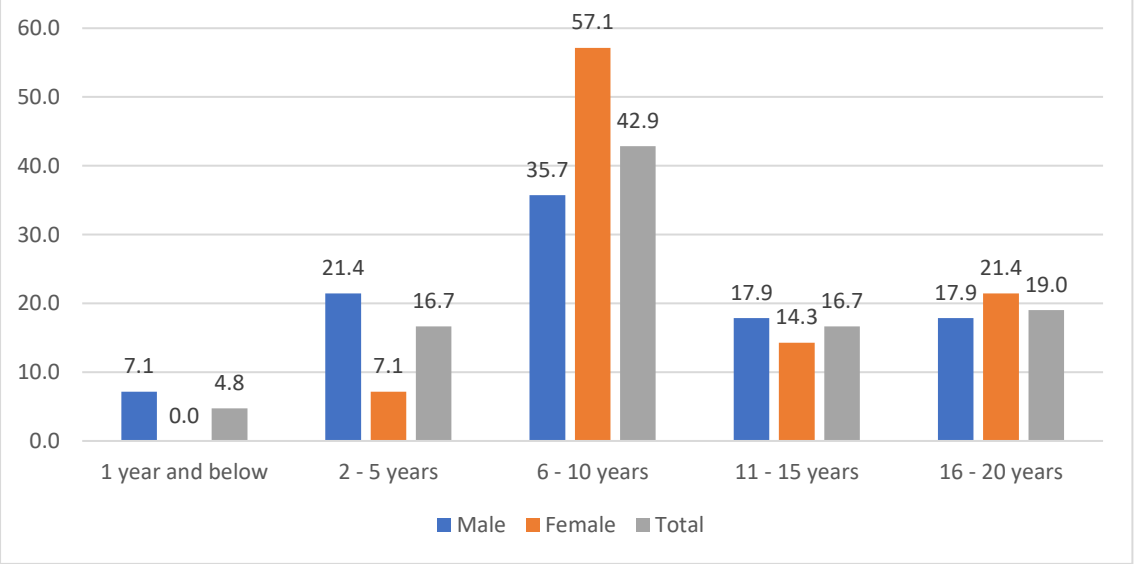

Figure 5: Respondents by number of years employed and sex

3.2 Organisational readiness for implementation of the new Public procurement Act

The researchers found that more than 52 percent of the respondents disagree that training was received by employees on the new procurement process, information was shared on implementation of new system with all the employees, employees know their roles in implementation of new Public Procurement Act and that they are ready for implementation of the new Public Procurement Act. About 52 percent reported that they do not know whether the implementation of the new Public Procurement Act was accepted by all employees (See Table 2). The literature reviewed revealed that people should be developed and trained to understand every aspects of

change process and what is intended to be achieved with the implementation of a change initiative. Prosci (2013) proposed that training and coaching should be provided to create knowledge about how to change.

Table 2: Summary of respondents' perception on organizational readiness for implementation

ORGANISATIONAL READINESS FOR IMPLEMENTATION	Strongly disagree	Disagree	Do not know	Agree	Total
	%	%	%	%	%
Training received by employees on the new procurement process	38.1	57.1	4.8	0.0	100.0
Information sharing on implementation of new system with all the employees	40.5	52.4	7.1	0.0	100.0
Employees know their roles in implementation of new Public Procurement Act	26.2	59.5	11.9	2.4	100.0
Are you ready for implementation of the new Public Procurement Act	21.4	59.5	9.5	9.5	100.0
Is the implementation of new act accepted by all employees?	16.7	31.0	52.4	0.0	100.0

It is believed that an ability to implement the change on a day-to-day basis and reinforcement to keep the change in place is critical to ensure successful change management, as described in chapter two. In contrast, it is evident from the data collected that a vast majority of respondents (95.2%) never received any training on the new Public Procurement Act (No.15, 2015) that would ensure successful implementation of the new procurement guidelines and regulations. The literature reviewed indicates that the managers should also have a complete understanding of the need of change and know the type of change required to be able to best communicate it with the employees and manage their teams through the change process. This would also enable the managers to convince the employees about the new challenges of the implementation of the new regulations and guidelines (Kok, 2011). However, the data collected also revealed (92.9%) that there was no information of the implementation of the new system with all the employees before or as part of the implementation. The data collected also revealed that a vast majority of respondents (85.7%) (26.2% strongly disagree and 59.5% disagree that the employees know their roles in the implementation of the new Public procurement Act.

It is evident from the literature reviewed that change readiness is the best early indicator of what lies ahead as well as the legacy of change initiatives in terms of scars left by successful and unsuccessful initiatives (Bridges, 2012). In contrast, the data collected also revealed that a vast majority of the respondents (80.9%) indicated that they are not ready for the implementation of the new Public Procurement Act. Moreover, the literature reviewed disclosed that change leaders must support the change efforts by creating sense of urgency in the organisation, building a team that can guide the change process, continually communicating the need for change and then empowering people to carry out the required change efforts (Bennis, 2010). The data collected shows that most of the respondents (52.3%) do not know whether all the employees accepted the implementation of new Public procurement Act, whereas 47.7% indicated that they disagree that all the employees accepted the implementation.

3.3 Implementation planning

Table 3 illustrates that a half of the respondents (50%) reported that they do not understand the new Public Procurement guidelines, regulations and procedures. Close to three out of five respondents revealed that they are not familiar with the content of the new procurement procedures and regulations. About 40 percent of the respondents indicated that they do not know their role in the implementation of new Public Procurement Act. About 66 percent of the respondents revealed that there are new skills and resources required for effective implementation of the new Public Procurement Act. Slightly more than a third (33.3%) reported that is no implementation plan in place to guide entire process. About 71 percent of the respondents indicated that they face challenges in implementation of new system.

It is evident from the data collected that a vast majority of respondents (78.6%) do not understand the new Public Procurement guidelines, regulations and procedures. People need clear direction and understanding of what the organisation is trying to achieve and what role they play in making it happen (Hale, 2014). Therefore, a leader should be able to communicate a clear picture of the change initiative and help people to see those images so that they can feel and experience change process. In contrast, the

data collected revealed that a vast majority of respondents (83.3%) are not familiar with the content of new procurement procedures and regulations.

Literature reviewed revealed that effective system should be in place as well as appropriate accountability, reporting systems, information and authority, and resource allocation for successful change implementation (Carnall, 2016). In contrast, the data collected revealed (81%) that that there are insufficient skills and resources to ensure successful implementation of the new procurement guidelines and regulations.

Table 3: Summary of respondents' perception of implementation planning

IMPLEMENTATION PLANNING	Definitely not	No	Uncertain	Yes	Yes definitely	Total
	%	%	%	%	%	%
Do you understand new Public Procurement guidelines, regulations and procedures	28.6	50.0	0.0	19.0	2.4	100.0
Are you familiar with the content of new procurement procedures and regulations?	23.8	59.5	0.0	14.3	2.4	100.0
Do you know your role in implementation of new Public Procurement Act?	16.7	40.5	28.6	14.3	0.0	100.0
Are there any new skills and resources required for effective implementation?	2.4	2.4	14.3	66.7	14.3	100.0
Is an implementation plan in place to guide entire process?	33.3	33.3	31.0	2.4	0.0	100.0
Do you face any challenges in implementation of new system?	2.4	7.1	16.7	71.4	2.4	100.0

The literature reviewed put emphasis on the proper planning of change process, implementation timing, commitment of employees and leadership as well as consideration of various business components such as structure, culture, vision, strategy and mission. All these factors were identified as challenges, which are the main causes of poor implementation of any change initiative within an organization. In contrary, the data collected indicates (66.6%) that there is no implementation plan in place within the organization to guide the entire process of implementing the new public procurement act. The data collected shows that a vast majority of respondents (73.8%) indicated that they face any or more challenges in implementing the new system compared to the previous system.

3.4 Leadership and management during implementation

The researchers found that more than three out of five respondents revealed that the management have no clear vision of the new Public Procurement Act, they do not receive any support from top management during implementation process and they do not think the implementation of the new Public Procurement Act is well-planned. About 57 percent of the respondents reported that there are no people who are drivers of the implementation process.(See Table 4).

Table 4: Respondents perception on leadership and management during implementation

LEADERSHIP AND MANAGEMENT DURING IMPLEMENTATION	No	Uncertain	Yes	Total
	%	%	%	%
Does the management have a clear vision of the new Public Procurement Act?	61.9	23.8	14.3	100.0
Are there any people who drivers of the implementation process?	57.1	19.0	23.8	100.0
Do you receive any support from top management during implementation process	61.9	21.4	16.7	100.0
Do you think the implementation of new Public procurement Act is well-planned?	66.7	23.8	9.5	100.0

Stensgaard (2007) cited that a clear change vision and strategy should be created for the organisation, because without if the change efforts would be futile, which was also construed as the main responsibility of the leadership. It is in this context that Amanto (2009) cited that a leader must set strategic direction for the organisation and align organisational goals with the vision. The lack of vision by leaders at the City of Windhoek was also expressed by most of the respondents (61.9.%). The researchers found that this could be attributed to the lack of a change vision. Implementation of the new Public Procurement as a change initiative is pivotal to the strategy of the organisation and to ensure readiness is prudent (Canterucci, 2008). The vision and mission statements are the foundations of successful change, and the strategic plan is the roadmap to achieve the vision and mission. Hence, without it the change initiative and its implementation will certainly prove useless. According to the data collected, most of the respondents (57.1%) indicated that there are no people driving the implementation process of the new system. The literature reviewed revealed that an important aspect for a leader to manage change, as described in chapter two, is to facilitate the process of associating more pain to not changing and to associate pleasure to changing. It means that a leader must have a clear vision of the change process, and be able to effectively drive, communicate and show commitment to the change process in question (Amanto, 2009). It is evident from the data collected that a vast majority of respondents (61.9%) did not receive any support from the top management during the implementation of the new procurement system. 21.4% of the respondents are uncertain about the top management support during this process. Amonto (2009) contended, as described in chapter two, that the best way of involving employees in a change process is through empowerment, encouraging employees to share and provide new ideas, and to make sure that the reasons behind the change are well - communicated and easily understood by each member of the group.

The data collected revealed that most of the respondents (66.7%) agreed that the implementation of new Public Procurement Act No.15, 2015 was not planned very well, whereas 23.8% indicated that they are not certain whether the implementation was well planned. The literature reviewed indicates that the change process should be planned with the main objective being to get support and buy-in from the employees and all the stakeholders. In this context, D'Ambrosio's (2007) proposed that the planning of change should be structured in such a way to include a logical thought process, which will also address both the external and internal environments and looks at the past, present and future. D'Ambrosio (2007) maintains that all the stakeholders would be taken into consideration and the focus would be on meeting the needs of the organisation's various stakeholders.

3.5 Best practices for effective implementation process

Table 5 shows that 35.7 percent of the respondents revealed that they never communicate the new system with the fellow employees. About 54 percent of the respondents indicated that they are often excited about the new skills and knowledge to be learned. More than 42 percent of the respondents revealed that they rarely encourage other employees to give support to the new system. About 66 percent of the respondents reported that they are willing to support implementation of new act. The data collected reveals that most of the respondents (35.7%) never communicate the new procurement system with fellow employees, whereas 7.1% respondents indicated that they rarely communicate the new system with fellow employees. Only 26.2% of the respondents indicated that they communicate sometimes the new system with fellow employees, whereas 28.6% respondents often communicate it with the fellow employees. The remaining 2.4% agreed that they always communicate it with the colleagues. Employees should have a conceptual understanding of what the new Public procurement Act entails and how they can benefit from such a new system as advocated by Hale (2014). Kok (2011) and Van Tonder (2011) echoed this view and contended that without communication change cannot happen and that people should understand its' purpose to enable them to perceive change as valid and relevant. Lorenzi and Riley (2008) contended that enhanced communication on change initiatives within the organisation will ensure a continuous dialogue between the manager/supervisors and subordinates, which would be open, direct, deliberate, and respectful and based on shared change responsibility and new ideas. Thus, the management, employees and the change agents should commit to and take responsibility for working out change related problems together, understand each other, and use communication skills necessary to do so through purposeful discussion (Lockett, 2011).

Table 5: Respondents perception on best practices

BEST PRACTICES	Never	Rarely	Sometimes	Often	Always	Total
	%	%	%	%	%	%
Do you communicate new system with the fellow employees?	35.7	7.1	26.2	28.6	2.4	100.0
Are you excited about new skills and knowledge to be learned?	11.9	14.3	11.9	54.8	7.1	100.0
Do you encourage other employees to give support to the new system?	11.9	42.9	9.5	28.6	7.1	100.0
Are you willing to support implementation of new act?	0.0	0.0	4.8	66.7	28.6	100.0

However, the data collected revealed that 11.9% of the respondents never encourage the other colleagues to give support to the new system. 42.9% of the respondents indicated that they rarely encourage the others. 9.5% of the respondents sometimes encourage other employees to support the new system, whereas 28.6% respondents often encourage other employees. The remaining 7.1% respondents agreed that they always encourage other employees to support the new system.

The data collected shows that all the respondents are willing to support the implementation of the new Public Procurement Act No.15, 2015. However, the data collected indicates that 4.8% respondents are sometimes willing, 66.7% are often willing and 28.6% of the respondents are always willing to support the implementation of the new act. Robbins et al. (2014) and Nickols (2013) underpin the notion of making people willing to be a part of change process by referring to various approaches to managing organisational change, namely, unfreezing the status quo, movement to a new state, and refreezing the new change to make it permanent. It means that people should be moved to the new culture, and reluctant people should be driven away through "unfreezing" the status quo and institutionalising the new state (Robbins et al., 2014).

4. Conclusion

Reflecting on the data collected and discussions of the findings in the previous chapter and as an outcome of this study, it has become evident that the problems surrounding the change readiness of the Local Authorities in Namibia for successful implementation of the new Public Procurement Act as well as the pre-conditions for change cannot be dealt with in isolation. All these elements are the main determinants for successful implementation of the new Public Procurement Act (No.15, 2015) within the organisation. Thus, a focus on one aspect is not sufficient to ensure successful implementation of Public Procurement Act (No.15, 2015) within the organisation, as also concluded and summarised in this chapter. The concern was raised that people do not understand the new procurement process as well as the procurement regulations and guidelines, and that the employees are not familiar with the content of the new act. A need has arisen to encourage the management to develop a clear vision of the change process and to drive the process. It is evident from the data collected that the Local Authorities are not yet ready to implement the new Public Procurement Act (No.15, 2015), and that the employees have negative feelings towards the implementation of the new act. However, there is no doubt that the employees are willing to be a part of the change process, provided that if the change process is planned, managed and communicated well to ensure that all employees affected understand and buy-in to the change process.

5. Recommendations

The recommendations made are based on the research question, which emerged through this inquiry on the implementation of the new Public Procurement Act, No.15, 2015 at the City of Windhoek municipality. The researcher believes that these recommendations would lead to the improvement of the implementation process, in general, and to the successful implementation of the new Public Procurement Act, No.15, 2015 within the City of Windhoek municipality, in particular.

1. Before implementation of the new Public Procurement Act, No.15, 2015, there is a need for stakeholder management whereby stakeholders should be identified and their roles and responsibilities should be communicated clearly (Bennis, 2010). This involves conducting stakeholder impact analysis to address the concerns, challenges, risk and assumptions perceived by the stakeholders. Hence, an action plan must be produced with specific responsible people assigned thereto and be monitored both for the execution and ongoing awareness.

2. As proposed by Lockett (2011), a communication strategy must be developed to ensure that the information provided are aligned with the project goals, organisational objectives as well as the vision and mission of the organisation. This strategy would also include a communication plan, which must identify the milestone communication interventions as well as roles and responsibilities of all the parties involved in the change process. It means the communication plan would contain information on when do we communicate, what is the content, how will we deliver the communication – medium and who is responsible for the content and the delivery thereof.
3. As proposed by Flanagan and Finger (2012), the ideas on implementing new Public Procurement Act, No.15, 2015 should be sold within the organisation and in selling ideas, the seller should know what he/she wants, double-check everything, consider current circumstances, highlight the benefits, be prepared for the objections, make your ideas their ideas, get an agreement early on in the process, solicit the support of colleagues, prepare for a simple and effective presentation, check timing and sequence, and check your fallback position.
4. It is recommended that success factors for implementation of new Public Procurement Act, No.15, 2015 should be indicated and workshop conducted with the relevant role players. This would enable the stakeholders and those concerned with the change process to get a clear understanding of the change vision, mission and strategy as well as the deliverables to be achieved through the change process.
5. All the stakeholders should participate in building a case for change, which must be a collaborative view of the goals of the change initiative and be communicated as such. Divided views and non-aligned communications will send confused messages to employees and present management as divided rather than together (Canterucci, 2008). Divided opinions and messages are a sure indicator for failure of change initiatives. Thus, all the stakeholders should have a common understanding of why change, what change is needed, what should not be altered, what is the best way to make change vision a reality, and what change strategies are unacceptable and what is acceptable (Bennis, 2010).
6. Change readiness assessment should be done before implementation of new Public Procurement Act, No.15, 2015 to identify culture, areas of concern, buy-in status for change management, and to suggest actions to manage concerns. Focus groups can be established or surveys or one-on-one interviews can be conducted to achieve this.
7. Adequate human resources should be allocated to serve as change agents and being developed to be able to facilitate the change processes. They should be able to conduct a change impact assessment in order to identify risks and impact of change on people and business, and subsequently implement an action plan to manage the impact of change (Kelman, 2010).
8. There is need for leadership development and capacity building to enable and encourage strong change leadership in order to ensure that the change initiatives are driven by the line management and championed by the most influential people within the organization (Lockett, 2011).
9. It is crucial to consider the resources allocated as well as the organisational structure for role mapping, and to identify and map new roles and responsibilities to all roles players of the change initiative. This would also involve development and implementation of workforce transitioning plan, which would include identification of skills and competency gaps, training, education, competency feedback, results, implementation of development requirements, and development of continuity plan (Nickols, 2013).
10. Pre go-live preparation has to be conducted, which is a readiness audit in order to determine the progress/status of risk and change management on people and to resolve any outstanding issues before go-live. Pre go-live audit report could be compiled (Hale, 2014). The next step would be go-live (implementation) and be based on marketing (announcement of support process, present people who will provide support and present the final product), support (ensure that support plan is in place and everyone knows about the change and role players), and monitor and measure (monitor results and measure success of the implementation) (Hale, 2014).
11. There is a need to conduct audits within the City of Windhoek municipality to determine the success of the implementation and any new issues that have arisen. Thus, it is important to continue the success journey after the implementation and to perform intermediate system-user audits (Amanto, 2009). This would enable the change agents within the organisation to understand the challenges of the user-system. Hence, it is also recommended that change agent should continue to be visible and pro-active.
12. Change in any organisation happens on business dimension (business need for change) and people

dimension (critical success factor), and successful change can only happen when both dimensions of change occur simultaneously. Therefore, ADKAR model (awareness, desire, knowledge, ability and reinforcement), which is the underlying framework for change initiatives can be used within the City of Windhoek municipality to identify why changes are not working. This model can help to break down the change into parts, understand where the change is failing and address that impact point (Canterucci, 2008).

13. Change architecture is one of the most fundamental aspect and a cornerstone strategy for the implementation of a PMS at the City of Windhoek municipality. Therefore, it is proposed that a change architecture should be considered before implementing a PMS, because it is concerned with setting arrangements, systems, resources and processes through which to engage people in "productive reasoning"' focused on creating a new future (Greenly & Carnall, 2013).
14. Chapman (2006) contended that the best way is to concentrate on developing people from the inside out, which means facilitating learning and not imposing training, which implies putting skills into people. Therefore, employees at the City of Windhoek should be trained and educated to understand fully change initiatives, which would ensure successful implementation.
15. It is advised that the development of the employees should be encouraged and noted that people learn in different ways, which means that they need to be given a choice as they have own strengths and potential, waiting to be fulfilled (Robbins, 2010).
16. Business coaching is defined by Letsoalo (2007) as a systematic practice of developing and perfecting efficient business skills in order to improve performance and productivity of the organisation. Therefore, it is recommended that the management of the City of Windhoek municipality be steered during coaching towards achieving significant results in the organisation through successful implementation of change initiatives.

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Original Research Article

Facebook as a Learning Support Tool for NSSCO Physical Science Grade 12 Learners in Selected schools in the Oshikoto Region, Namibia

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ABSTRACT

Facebook remains a popular social media application for Namibian youth (Peters, Winchiers-Theophilus & Mennecke, 2015). Thus, it is important to investigating using Facebook as a support tool for academic performance. The purpose of the study was to explore whether Facebook has the potential to support learning and mastery of Physical Science content to improve learners' academic performance on the topic of stoichiometry at Grade 12 level in selected schools in the Oshikoto Region. The study uses a quasi-experimental design with pre-test, Facebook intervention with experimental group and post-test. The results show there exists a significant difference in favour of the experimental experimental group's score marks when Facebook was used as a learning support tool. Furthermore, data from the study revealed anecdotal evidence of learner collaboration and communication. The relevance of this study shows that teachers should embrace a pedagogy of using Facebook to support learning outside of the classroom.

1. Introduction

Social media allows users to create online communities and to share various forms of media content such as: pictures, video, ideas, personal messages, and other sources of information (Kaplan & Haenlein, 2010). In Namibia, the use of Facebook increased various web-based interactions, such as maintaining contact for friends and relatives, allowing people to conduct business, learn new skills and get updated with daily news (Peters, Winschiers-Theophilus & Mennecke, 2015). Among all the social media sites, Facebook has become the most commonly used application to support interpersonal interactions, communications, entertainment, and social bonding among its users (Jonson, 2014). Similarly, 80% of Namibian university students indicated Facebook as the social media of choice (Peters, Winchiers-Theophilus & Mennecke, 2015).

A belief that technology positively impacts the students' learning has led to the Namibian government creating programs for ICT integration at schools, intended to strengthen 21st century skills of critical thinking, lifelong learning, and social responsibilities (Bingimlas, 2009). Furthermore, it is important for the Namibian educational systems to seek innovative learning methods that integrate the use of supportive technologies for the purpose of mastery of content, development of critical thinking, communication, collaboration and creativity (Partnership for 21st century learning, 2016).

The Oshikoto Region in Namibia is a heterogeneous region which consists of 8 school circuits that comprise various secondary, combined and primary schools. The Oshikoto Educational Region is a multicultural region with learners from different geographical locations, backgrounds, financial status, and levels of access to technology. Social media and technology is accessible in some schools in the region through the use of school computer labs or through the use of personal mobile devices. Even though cell phones and personal devices are not permitted in Namibian schools, learners have access to them after school when they are at home or during holidays. It is against this background that the purpose of the study was to explore whether Facebook has the potential to support learning and mastery of Physical Science to improve learners' academic performance on

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the topic of stoichiometry at Grade 12 level in selected schools in the Oshikoto Region.

1. 1. Statement of the problem

Academic failure is not only frustrating to the learners and the learners' parents, but it affects the society in terms of resulting in a lack of manpower in all spheres of the economy (Aremu, 2000). In addition, teachers whose subjects performed well are awarded prizes at regional and circuit levels, while teachers whose subjects performed poorly are labelled by learners and parents as the reasons why learners could not go to institutions of higher learning. Just like other learning support systems such as tutoring and studying in groups, Facebook can enhance learners' understanding of subject content and it can be a learning environment where 21st century skills such as collaborative learning, communication, critical thinking and creativity are developed (Partnership for 21st century learning, 2016).

In a recent study of Facebook used by Namibian youth, the prevalence of Facebook usage was 80% with an average of 2.6 hours per day active time on Facebook (Peters et.al, 2015). It was found that 23% of Namibian youths' time was used for updating their Facebook status (Peters et.al, 2015). The Namibian youth perceived Facebook as more fun and less expensive than SMS/texting. The study further revealed that the learning component was of less importance to Namibian youth; however, this could simply be because it is not commonly used as a learning support system (Peters, Winschiers-Theophilus & Mennecke. 2015).

The 2016/2017/2018 Directorate of National Examinations and Assessments (DNEA) examination reports indicated that the overall performance in NSSCO Physical Science was poor. From the list of questions reported in the 2017/18 report, when matched with the question paper, it was clear that Stoichiometry is one of the areas of poor performance. The common difficulties identified on the topic are: Learners finding it difficult to write correct chemical equations or formulae (DNEA examiner reports, 2016, 2017 and 2018). The above-mentioned examination reports further indicated that most students have trouble finding the difference between the bonding forces (Intramolecular, Intermolecular, and Electrostatic), strength of bonding forces, and between ions, electrons and atoms. These difficulties can be reduced through discussions, pictures and video sharing on Facebook.

Given the rationale indicated above, Facebook could be an inexpensive, accessible and effective support tool to improve learners' academic performance, if it is used in an appropriate way. This study is therefore intended to explore a model of best practice, approach and strategies on how Facebook can be used effectively to enhance understanding and improve academic performance of learners in Physical Science on the topic of stoichiometry.

1.2 Hypothesis

H_0– There is no significant difference in the learners' academic performance in NSSCO Physical Science on the topic of stoichiometry when Facebook is used as a learning support tool.

H_1 – There is a significant difference in the learners' academic performance in NSSCO Physical Science on the topic of stoichiometry when Facebook is used as a learning support tool.

2. Literature Review

Due to an increase in online accredited courses and E-learning, the use of portable technology and mobile phone applications is perceived to play a major role in enhancing effective learning (Dunn, 2014). Different people have different views on the effect that social networks may have on academic performance of the learners. Some people perceive the use of social media such as Facebook by learners as a distraction from learning while others view Facebook as learning support tool that may boost academic performance. The expectation placed on the role of technology or mobile devices and social media on education is ascending gradually, hence their use among students and educators have been the topic of greater concern and discussion worldwide (Aydin, 2012). This resulted in numerous studies being conducted to assess the impact of technology on the education system.

Facebook is an interactive environment having diverse learners, educators and experts hence students communicate and get engaged in interaction with experts online, or in collaborative peer discussions. These equip them with adequate knowledge and information (Siemens, 2014). Through the interaction with knowledgeable members, collaboration with peers and availability and acquired information, learners think critically and hence enable to construct quality and meaningful content that foster learning in them and in others in a well-known and used technology enabling environment. The framework for 21st century offers learning environments as a basis to create the (1) learning practices, (2) human support, and (3) physical environments that will support the teaching and learning of 21st century skill outcomes.

In Africa, Facebook is a popular social networking site (Wang, Woo, Quek, Yang, & Liu, 2012). Youth use Facebook for different reasons, for example, to communicate and connect with friends, for marketing,

work, social enrichment and entertainment, or as a space for information sharing and updates through video, notes, pictures and get notification of parties, events, and social functions (Christy, Cheung, Chiu, & Lee, 2011). Among other social networks such as Twitter and Instagram, the majority choose to use Facebook instead. This is because Facebook is affordable (Wang, et.al, 2012), people can access Facebook either on the Web or through mobile devices using wireless networks or little data. In Namibia Facebook uses cheaper data, the internet provider of Namibia MTC sell data for social media at a lower cost than the price for general data for internet use.

Educators do not only teach students subject content but also prepare students how to be responsible citizens of the nation in future, hence apart from improving academic performance Facebook can be a tool to develop cognitive, psychosocial, morals and ethics among students (Junco, 2012). In addition, learners spend much time in an informal learning environment interacting with peers and receiving content more than they do with teachers in traditional classrooms (Phillips et.al, 2011). Facebook offers an environment that helps engage students and enriches the quality of student's experience and support their academic & social goals through interactive learner's activities (Irwin, et.al, 2012). In addition, Facebook can help with LMS (Learning Management System - Facebook group) as teachers can easily create new courses and enrol students. LMS have a lot of benefits as it shifts the focus from content-based learning to process–based learning. Facebook facilitates change from passive to active learning, it further promotes interaction between students and faculty members and (Wang et.al, 2012).

The use of Facebook should meet the needs of digital natives and digital learning style (Phillips, Baird, & Fogg, 2011). This is because it allows students to create their own content through interact and to express their identity and creativity. Facebook improves reading habits and texting frequency among the learners (Aydin, 2012) and it demolishes the communication barriers between educators, between educators and students as well as between learners and their peers (Aydin, 2012). Dunn (2014) further states that Facebook boosts learners' motivation, connectivity and engagement with materials that accelerate information sharing. It also equips students with the 21st century skills that enable them to suit in digital community (Dunn, 2014), as it gives the students the freedom to use it in any way that best suits their individual learning style (Phillips, et.al, 2011).

3. Methodology

The study uses a quantitative approach with a quasi-experimental design, constituted of a Non- Equivalent-Groups Pre-test, Intervention and Post-test design to gain insight in the impact of Facebook as a learning support tool on the performance of learners in Physical Science on the topic of stoichiometry. The population of the study was all the senior secondary schools in the Oshikoto region offering Physical Science. The sample was selected using stratified random sampling method in order to ensure that not all students of the same academic ability are in the same group. The intervention group consists of 19 learners and 19 learners where used as a control group while the remaining did not take part in the study. These 38 learners represented grade 12 Physical Science learners at the selected school.

A pre-test and a post-test after the intervention tools were used to obtain data from the sample. The intervention consists of a Facebook group on which the support materials were uploaded and where discussion on the topic took place. The control group received worksheets and exercises on the topic, which is the traditional support mechanisms usually provided by teachers. The participating learners were divided into two groups: the control group and the experimental group. During normal class time, all learners received the same presentation, the same notes, and the same oral and written activities based on the specific learning objectives as stipulated in the syllabus. The researcher created a closed group on Facebook and added the participant learners of the experimental group. The researcher further uploaded the instruction which explained the primary purpose of creating the group, the expectations from the group members and a brief logic to be followed. The researcher conducted a pre-research questionnaire aiming at acquiring the participants' demographic information. In the pre-research questionnaire students were asked to indicate their age, gender and the device through which they access Facebook.

3.1 Pre-test

All the learners who participated in the study wrote the same pre-test on the topic of stoichiometry at the same time, irrespective of whether they fell under control or experimental group. The test was set following the guidelines of assessment and the required level of difficulty as specified in the syllabus.

3.2 Intervention

During the intervention, the participant learners of the control group were supported in a traditional way of teaching, i.e. they received notes, Power Point presentations, as well as exercises and homework in the afternoon. The experimental group received notes and they were given exercises and homework in the afternoon just like the control group. However, they

additionally received a Facebook intervention, where they were given the opportunity to listen to videos and audio presentations, and participate in postings, uploading pictures, as well as additional PowerPoint presentations and further study materials on the topic. They were also allowed to interact with fellow group members and teacher on Facebook around the topic.

3.3 Post-test

After 5 teaching days, a post-test was conducted. Both the control group and experimental group wrote the same post-test to test the effect of the interventions on the learners. The post- test results were then used to assess if there exists a significant difference between the control and experimental group score outcome. Whatever difference that might arise, it is believed to be caused by the interventions.

3.5 Analysis

The data from the pre-test and post-test are compared, and statistical significance levels (the p-value or t-value) are calculated. The correlation is calculated in order to indicate a possibly significant level of Facebook use for learning support. In addition, the discussions from Facebook are analysed by tallying categories of 21st century learning support and providing a frequency table or graph to indicate what type of curricular learning support was identified on Facebook.

4. Findings

The researcher observed the actions of the participants during the intervention period. These involved the types of device the participant used or willing to use, the interaction between participants and between the participants and the teacher, amount of time spent online, participation, motivation among participants during the study, behaviour and ethical conduct of learners on the group, contribution and freedom of expression.

Devices used: Despite the school making 7 computers available in the library, participant learners preferred taking along and using their personal mobile devices. Only 10.5 % of the participant learners opted to use school desktop computers, while 18.4 % of the participant learners used laptops and the majority of participant learners forming 71.1 % of the sample utilised their smartphones.

4.1 Pre-test outcome score

The pre-test was piloted to assess the initial learners' level of understanding and the level of equivalence between the control group and experimental group before the intervention. As shown in Table 1, only 4/19 participants in the experimental group scored 50% and above in the pre-test. The average score in the pre-test for experimental group participant learners is 14.7 out of 40, forming up 36.8 % average percentage score in the pre- test.

Table 1: Pre-test scores

Statistical Calculations	Value	
	Control Group	Experimental Group
No of participants	19	19
Mean	16.1578	14.7368
Variance	38.0292	67.0935
Standard deviation	6.1667	8.1910
Standard error	2.3521	
Degree of Freedom	36	
T-value critical	2.750	
T-value calculated	0.6041	

4.2 Control group

On average, participant learners of the control group performed poorly in the pre-test. Only 6 learners (31.6%) of the control group participant learners 19 scored 50% and above in the pre-test. The average score of the control group in the pre-test is 16.2 out of 40; this made the average score percentage to be 40.5.

4.3 Post Test

The control group participant learners performed quite well in the post-test, with 11 of the 19 participant score above 50%. The average outcome score for the control group in the post-test is 20.6 out of 40 (forming up 51.5%).

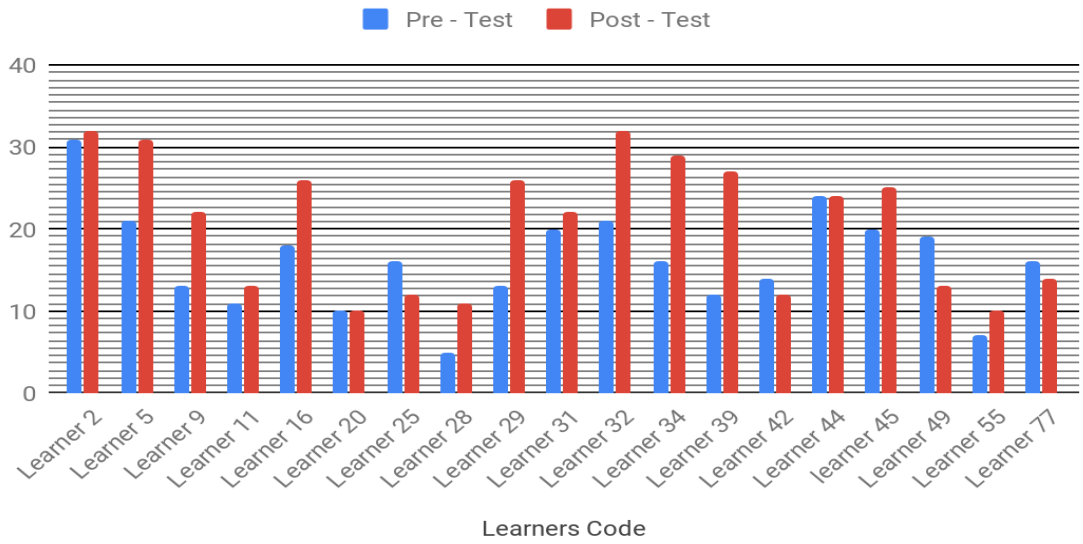
4.4 Experimental group

All participants in the experimental group have scored above 50% in the post-test, the mean post test score for the experimental group is 30.7 out of 40.

4.5 Pre-test vs post-test

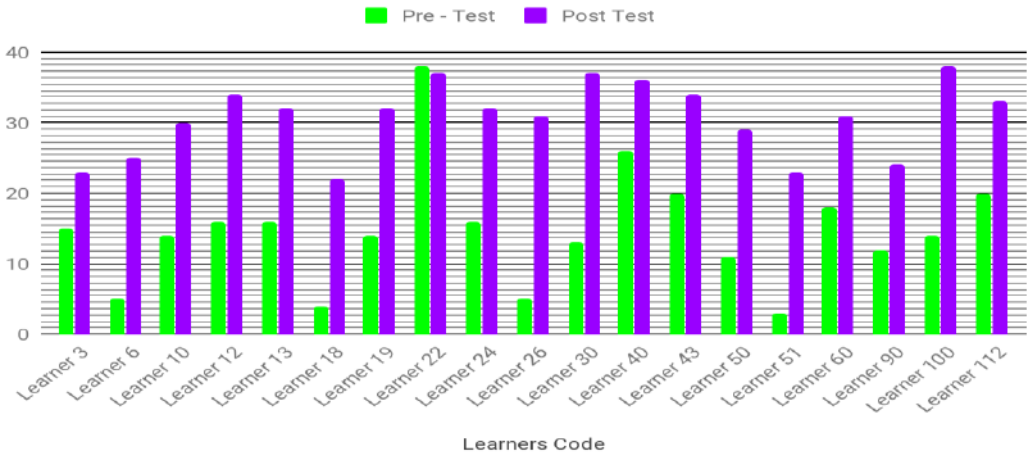
On average, both the control group and experimental group participants performed better and demonstrated a better level of understanding in the post-test than in the pre-test. These results show that learners earn better understanding during the study time when appropriate support is provided. The results can be compared with each other in Fig. 1 (Control group) and Fig. 2 (Experimental group) below. The aim is to detect any change in outcome score of participants during the two stages of the research [before and after the intervention].

Figure 1: Control group pre-test and post-tests score



There is an increase in outcome score obtained in the post-test when compared to the outcome scores of the pre-test. 15 to of 19 participants increased their outcome score, 2 out of 19 participant learners maintained their score and 2 dropped after the intervention. On average, there is a difference of 4.4 outcome scores between the pre-test and post-test, this forms 27.1 % outcome score increment.

Figure 2: Experimental group pre-test and post-test score



4.6 Experimental group

In Table.2 below, the t - critical value = 2.750 as obtained from the table at p = 0.05 and t- calculated value = 4.5802363101 with a degree of freedom equal to 36. T - critical is less than t - calculated.

Table 2: Post Test scores

Statistical Calculations	Value	
	Control Group	Experimental Group
No of participants	19	19
Mean	20.57894	30.6842
Variance	66.4795	26.0058
Standard deviation	8.1534	5.0995
Standard error	2.206	
Degree of Freedom	36	
T-value critical	2.750	
T-value calculated	4.5802	

Most of the participants preferred using smartphones to participate in the study. The pre-test score showed low average for both control and experimental group. Also the t-critical value is greater than the t-calculated value. However, the post-test score shows a big difference between the mean score for the control group and the experimental group, of which the experimental group had a greater average than the experimental group.

4.7 Before the Intervention

All participants of the study (the experimental and control group) had an equivalent level of knowledge and understanding. This was proven by the pre-test results in which both groups of participant learners scored marks below 50 percent, which resulted in a low average. In addition, the calculated statistical value (t-value = 0.604141249) at p = 0.05 with a degree of freedom of 36 was less than the critical t-value (t=2.750). Therefore, there was no significant difference between the experimental and control group score marks at the initial stage of the study.

4.8 After the intervention

It was observed that the mean score of the experimental group highly increased exceeding the mean score of the control group. Secondly, all the participant learners in the experimental group scored above 50% in the post-test while only 11 out of 19 of the control group participant learners scored 50% and above in the post-test. In addition, although there was an increase in marks for both the control and experimental group result from pre-test to post-test, the average mark increased for the experimental group (t= 16 or increase by more than 100%) and was higher than the average marks increase of the control group (t= 4.42 or increase by 27.4%).

It is further noticed that the calculated statistical value after the intervention (t-value = 4.5802363101) at p = 0.05 with a degree of freedom of 36 is greater than the critical value (t - critical =2.750). Therefore, it can be stated that a significant difference between the control and experimental score marks existed when Facebook was used as a learning support tool. *These results reject the null hypothesis and accepts the alternative hypothesis, that there is a significant difference in the learner's academic performance in NSSCO Physical Science on the topic of stoichiometry when Facebook is used as a learning support tool.*

5. Limitations

In setting up the learning support environment, there were certain limitations that required highlighting in order for future studies to improve upon. The following were the limitations of the study:

Technological Resources

Personal telephones are not allowed in schools, even though permission was granted, learners could only use the mobile devices (smartphone) at specific given time and at identified place in order to adhere to the school rules and regulations. As the researcher had to keep the devices and only hand them to the participants during a specified time frame, Facebook was not used anytime and anywhere as in a real-life setting.

Learners conduct with the phone and online behaviour

It was out of the researcher's power and scope of this study to monitor the behaviour and activities that learners may have be engaged in during the study. However, the researcher was in a position to monitor what the learners were posting in the group, but not other activities that learners could be doing with their phones that may not have given insight to the learning behaviour of learners.

Internet connectivity and access

At times the school Wi-Fi was slow which made it difficult for the participant to log in and participate in

the discussions and activities on the Facebook platform. However, the researcher took the responsibility to use Tethering and Portable Wi-Fi hotspot to connect the participant learners to the Internet.

Support from school teachers and management

Due to the belief that Facebook is the main source of ill-discipline in Namibian schools, school teachers and management members where neither interested, motivated nor involved in the intervention or study period. Instead they distanced themselves from the study, reasoning that the researcher should be accountable for any wrong-doing that may arise from the activity.

Gender equity and protection

Although more girls are enrolled on Facebook than boys amongst the study sample, most of the girls in the classroom indicated not being comfortable to use their Facebook account to interact with the teacher and they indicated that they do not want the teacher to know their Facebook names. They preferred to use their account for social means with their peers and not for education where teachers were involved.

6. Conclusion

The use of Facebook as a support tool has shown that it has the potential to support learning and mastery of Physical Science to improve learners' academic performance on the topic of stoichiometry at Grade 12 level. Additionally, this study showed that the learning support environment encourages the 21st Century learning skills (4 Cs). Further research is needed to show teachers how they can approach and setup Facebook for learning support. Strategies and approaches are needed to engage the female learners to participate in Facebook from a learning perspective. Furthermore, research on mobile pedagogies and strategies are needed for teachers if they were to integrate Facebook as their learning support tool. The relevance of this study shows that teachers can no longer hide from using technologies that learners are so easily attuned to.

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Original Research Article

An analysis of people's perceptions on Chinatown in Windhoek, Namibia.

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ABSTRACT

This study set out to find the people's perceptions about Chinatown in Windhoek, Namibia. This was prompted by the negative publicity in the local media about Chinese businesses and their negative impact on local businesses in the various sectors of the economy. Chinatown in Windhoek represents an embodiment of Chinese businesses because of the large concentration in one area. Was the negative publicity in the local media, affecting peoples' perception of Chinatown? Answers to this were sought from local traders who sell more or less the same products as the Chinese in Chinatown and from Chinatown customers. Most of the local traders and Customers appreciated the existence of Chinatown for different reasons. Local traders buy things from Chinatown to resell to their customers at a profit. The customers indicated that the Chinese products are affordable. However, on the other hand, a few traders were against Chinatown because it increases competition. Some customers complained about the quality of goods but this did not deter them from shopping in Chinatown as Chinese products continued to grow since and Chinese entrepreneurs are encountered everywhere in the country, including remote villages and towns. Henceforth, this study gauged at how the local shop owners and customers perceived whether they support and approve the existence of Chinese retail enclaves in Windhoek and elsewhere across the country.

1. Introduction

Chinese traders have emerged to dominate the trade market in Namibia and such is seen in their extending presence in the local business sector. It is within this context that this study explored the attitude of small local traders and customers in Windhoek towards Chinatown and Chinese retailers. This is an interesting question because not only do Chinese appear to dominate Namibian local businesses but also are shunning away local products with Chinese products. Although most of the Chinese shops are situated in Chinatown which is located close to Katutura, there are a few Chinese traders in downtown Windhoek and in shopping centres and malls in the Central Business District (CBD). Chinese traders extend to outside Windhoek. There are in fact, more Chinese traders in Oshikango, at the Namibian border with Angola.

2. Materials and Methods

The study used descriptive design of qualitative research framework and adopted questionnaires as methodologies of gathering data. Two sets of questionnaires, one for the local traders and another for customers, were distributed with random sampling of respondents done as described by Taherdoost (2016) and Elder (2009) for diverse response in Chinatown. Questionnaires were selected because they allowed complete invisibility, which maximized comfort for respondents who answered, hence, ethical consideration in less space of time. However, there were challenges in gathering information as the study was conducted during working hours and a high percentage of respondents were navigating different shifts, such as work, school and domestic duties at the time, both for local traders and customers. Therefore, the study had less time to further gather more in-depth information, hence, these problems affected the outcome of the study.

3. Results

Table 1 presents the demographic characteristics of the local traders in terms of gender, age and academic qualifications. Seventy (70) per cent of the respondents to

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the local retailer's questionnaire were male. This was in line with the general observation of local retailers. The explanation received in particular from the female retailers was that shop ownership is dominated by men as shown below.

Table 1: Gender Distribution of Local Retailers.

Gender	*Male*	*Female*	*Total*
Number	*21*	*9*	*30*
Percentage (%)	*70*	*30*	*100*

There was also a basic difference between what was sold by the two groups. Local women traders sold beauty products and small products like sweets and cakes and sometimes clothes, whereas male local traders sold electronics and household items. Gender was argued sometimes to be a hinderance for one to being prosperous because a prospect client may not believe that females are capable, said one of the female local traders in Chinatown.

Table 2: Age distribution for local traders

Age	*20-30 yr*	*30-40 yr*	*40+ yr*	*Total*
Number	*4*	*10*	*16*	*30*
Male	*3*	*8*	*10*	*21*
Female	*1*	*3*	*5*	*9*

According to the age distribution in Table 2, it is clear to see that local traders around Chinatown was operated by people of different ages. In both age groups, the male gender dominated. Respondents argued how male inferiority has discouraged women to enter the trade industry. Those who were operating their local trading businesses said they represent women empowerment in the business field. This was supported by the fact that some had high academic qualifications. Those females who did not have academic qualifications to run their businesses, based their argument on having a good financial knowledge and "*connections*" with Chinese traders as well as male local traders operating around Chinatown.

Table 3: Qualifications for local traders

Qualifications	*Masters*	*Degree*	*Diploma*	*Others*	*None*	*Total*
Number	*3*	*6*	*6*	*7*	*8*	*30*
Male	*1*	*3*	*4*	*7*	*6*	*21*
Female	*2*	*3*	*1*	*2*	*1*	*9*
Percentage	*10*	*20*	*20*	*23*	*27*	*100*

It emerged from the data in the table above that a large percentage of respondents who are local traders obtained their qualifications but they are selling as jobs are scarce. Fifty percent (50%) of the local traders had qualifications of a diploma and above. This is contrary to the expectation that local shop owners would be those with higher education. Having academic knowledge was not enough to guarantee that one will establish a business opportunity by those with higher academic qualifications. Therefore, respondents said that having a stable capital and large "connections" in the trade industry is an advantage.

3.1 Local traders buying from Chinatown to re-sell

A high number of local traders said they buy from Chinese shops to re-sell. Chinatown's local traders said they sold Chinese products, such as clothes, shoes, kitchen utensils and electronics although some were of poor quality compared to products from Namibian manufacturing companies. Nonetheless, the rest indicated that not all Chinese products were of poor quality, and that Chinese made items for everyone, those with money and those without. Therefore, local traders bought items to re-sell to customers as well because of the need to reach out to customers of all social status background, and they generated more income. Some even argued that some products sold in local shops are Chinese imports but are more expensive because they are sold by locals.

3.2 Relations and competition between local traders and the Chinese in Chinatown

Responses on the existing relations between the local traders and the Chinese in Chinatown indicate that they were generally good (63%). This was in part influenced by the fact that a number of local traders bought their goods from Chinatown to re-sell to their customers. This was particularly the case with local

traders in the vicinity of Chinatown. Those who indicated bad relations with the Chinese in Chinatown (37%) complained that their customers preferred to shop directly in Chinatown because of the very low prices there. This definitely affects the operations of their businesses. It was pointed out by the local traders that the Chinese are supported by Chinese manufactures in China, and receive goods in bulk and at very low prices. It is this reason that allow them to charge low prices for their goods. This is not the case for local traders. There seems to be a general consensus among local retailers that government favours Chinese businesses and make the environment more conducive for Chinese businesses than it does for the local businesses. Local businesses face more stringent labour laws than Chinese businesses. Local traders said that there was nothing wrong with a healthy competition.

Table 4: Products bought by customers in Chinatown

Products	*Household*	*Electronic Gadgets*	*Beauty Products*	*Others*	*Total*
Number	*70*	*35*	*60*	*15*	*180*
Percentage	*39*	*19*	*33*	*9*	*100*

The three main items that often bring customers to Chinatown are beauty products, (33 per cent), household goods (39 per cent) and electronic gadgets (19 per cent). It was already noted above that most women are attracted to Chinatown because of the low prices on beauty products. It needs to be noted that the biggest purchases in the over 35 age group in particular men is for household items. These comprised of beds, pots, stoves, television, blankets, plates and tables to mention a few. Furthermore, one need to note that there is an existence of repair shops for computers and cell phones as well as school/academic shops that focus on selling uniforms and other school related products.

3.3 Chinatown's Product Quality

Most customers were not concerned about the quality, since the so called "original" brands are too expensive for them in other shops. Twenty-eight (28) per cent of customers indicated that they were of bad quality. Customers noted that the quality of Chinese goods is determined by the market itself. Major local retailers such as Edgars, Foschini, Markham and Truworths also source their products mostly clothes from China. Products from China are graded into different categories from A to D and sold according to levels of development in the world regions. Other countries like South Africa are to a certain extent also buying products in Grade C from China and those are the ones that we find in big retail shops in Namibia.

Table 5: Chinese relations and customers around Chinatown

Relations with Chinese	*Good*	*Bad*	*Total*
Number	*144*	*36*	*180*
Percentage (%)	*80*	*20*	*100*

The data was divided into two categories to bring out a clear view of how relations with the Chinese and the local customers emanated. The communication between the customers and Chinese was good and most respondents argued that it is one of the reasons they keep shopping from Chinatown. Yet, despite selling cheap goods and appearing to be one of the most preferred shopping centres, Chinatown was accused of having some common negative trends such as weak customer care, hostile attitudes by Chinese workers towards customers, and language barrier between Chinese traders and local customers.

Table 6: Customer support of Chinatown in Namibia

Gender	Support	Against	Total
Number	174	6	180
Percentage (%)	97	3	100

A high percentage of customers answered that they supported it and few were against it. However, the latter shopped from Chinatown because of cheap products. A high percentage of Chinatowns' customers around the nation included both males and females from different age groups, race and class supported the existence of Chinese retail shops in Namibia and provided the following reasons such as Chinatown sells cheap products, they sell everything including things you never knew existed, customers get to shop for

everything you need 'under one roof'- it is convenient, Chinese are providing jobs to locals. In support of the latter reason, it is important to note that now, the same amount of Namibian as Chinese traders are running stores around the city.

4. Discussion

Indeed, the growth of Chinese investments accompanied by the growth of Chinese migration to Namibia has provoked various reactions. These need to be properly analysed prior to paying special attention to the Chinese's presence in Namibia. Chinatown, as the main Chinese business sphere has sparked scepticism about the true intentions of Chinese in the Namibian economy and the intentions they have regarding the development of the nation's economy. Analysis have been provided from an economic and political perspective, with little attention provided to the legal and social consequences. The impact of Chinatown in Windhoek emerged with direct and indirect effects as well as competitive and complementary effects. Direct effects are associated with consensual trade whereas indirect effects arise from China's global economic impacts. Competitive effects arise because Chinese economic products are close replacements for those produced by local production, whereas complementary effects arise where products concerned are complements. Imported Chinese goods compete with local products of domestic manufacturers despite, on the other hand, being complementary to other local producers who use Chinese inputs to boost their businesses.

4.1 Chinatown and Chinese traders' presence in Namibia

Chinatown has emerged as a threat to the local business population. Nevertheless, cheaper access to capital and intermediate inputs imported from China boost profitability of domestic production. The productivity responses by domestic firms to increased competition together with the elimination of inefficient firms may have left the Namibian trade businesses better placed for expansion in future. Adewunmi (2012), postulates that some of these losses have been offset by increases in employment in the market mostly in the clothing retail sector. By reducing inflation, Chinese imports may have aided to keep interest rates low (Melber 2018).

4.2 Negative perceptions on Chinatown

Chinese investment has had a negative direct competitive effect on domestic manufacturing output and employment, with several industries, most notably textiles and clothing, rubber, paper and metal products, demanding increased protection from Chinese imports (Morris & Einhorn, 2008). Concerns have been raised that local exports of manufactured goods to have been indirectly imbued and crowded out by Chinese exports (Burke & Edinger 2008). Although there is recognition that local exporters of resource-based products have indirectly benefited from higher commodity prices. The contradictory impacts of Chinatown's expansion make it a particularly interesting case to study.

5. Conclusion

The growth in the number of Chinese citizens and enterprises in Namibia towards the end of the last decade (2008-2009) sparked a number of studies on the impact of Chinese presence in the country. The main focus of these concerns was on market trade and economic development. The increasing number of Chinese retailers is a hazard to the unionised local market. Chinese presence has continued to grow since and Chinese retail traders are encountered everywhere in the country, including remote villages and towns.

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Original Research Article

Investigating the impact of leadership on work engagement of employees within the Khomas region, Namibia.

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ABSTRACT

Leadership has an effect on constructive or deviant behaviour and the work engagement levels of employees. Considering the current economic and social climate of Namibia, it is of utmost importance that leaders initiate and identify ways in which work engagement can be enhanced. Making use of an electronic survey (survey research), this study investigated the effects of different leadership styles on work engagement of employees in the Khomas region (n=157). An analysis of the data was done with SPSS (version 24), making use of Pearson's correlation and Stepwise multiple regression. Work engagement reported a negative relationship with transactional ($r = -0.43$, $p < 0.05$; medium effect) and laissez-faire leadership ($r = -0.37$, $p < 0.05$; medium effect); a positive relationship was reported with transformational leadership ($r = 0.52$, $p < 0.05$; large effect). Transactional leadership ($\beta = -0,27$; $t = -2.85$; $p < 0.01$) and transformational leadership ($\beta = 0,45$; $t = 4.88$; $p < 0.00$) were found to be significant predictors of work engagement. Leaders need to avoid compulsive focus on the mistakes or failures of employees. Focusing constantly on mistakes, problems and failures may cause anxiety amongst employees and halt work engagement. Work engagement can be enhanced when leaders clearly and confidently communicate performance standards and expectations; provide praise and recognition; involve employees in decision making whilst discussing different approaches to task completion; and help to develop employees based on their individual strengths and abilities. This study may add to existing knowledge within Industrial/Organizational Psychology, leadership and interventions to improve work engagement and performance of employees.

1. Introduction

Namibia faces significant challenges regarding economic and social functioning (Chiwara & Lombard, 2017; Littlewood, 2014). The Khomas region has the largest labour force compared to other regions within Namibia (NSA, 2018). Due to the nature (focus on employees) and scope (exploratory study) of this study, the researchers focused on the Khomas region to conduct the study. Within the current economic and social climate, it is of utmost importance that leaders take the initiative and identify ways to enhance work engagement of employees. Due to Namibia's small population and dependence on the export of local goods, the country faces the challenge of competing trade-wise on the international stage (IPPR, 2014; IPPR, 2019). The optimisation of organisations is highly dependent on the commitment and engagement of employees within organisations (Geldenhuys, Laba, & Venter, 2014; Sharma & Sharma, 2014).

Leadership has a direct effect on constructive and deviant behaviour and work engagement levels of employees (Yao, Fan, Guo, & Li, 2014; Meswantri & Ilyas, 2018). If one is to consider the effects of leadership on the functioning of the organisation, it is important to clarify what is meant by leadership. In essence, we find that leadership has one main purpose: to improve the organisation (Summerfield, 2014). This may imply that a leader should enhance all the relevant aspects of the organisation, which includes the personnel. Furthermore, leadership is not a novel idea, it has been researched extensively and has been found to direct workgroups, initiate improvements in the functioning and performance of organisations, and subsequently help organisations achieve their goals (Elwell & Elikofer, 2015; Saleem & Naveed, 2017). Common sense dictates that the organisation is not merely a lifeless and mechanical construct. As a social construct, leadership influences

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employees to participate in their own accord with the purpose to achieve organisational objectives (Omolayo, 2007). Furthermore, leadership facilitates the achievement of personnel goals (Jannesari, Khorvash, & Iravani, 2013). Research has shown that leadership types/styles do influence the work engagement of employees (Li et al., 2018). More specifically, the authors identified that transformational and transactional leadership positively affects the level of work engagement. Highly efficient organisations are characterised by employees who are engaged on a cognitive, emotional, and physical level (Strom, Sears, & Kelly, 2014). This form of engagement is characterised by vigour, dedication, and absorption (Schaufeli, Salanova, González-Romá, & Bakker, 2002).

The objective of this study was to determine by means of non-experimental research design the effects of leadership styles on work engagement of employees in the Khomas region.

2. Literature review

2.1 Transformational and transactional leadership

Leadership is the social influence and improvement of individual endeavours and group performance for the purpose of accomplishing joint goals (Sethuraman & Jayshree, 2014; Yukl, 2012). Transformational leadership is defined as the combined persuasive emotional connection between the leader and the organisation that enhances the performances of followers to levels that exceed expectations while being committed to a greater cause (Diaz-Saenz, 2011). Additionally, transformational leadership is defined by Warrilow (2012) as direct influence on individuals and collectives, and inspiring positive change by accounting for their personal and shared pursuits.

Alternatively, transactional leadership is a collective goal-oriented approach while offering rewards for achieving these predetermined goals (Bryman, Collinson, Grint, Jackson, & Uhl-Bien, 2011). Furthermore, transactional leadership is rooted in the premise that the exchange of effort for rewards with the aim of attaining specific goals or tasks but excludes the additional motivation of employees to exceed expectations as with transactional leadership (Bryman et al., 2011). Similarly, Lee (2020) defines transactional leadership as a bond between superiors and subordinates through a reward-exchange system to increase the progression of the organisational and the individual.

2.2 Antecedents of transformational and transactional leadership

A literature review on the antecedents to transformational leadership indicates that leadership characteristics such as self-efficacy, emotional intelligence, attributes, and beliefs; characteristics of the organisation such as fair practices within the company and collaborative organisational cultures; and co-workers such as co-workers' levels of emotional intelligence and levels of development; all influence leadership behaviours to some extent (Sun, Chen, & Zhang, 2017). Barbuto and Burbach (2006) found a positive relationship between emotional intelligence and transformational leadership. Research has found that leaders who experience changes in self-efficacy, perspective taking, and positive affect also report improved transformational leadership behaviours and that these leadership behaviours changes were supported by co-workers and superiors (Fitzgerald, & Schutte, 2010; Mason, Griffin, & Parker, 2014). Additionally, Cerni, Curtis, and Colmar (2010) indicated that a targeted intervention programme which provided executive coaching over a 10-week period enhanced the levels of reflective thinking and leadership behaviours. Co-worker relationships, especially when positive, have been shown to enhance autonomous motivation and self-efficacy in abilities to manage. Consequently, these factors enhanced transformational leadership behaviour (Trépanier, Fernet, & Austin, 2012).

Bass (1997) asserts that there are three dimensions that define transactional leadership behaviours, contingency reward, and management-by-exception (active or passive). Contingency reward is defined by the implementation of system of rewards that extrinsically motivate followers to ensure the achievement of goals or tasks. Management by exception (active) is defined as the implementation of specific interventions and meticulous inspection of cohort behaviours to maintain obedience to the rules and regulations of the organisation, which is accomplished by corrective action when specific transgressions occur. Management by exception (passive) allows employees with the necessary freedom to function in their roles within the workspace, with corrective action only required when employees do not meet or deviate from the expected levels of performance. Camps and Torres (2011) found that organisational learning capability and how employable the follower serve as antecedents of transactional leadership behaviour.

2.3 Outcomes of transformational and transactional leadership

Clarke (2013) found that transformational leadership positively correlated with perceptions of safety climate and safety behaviour (safety compliance and safety participation). Furthermore, the transactional leadership ensured that employees complied with the rules and regulations of the organisation, this in turn was also correlated to promoting employees participating in safety. Ma and Jiang (2018) found that creativity amongst employees and transformational

leadership showed no significant correlation, while transactional leadership was positively correlated to the creativity of employees. Cho, Shin, Billing, and Bhagat (2019) found that transformational leadership positively correlated to affective organisational behaviour, more so for American employees than Korean employees. However, transactional leadership was only positively correlated to affective organisational behaviour for Korean employees.

Sundi (2013) found a positive correlation between transformational leadership, transactional leadership and employee motivation. Employees' motivation, transformational leadership and transactional leadership was positively correlated to employee performance. Ismail, Mohamad, Mohamed, Rafiuddin and Zhen (2010) found a positive correlation between transformational leadership and procedural justice. Furthermore, a positive correlation between transactional leadership and leadership trust of employees was found. A positive relationship was found between transactional leadership, distributive justice, and employees' levels of leadership trust. Riaz and Haider (2010) found positive relationships between transactional leadership, transformational leadership, job satisfaction and career satisfaction. Lan, Chang, Ma, Zhang and Chuang (2019); Nazim (2016) found a positive correlation between transformational, transactional leadership and job satisfaction. Transformational leadership and transactional leadership have been shown to correlate to job satisfaction, organisational commitment, perceived performance and intentions to quit (Nazim Ali, Ali, & Tariq, 2014).

Transformational leadership and contingent rewards significantly influence work engagement (Breevaart et al., 2014). Furthermore, both transactional leadership and transformational leadership has been shown to positively correlate with work engagement, however transactional leadership showed higher predictability related to work engagement and the psychological capital of employees (Li, Castaño, & Li, 2018). Dartey-Baah and Ampofo (2015) found that transactional leadership correlates positively with job stress, while transformational leadership correlates negatively with the job stress levels of employees. Alternatively, Pishgooie, Atashzadeh-Shoorideh, Falcó-Pegueroles and Lotfi (2019) researched on the relationship between leadership styles of nursing managers and nursing staff and found that both transformational leadership and transactional leadership reduced the levels of employees' job stress and their intentions to quit their jobs.

2.4 Work engagement

One of the reasons why there has been an increase in the interest in work engagement is because of its predictive relationship to job performance (Tims, Bakker, & Xanthopuulou, 2011). Work engagement is defined as positive organisational behaviour that constitutes vigour, absorption and dedication (Bakker, Demerouti, & Sanz-Vergel, 2014). Positive organisational behaviour comprises of hard-working and engaged employees. Furthermore, engaged employees are more energetic and see their jobs as a challenge (Barnes & Collier, 2013). Vigour speaks to how energetic employees are as well as their levels of resilience and the amount of effort the employees put into their work (Bakker, 2017). When employees are dedicated, they are highly involved with their work, enthusiastic, inspired and find meaning in their work (Bakker, 2017). Lastly, absorption is the way that employees become, immersed in their work that they are not even conscious of how fast time passes by whilst working (Bakker et al., 2014).

2.5 Antecedents of work engagement

Job resources are a good predictor of work engagement (Albrecht, 2013). It helps employees do their jobs well, achieve work-related goals, motivate personal growth and lessen the job demands (Bakker et al., 2014). The job resources that have been identified as predictors of work engagement were task significance, performance feedback, relationship with supervisor, social support from co-workers, task variety, autonomy, learning opportunities, and transformational leadership (Albrecht, 2013; Bakker et al., 2014). Leadership influence many of these resources. Job resources have an intrinsic and extrinsic motivational role in an employees' work life. Job resources (extrinsic motivational role) are important in achieving work goals (Bakker, 2011). When employees feel supported it helps them achieve their work goals. Employees' growth, learning, and development forms part of the intrinsic motivational role (Bakker, 2011). This is when an employee receives performance feedback, they know in which areas they need to improve or perform well in and learn.

Personality has been shown to play an important part in work engagement (Albrecht, 2013). Certain individuals can use their job resources for optimal functioning as opposed to others and this is due to differences in their personalities (Albrecht, 2013). Individuals that are extroverts will be more social and experience more positive emotions. These employees are more engaged in their work because they can reap social support from their co-workers and supervisors, perceive problems as challenges and ask for performance feedback (Bakker et al., 2014). Furthermore, it has been shown that extroversion, conscientiousness, and emotional stability are related to higher levels of work engagement (Bakker et al., 2014).

2.6 Outcomes of work engagement

Work engagement has been shown to improve the overall health of employees (Bakker et al., 2014). This is because engaged employees were found to partake in activities that relax them and help them to detach psychologically from work such as sports (Bakker et al., 2014). Furthermore, according to the *Broaden-and-build theory* employees that are engaged are open to new experiences more than non-engaged employees (Bakker et al., 2014). This is because when employees can adapt to a work environment that is always changing they become more engaged in their work. Engaged employees learn more and exhibit proactive behaviour especially those that are high in conscientiousness (Bakker et al., 2014). There are four reasons why engaged employees perform better than non-engaged employees. Firstly, engaged employees are known to experience positive emotions which increases their thought-action repertoire by building physical, social, psychological and intellectual resources (Bakker et al., 2014). Secondly, engaged employees experience better health which gives them more time to focus on their work (Bakker, 2011). Individuals that experience positive emotions are less likely to develop cardiovascular disease (Boehm & Kubzansky, 2012) and get flu less often than those who experience negative emotions (Kok et al., 2013). Thirdly, engaged employees seek performance feedback and social support from their co-workers and supervisors to generate new resources (Bakker, 2011). Lastly, engaged employees transfer their engagement which in turn increases the team's overall performance (Bakker, 2011). The *Social Contagion Theory* explains this better. It proposes that when an individual has ties to another individual; they start to exhibit similar behaviour, attitudes, or personality (Burgess, Riddell, Fancourt, & Murayama, 2018).

Based on the literature discussed above, the following hypotheses have been developed:

Hypothesis 1: There is a positive relationship between transformational leadership and work engagement.

Hypothesis 2: There is a positive relationship between transactional leadership and work engagement.

Hypothesis 3: There is a negative relationship between laissez-faire leadership and work engagement.

Hypothesis 4: Transformational leadership is a significant predictor of work engagement.

Hypothesis 5: Transactional leadership is a significant predictor of work engagement.

Hypothesis 6: Laissez-faire leadership is a significant predictor of work engagement.

3. Methodology

3.1 Research approach

This study made use of an electronic survey (quantitative research). The link, with a cover letter explaining the purpose of the study and all ethical requirements, were sent to different employees working in the Khomas region. Data were collected based on participants' biographical information, leadership style, and work engagement levels. It took participants approximately 30 minutes to complete the questionnaire.

The study made use of the convenience sampling technique which is defined as the population components that are included in the sample based on the ease of access and availability (Martínez-Mesa et al., 2016). All participants were informed of the right to privacy, confidentiality and the purpose of the study. Participants were informed of their right to withdraw from the study without any negative consequences. After employees' consent was obtained they could proceed with the completion of the survey. The surveys were submitted electronically after completion and kept on a secure data server. A total of n=157 individuals responded to the survey.

3.2 Participants

The sample consisted of 157 respondents from the total of 241 321 employed people in the Khomas region (NSA, 2018). The only restrictions for participants of this research study were that they are employed within the Khomas region. The study does not aim to generalise the findings to the entire Khomas region but rather to gather exploratory data for future studies and gain initial insight into the topic under investigation. Of the sample, 104 were woman (66.2%) and 52 were men (33.1%). The ages of the respondents were mostly evenly distributed, with the ages 41 to 45 (n=30, 19.1%) representing the largest proportion of the respondents and the under 24 age category having the least responses (n=10, 6.4%). From the sample, the longest job tenure length was amongst employees working for 16 years or longer (n=43, 27.4%). The distribution between single (n=70, 44.6%) and married employees (n=72, 45.9%) were fairly evenly distributed. The most frequent qualification was an Honours degree (n=35, 22.3%). Most of the respondents worked at a Non-management level (n=81, 51.6%). The rest of the biographical data can be found in Table 1.

TABLE 1: Frequency distribution of the sample (n=157)

Category:	Item:	Frequency:	Percentage:
SEX:	Male	52	33.1
	Female	104	66.2
	Missing values	1	0.6
AGE:	Below 24	10	6.4
	24-28	18	11.5
	29-31	15	9.6
	32-35	23	14.6
	36-40	26	16.6
	41-45	30	19.1
	46-50	15	9.6
	51 and older	20	12.7
JOB TENURE:	Less than 1 year	17	10.8
	1-2	18	11.5
	3-4	20	12.7
	5-6	13	8.3
	7-8	18	11.5
	9-10	7	4.5
	11-15	20	12.7
	16 and more	43	27.4
	Missing responses	1	0.6
QUALIFICATIONS:	Grade 12	21	13.4
	Certificate	9	5.7
	Diploma	18	11.5
	Degree	31	19.7
	Honours Degree	35	22.3
	Master's Degree	32	20.4
	PHD	11	7.0
NUMBER OF DEPENDENTS (children):	None	53	33.8
	1-2	75	47.8
	3-4	21	13.4
	5-6	5	3.2
	10 and more	2	1.3
	Missing responses	1	0.6
MARITAL STATUS:	Single	70	44.6
	Married	72	45.9
	Divorced	13	8.3
	Widowed	1	0.6
	Missing responses	1	0.6
MANAGEMENT LEVEL	Non-management	81	51.6
	Mid-level management	48	30.6
	Senior management	28	17.8
TOTAL:		157	100.0

3.3 Measuring instruments

The survey comprised of three sections. The first section assessed the respondent's demographic characteristics such as age, gender, education level, job tenure, number of dependents, marital status and level of management.

The second section consisted of the revised *Multifactor Leadership Questionnaire* developed by Avolio and Bass (2004). The questionnaire consists of 28 items. Transformational leadership consists of inspirational motivation (The Person I Am Rating… "*Talks optimistically about the future"),* intellectual stimulation ("*Seeks differing perspectives when solving problems")*; and individual consideration, ("*Spends time teaching and coaching")*. Transactional leadership consists of contingent rewards ("*Provides me with assistance in exchange for my efforts'*), management by exception- active ("*Keeps track of all mistakes*"), management by exception- passive ("*fails to interfere until problems become serious*"); and Laissez-faire, ("*Fails to interfere until problems become serious*"). The response scale ranges from 0 (not at all) to 4 (frequently, if not always). Bagheri, Sohrabi, and Moradi, (2015) found a reliability coefficient of α=0.90. Work engagement was assessed using the *Utrecht Work Engagement Scale* (UWES-9) developed by

Schaufeli et al. (2006). The scale focused on vigour ("*At my work, I feel bursting with energy"*), dedication ("*When I get up in the morning, I feel like going to work"),* and absorption ("*I am immersed in my work"*). Pieters, Van Zyl and Nel (2020) found the reliability for vigour at α=0.81, dedication α=0.81 and absorption α=0.82. Kazimbu and Pieters (2020) found a reliability for the instrument of α=0.91.

3.4 Analysis

Version 24 of the IBM SPSS Programme was used for the analysis of the collected quantitative data from the electronic questionnaire (SPSS, 2016). The results were presented as descriptive statistics, with the mean, standard deviation, and reliability. Cronbach's alpha coefficient (α = .70) was used to measure the reliability of the instruments. To determine the relationship between the different variables the Pearson's product-moment correlation was used. Stepwise multiple regression analysis was used to determine which variable best predicted the dependent variable.

Ethical consideration

The cover page of the electronic survey explicitly stated the objectives of the study and required that the participant consent to taking the subsequent questionnaire before being able to continue. Furthermore, participants were informed of their right to refrain or withdraw from taking and/or completing the survey.

3.5 Limitations

The study was conducted within the Khomas region which limits the generalizability of the findings to the rest of Namibia. The study made use of a cross-sectional research design that has limitations in terms of predictability and establishing cause-effect relationships.

4.Results

4.1 Descriptive statistics and correlations

The means (M), standard deviation (SD), Cronbach's alpha coefficient, and correlations are recorded in Table 2.

TABLE 2: Cronbach Alpha, Mean and Standard deviation (SD)

Item name:	A	Mean	SD
WE_VIG	.91	15.02	5.30
WE_DED	.84	16.92	4.68
WE_ABS	.72	17.13	3.87
TOTAL_WE	.92	49.07	12.58
TRA_CR	.78	12.93	4.22
TRA_MEP	.78	9.76	4.14
TOTAL_TRA	.76	15.22	5.04
LF	.84	9.36	4.56
TRF_IS	.79	12.89	4.08
TRF_IM	.88	13.96	4.42
TRF_IC	.72	12.13	4.08
TOTAL_TRF	.92	38.98	11.62

WE_VIG = Work engagement (Vigour); WE_DED = Work engagement (Dedication); WE_ABS = Work engagement (Absorption); WE_TOTAL = Total work engagement; TRA_CR = Transactional leadership (Contingent rewards); TRA_MEP = Transactional leadership (Management by exception- passive); TOTAL_TRA = Total transactional leadership; LF = Laissez-faire; TRF_IS = Transformational leadership (Intellectual stimulation); TRF_IM = Transformational leadership (Inspirational motivation); TRF_IC = Transformational leadership (Individual consideration); TOTAL_TRF = Total Transformational leadership.

The *Utrecht Work Engagement Scale* (UWES-9) was found to be reliable with Cronbach's alpha of 0.91 for vigour, 0.84 for dedication, 0.72 for absorption and for Total work engagement (α=.92). The Cronbach's alpha coefficient for The Multifactor Leadership Questionnaire was found to be reliable in this study. For transactional leadership (contingent rewards) the Cronbach's alpha coefficient of 0.78 was found, α=.78 for transactional leadership (management by exception-passive) and Total transactional leadership (α=.70). A Cronbach's alpha coefficient of α=.84 for Laissez-faire. For the dimensions of transformational leadership reliability results were found at α=.88 for inspirational motivation, α=.79 for intellectual stimulation, α=.72 for individual consideration and for Total transformational leadership (α=.92). Transactional leadership (management by exception-active) were found to be unreliable in this study and excluded from any further analysis.

Vigour reported a mean of 15.02 and a standard deviation of 5.30; dedication reported a mean of 16.92 and a standard deviation of 4.68; absorption reported a mean of 17.13 and a standard deviation of 3.87; and a mean score was reported for Total work engagement of 49.07 and SD of 12.58. A mean of 12.93 were recorded for transactional leadership (contingent

rewards), SD of 4.22; mean of 9.76 for transactional leadership (management by exception-passive) and SD of 4.14; a mean of 15.22 for Total transactional leadership and SD of 5.04. A mean of 9.36 was reported for Laissez-faire and SD of 4.56. A mean of 12.89 was reported for transformational leadership (intellectual stimulation) and SD of 4.08; mean of 13.96 for transformational leadership (inspirational motivation) and SD of 4.42; and mean of 12.13 for transformational leadership (individual consideration) and SD of 4.08; and mean of 38.98 for Total transformational leadership and SD of 11.62.

Table 3: Pearson Correlation Coefficient

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. WE_VIG	-								
2. WE_DED	.83++	-							
3. WE_ABS	.63++	.72++	-						
4. TOTAL_WE	.92++	.95++	.84++	-					
5. TRA_CR	.47*+	.47*+	.40*+	.49*+	-				
6. TRA_MEP	-.42*+	-.41*+	-.32*+	-.43*+	-.58++	-			
7. TRF_IS	.51++	.49*+	.41*+	.52++	.82++	-.58++	-		
8. TRF_IM	.45*+	.45*+	.38*+	.47*+	.85++	-.59++	.80++	-	
9. TRF_IC	.46*+	.42*+	.29*	.44*+	.79++	-.53++	.78++	.76++	-

* Statistically significant: $p \leq 0,05$

+ Practically significant correlation (medium effect): $0,30 \leq r \leq 0,49$

++ Practically significant correlation (large effect): $r \geq 0,50$

WE_VIG = Work engagement (Vigour); WE_DED = Work engagement (Dedication); WE_ABS = Work engagement (Absorption); WE_TOTAL = Total work engagement; TRA_CR = Transactional leadership (Contingent rewards); TRA_MEP = Transactional leadership (Management by exception- passive); TRF_IS = Transformational leadership (Intellectual stimulation); TRF_IM = Transformational leadership (Inspirational motivation); TRF_IC = Transformational leadership (Individual consideration).

Pearson's correlation coefficient in Table 3 indicates that Vigour reported a positive relationship with Dedication (r = 0.83, p < 0.05; large effect), Absorption (r = 0.63, p < 0.05; large effect) and Total work engagement (r = 0.92, p < 0.05; large effect). Vigour reported a positive relationship with Contingent rewards (r = 0.47, p < 0.05; medium effect), and a negative relationship with Management by exception - passive (r = -0.42, p < 0.05; medium effect). Vigour reported a positive relationship with Intellectual stimulation (r = 0.51, p < 0.05; large effect), a positive relationship with Inspirational motivation (r = 0.45, p < 0.05; medium effect), and a positive relationship with Individual consideration (r = 0.46, p < 0.05; medium effect).

Dedication reported a positive relationship with Absorption (r = 0.72, p < 0.05; large effect) and Total work engagement (r = 0.95, p < large effect). Dedication reported a positive relationship with Contingent rewards (r = 0.47, p < 0.05; medium effect), a negative relationship with Management by exception – passive (r = -0.41, p < 0.05; medium effect); a positive relationship with Intellectual stimulation (r = 0.49, p < 0.05; medium effect), a positive relationship with Inspirational motivation (r = 0.45, p < 0.05; medium effect) and a positive relationship with Individual consideration (r = 0.42, p < 0.05; medium effect).

Absorption reported a positive relationship with Total work engagement (r = 0.84, p < 0.05; large effect); a positive relationship with Contingent rewards (r = 0.40, p < 0.05; medium effect), a negative relationship with Management by exception – passive (r = -0.32, p < 0.05; medium effect), a positive relationship with Intellectual stimulation (r = 0.41, p < 0.05; medium effect), a positive relationship with Inspirational motivation (r = 0.38, p < 0.05; medium effect) and a positive relationship with Individual consideration (r = 0.29, p < 0.05; small effect).

Total work engagement reported a positive relationship with Contingent rewards (r = 0.49, p < 0.05; medium effect), a negative relationship with Management by exception – passive (r = -0.43, p <

0.05; medium effect), a positive relationship with Intellectual stimulation ($r = 0.52$, $p < 0.05$; large effect), a positive relationship with Inspirational motivation ($r = 0.47$, $p < 0.05$; medium effect) and a positive relationship with Individual consideration ($r = 0.44$, $p < 0.05$; medium effect).

Contingent rewards reported a negative relationship with management by exception – passive ($r = -0.58$, $p < 0.05$; large effect), a positive relationship with Intellectual stimulation ($r = 0.82$, $p < 0.05$; large effect), a positive relationship with Inspirational motivation ($r = 0.85$, $p < 0.05$; large effect) and a positive relationship with individual consideration ($r = 0.79$, $p < 0.05$; large effect).

Management by exception – passive reported a negative relationship with Intellectual stimulation ($r = -0.58$, $p < 0.05$; large effect), a negative relationship with Inspirational motivation ($r = -0.59$, $p < 0.05$; large effect) and a negative relationship with Individual consideration ($r = -0.53$, $p < 0.05$; large effect).

Intellectual stimulation reported a positive relationship with Inspirational motivation ($r = 0.80$, $p < 0.05$; large effect) and a positive relationship with Individual consideration ($r = 0.78$, $p < 0.05$; large effect).

Inspirational motivation reported a positive relationship with Individual consideration ($r = 0.76$, $p < 0.05$; large effect).

Table 4: Pearson Correlation Coefficient (composite variables)

TOTAL_TRA	-			
TOTAL_TRF	-.55++	-		
LF	.69++	-.67++	-	
TOTAL_WE	-.43*+	.52++	-.37*+	-

* Statistically significant: p ≤ 0,05
\+ Practically significant correlation (medium effect): 0,30 ≤ r ≤ 0,49
++ Practically significant correlation (large effect): r > 0,50

TOTAL_TRA = Total transactional leadership; TOTAL_TRF = Total transformational leadership; LF = Laissez-faire leadership; TOTAL_WE = Total work engagement.

Total transformational leadership reported a negative relationship with Laissez-faire ($r = -0.67$, $p < 0.05$; large effect), and a positive relationship with Total work engagement ($r = 0.52$, $p < 0.05$; large effect).

Total transactional leadership reported a negative relationship with Total transformational leadership ($r = -0.55$, $p < 0.05$; large effect), a positive relationship with Laissez-faire ($r = 0.69$, $p < 0.05$; large effect), and a negative relationship with Total work engagement ($r = -0.43$, $p < 0.05$; medium effect).

Laissez-faire reported a negative relationship with Total work engagement ($r = -0.37$, $p < 0.05$; medium effect).

4.2 Multiple regression analyses

Stepwise multiple regression analysis was performed to evaluate how well transactional leadership, transformational leadership and laissez-faire leadership predict work engagement, assessing hypotheses 4, 5, and 6. To test these hypotheses Total transformational leadership was used as the independent variables in the first model, Total transactional leadership was added in the second model and Laissez-faire leadership in the third model with Total work engagement being the dependent variable. The results are reported in Table 5.

Table 5

Multiple Regression with Total work engagement being the dependent variable and Total transformational leadership, Total transactional leadership and Laissez-faire leadership being the independent variables.

Model	Unstandardized Coefficients Beta	Coefficients Standard Error	Standardized Coefficients Beta	T	Sig	F	R^2	ΔR^2
1						56.81	.268	.263
					(p < 0.00)			
(Constant)	27.23	3.02		9.01	.00*			
Total TRF	.56	.07	.52	7.54	.00*			
2						33.09	.301	.291
					(p < 0.00)			
(Constant)	40.35	5.74		7.03	.00*			
Total TRF	.43	.09	.40	4.97	.00*			
Total TRA	-.54	.20	-.22	-2.67	.01*			
3						22.47	.306	.292
					(p < 0.00)			
(Constant)	37.37	6.37		5.87	.00*			
Total TRF	.49	.10	.45	4.88	.00*			
Total TRA	-.67	.24	-.27	-2.85	.01*			
LF	.32	.29	.12	1.08	.28			

t, test; *p*, probability value; *F*, overall significance; *R*2, percentage variance explained; Δ*R*2, change in percentage variance explained; B, regression coefficient; SE, standard error.
a, Dependent variable: Total work engagement.

A Stepwise multiple regression analysis was done to evaluate how well Total transformational leadership, Total transactional leadership and Laissez-faire leadership predict Total work engagement. Table 5 indicates that Total transformational leadership produced a significant model in step 1 ($F_{(1,156)}$ = 56.81; p < 0,00) and account for 26.3% of the variance. In Step 2, Total transactional leadership was added to the model, producing a significant model ($F_{(2,156)}$ = 33.09; p < 0,00), accounting for 29.1% of the variance. In step 3, Laissez-faire leadership was added to the model, producing a significant model ($F_{(3,156)}$ = 22.47; p < 0,00), accounting for 29.2% of the variance. The results show that Total transformational leadership (β = 0,45; t = 4.88; p < 0.00) is the strongest significant predictor of Total work engagement, followed by Total transactional leadership (β = -0,27; t = -2.85; p < 0.01). Laissez-faire leadership (β = 0,12; t = 1.08; p < 0,28) is an insignificant predictor of Total work engagement.

5. Discussion

Management by exception- passive (transactional leadership) reported a negative relationship with work engagement. Leaders need to guide employees towards achieving organisational goals and when leaders fail to do that, employees may become less engaged or unable to achieve organisational goals. Gadirajurrett, Srinivasan, Stevens, and Jeena (2018) indicated that lack of guidance (e.g *Waits for things to go wrong before taking action*) may be the main cause of team ineffectiveness. This indicates that leaders need to provide guidance to reduce costs associated with corrective actions and poor performance of employees.

Intellectual stimulation (transformational leadership) reported a positive relationship with work engagement. This indicates that when leaders allow employees to think critically about new ways to complete tasks (e.g. *Seeks differing perspectives when solving problems*), they are more likely to be engaged in their work and find novel ways to execute their task more effectively. Almutairi (2015) found a positive relationship between brainstorming and creative problem solving skills.

Inspirational motivation (transformational leadership) reported a positive relationship with work engagement. It was noted that employers (leaders) need to motivate employees (e.g. *Expresses confidence that goals will be achieved*) to ensure that they perform their tasks effectively (Polackova, 2016). Poor performance can be related to a lack of motivation.

Individual consideration (transformational leadership, e.g. *Helps me to develop my strengths*) reported a positive relationship with work engagement. Jenkins (2012) found that employees are more motivated towards their work when they receive developmental opportunities. When employees are provided with opportunities to grow and develop they become persuaded to plough back these skills to their work.

This study found that contingent rewards (transactional leadership) are positively related to work engagement of employees. Communication regarding performance expectations and requirements forms part of contingent rewards (e.g. *Discusses in specific terms who is responsible for achieving performance targets*). Femi (2014) found that communication related positively with work performance and productivity. By providing feedback, employees can improve on future performance or know what they are doing well (Osborne & Hammoud, 2017). Praise (e.g. *Expresses satisfaction when I meet expectations*) and assistance (e.g. *Provides me with assistance in exchange for my efforts*) also forms part of contingent rewards. Jenkins (2012) found that praise and recognition motivated staff towards completing their duties. Supervisory support reported a positive relationship with engagement climate and work engagement (Albrecht, Breidahl, & Marty, 2018).

Hypothesis 1 of this study stated that there is a positive relationship between transformational leadership and work engagement. The findings of this study support this hypothesis and found that transformational leadership reported a positive relationship with work engagement. The results of this study are supported by Jangsiriwattana (2019) who found a positive relationship between transformational leadership and work engagement. Leaders who motivate, inspire and develop employees are likely to have employees that are engaged. Investing in employees through these different methods, employees are encouraged to work hard for the leader and achieve organisational goals. Transformational leadership (positively) predicted work engagement in this study. The result of this study supports hypothesis 4 of this study that assessed if transformational leadership is a significant predictor of work engagement.

Hypothesis 2 of this study aims to asses if there is a positive relationship between transactional leadership and work engagement. The findings of this study reject this hypothesis, contrary to some of the other studies. Most of the items that formed part of transactional leadership in this study stems from management by exception active (e.g. *Concentrates his/her full attention on dealing with mistakes, complaints, and failures*) and passive (e.g. *Demonstrates that problems must become chronic before taking action*). This indicates that when leaders are constantly focusing on the mistakes or failures and refrains from providing guidance it reduces employees work engagement levels. Employees may become too worried about failing again in future instead of being supported to take on new activities and use their own initiative. Aboramadan and Dahleez (2020); Jangsiriwattana (2019) found a positive relationship between transactional leadership and work engagement amongst employees. When a leader fails to intervene before matters become chronic it assures employees that they have their leaders support and guidance when tasks become difficult or when they need help. Transactional leadership (negatively) predicted work engagement. Hypothesis 5 of this study assessed if transactional leadership is a significant predictor of work engagement and was rejected.

Hypothesis 3 of this study aims to assess if there is a negative relationship between laissez-faire leadership and work engagement. The findings of this study support this hypothesis and found a negative relationship between Laissez-faire leadership and work engagement. The results of this study are supported by a study conducted by Moody (2012). When leaders fail to get involved with work activities, is available for guidance or avoids making decisions, it negatively

affects employees work engagement levels. Leaders are part of the job resources available for employees to be engaged in their work. Laissez-faire leadership was an insignificant predictor of work engagement. The results of this study rejected hypothesis 6 of the study that aimed to assess if laissez-faire leadership is a significant predictor of work engagement.

6. Recommendations and practical implications

When leaders "wait for things to go wrong before taking action", apart from costing organisations more money for corrective action, it may communicate a message related to a lack of direction. When employees don't know what the future holds for them or what their role is to achieve these goals, performance may be negatively affected. Leaders need to be vocal about the future, organisational goals and the role that employees need to execute. When leaders allow employees to execute their work duties and provide the needed support when needed, it communicates a message of support and allows employees to tackle new challenges with more confidence and ease.

This study recommends that leaders allow followers to think critically about how to execute work related duties. Through this way, followers feel empowered, have an opportunity to think creatively about ways to complete task and experience higher levels of ownership about the process. Instructing employees about work task, employees may feel excluded and does not necessarily "buy into" the task or its completion. Leaders are also cautioned to be aware about employees that may need additional guidance or support and which employees are able to function more independently.

Leaders are encouraged to communicate optimistically and confidently about the future as well as the outcome of future goals. Employees need to be motivated about the future goals and inspired about the possibility of success. Inspiration may be a catalyst that helps employees to persevere when duties get difficult and remain hopeful when faced with challenges at work. Being hopeful about the future motivates employees to become confident in their own abilities and the possibility of future success.

This study recommends that leaders spend time developing followers and provide opportunities within and outside the organisation to develop their skills and abilities. Employees may regard the development or developmental opportunities from their leader (organisation) as a token of appreciation and consideration. When followers notice that the leader (organisation) invests in them, they become more appreciative and reciprocate these gestures with additional effort and hard work.

Leaders need to praise and recognise employees for the work that they do well. By acknowledging the effort and extra determination employees invest in their job employees feel appreciated and become more engaged in their work. When employees are recognised for the work they do, they become more motivated towards the tasks and it enhances the quality of the relationship between leader and follower. A healthy relationship between leader and follower also reduces work stress and intention to leave.

Leaders need to motivate and inspire followers. This may persuade employees towards positive change and help them to achieve organisational goals. It is recommended that organisations specifically select or appoint leaders with charisma. Identifying potential leaders within the organisation would also benefit from leadership training where the ability to motivate and inspire followers can be cultivated. Specific focus can be placed on enhancing levels of self-efficacy and emotional intelligence.

It is suggested that leaders be involved with the processes and activities within the organisation. It is also suggested that when he/she gets involved that it's not only when things go wrong (chronic failure). Leaders need to get involved before things get out of control but also allow employees the necessary autonomy. It is suggested that leaders exercise control the same way they recognise and reward employees. Being overly focused on corrective measures, mistakes and disciplining employees instils fear, employees may become detach or withdrawn from the organisation.

Leaders need to respond timeously to enquiries and make decision when needed. Being an absent leader that does not respond to enquiries or one that does not make decisions frustrates employees and negatively affects productivity. Followers look up to leaders and expect them to provide guidance and rely on their judgement when needed.

7. Conclusion

This study adds to the limited literature within the field of Industrial/Organisational psychology and leadership in Namibia. A positive relationship was found between transformational leadership and work engagement. Transformational leadership was also a significant (positive) predictor of work engagement. Leaders that are able to inspire and motivate employees as part of this sample may enhance work engagement of followers.

A negative relationship was found between transactional leadership and work engagement. When leaders only focus on problems and mistakes, or avoids getting involved until problems become catastrophic, it reduces employees work engagement levels. Transactional leadership was also found to predict (negatively) work engagement.

Leaders that are absent, avoids making decisions or does not respond to enquiring reduces work

engagement. This study found that Laissez-faire leadership has a negative relationship with work engagement.

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Original Research Article

Antibacterial and anti-biofilm properties of *Aptosimum albomarginatum* (Marloth & Engl.) and *Dicoma schinzii* (O. Hoffm.) crude methanolic extracts against *S. aureus* and MRSA.

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Aptosimum albomarginatum, *Dicoma schinzii*, antibacterial, anti-biofilm, *S. aureus*, MRSA

ABSTRACT

Background: The effectiveness of phytomedicine is often questioned by scientists. This study therefore aimed to test crude methanolic extracts from two traditional medicinal plants currently being used in Namibia for their antibacterial and anti-biofilm activity against *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA). ***Materials and methods***: *Aptosimum albomarginatum* (Marloth & Engl.) roots and *Dicoma schinzii* (O. Hoffm.) roots and leaves were used to prepare crude methanolic extracts by maceration, filtration, rotary evaporation and freeze-drying. Thin layer chromatography (TLC) was used to detect flavonoids, saponins and anthraquinones in the plant material. For antibacterial activity, two *S. aureus* reference strains (one susceptible and one multi-drug resistant MRSA) and 10 *S. aureus* nasal isolates from school children were used in disk diffusion assays with crude methanolic plant extracts. The microtiter plate assay with crystal violet stain was used to determine if these extracts could inhibit and/or eradicate bacterial biofilms. ***Results***: *Aptosimum albomarginatum* root extract displayed moderately antibacterial activity against five nasal isolates (one MRSA isolate) and two reference strains, of which one was multi-drug resistant MRSA. This extract was also the best biofilm inhibition agent, with highly active inhibition (86.0%) observed in *S. aureus* ATCC 33591 (MRSA). *Dicoma schinzii* root extract had moderate antibacterial activity against six nasal isolates and the two reference strains; its leaf extract was moderately active against two nasal isolates. The *D. schinzii* leaf extract moderately inhibited biofilms in two nasal isolates and *S. aureus* ATCC 25923. Flavonoids and saponins detected in both the roots and leaves of the two plants may have contributed to the extracts' antibacterial and antibiofilm activity. ***Conclusion***: *Aptosimum albomarginatum* roots and *D. schinzii* roots and leaves displayed anti-staphylococcal activity, indicating potential use against staphylococcal infections involving the bacteria under study. Noteworthy is both antibacterial and anti-biofilm properties of *A. albomarginatum* root extract against MRSA.

1. Introduction

Globally many communities make use of traditional medicine to remain healthy and treat a variety of ailments. Traditional medicine may be just as effective as conventional drugs, but its effectiveness is often questioned by scientists (van Wyk & Wink, 2015). *Aptosimum albomarginatum* (Marloth & Engl.) is commonly known as "!Guxa" by the Nama tribe in Namibia. The roots are pulverized, boiled as a tea and drunk to purify the blood and cleanse the uterus. Some believe that it can cure women who experience difficulty in conceiving (Coetzee, 2015, personal communication; Frederick, 2015, personal communication). *Staphylococcus* may be associated with infections of the uterus, for example in the medical condition known as endometritis (inflammation of the endometrium). One form of this condition is known as bacteriotoxic endometritis, where it is caused by the toxins of bacteria rather than the presence of the pathogens themselves (Dorland's illustrated medical dictionary, 2003). The tea also helps to alleviate cold symptoms (Coetzee, 2015, personal communication; Frederick, 2015, personal communication). Colds are viral infections, however, according to Bischoff et al. (2006) sneezing as a result of cold symptoms allows for rapid spreading of bacteria in the nose, including Staphylococcus aureus, to a person's surroundings and other people. *Dicoma schinzii*

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(O. Hoffm.) is also known as "Gu-!aru" in the Nama language (Coetzee, 2015, personal communication) or the "Kalahari fever bush" (Dugmore & van Wyk, 2008), since unspecified parts of the plant are used to treat febrile convulsions in babies (van Wyk & Gericke, 2000; Dugmore & van Wyk, 2008). The roots and leaves are pulverized, boiled as tea and drunk or used to steam oneself in the treatment of measles, chickenpox, the flu, colds and a blocked nose (Coetzee, 2015, personal communication). Measles, chickenpox, the flu and colds are caused by viruses, but staphylococci may be involved in congested nose or sinus infections.

Some strains of staphylococci are biofilm producers. Hutcherson et al. (2015) define biofilms as dense, surface-attached communities of bacteria or fungi encased within a microbial-derived matrix that helps with colonization and survival. According to Speziale and Geoghegan (2015) the nasopharynx, heart valves, lungs and oral cavity are all sites for biofilm growth involving staphylococci and streptococci. Mack et al. (2013) and Nazzari et al. (2014), say that this formation helps the bacteria to withstand the host's natural immune defense mechanisms and to resist antibiotic treatment. Cowan (2012) explains that biofilm bacteria are often resistant to the same antimicrobials that work against them when they are free-floating. When attached to surfaces their gene expression is altered, leading to different antibiotic susceptibility profiles. According to Stefanović et al. (2012) bacterial resistance to antibiotics is a significant health problem. Solving this problem and the search for novel sources of antimicrobial agents is a global challenge and the aim of many researchers. Scientists have been screening plant extracts with the goal to discover new compounds effective for treatment of bacterial infections.

The present work assessed the antibacterial activity as well as biofilm inhibition and eradication properties of crude methanolic extracts from *A. albomarginatum* roots and *D. schinzii* roots and leaves against *S. aureus* and methicillin-resistant *S. aureus* (MRSA) nasal isolates and reference strains. Extracts were also screened for secondary metabolites that may contribute to their activity. We concluded that *Aptosimum albomarginatum* roots and *D. schinzii* roots and leaves displayed anti-staphylococcal activity, indicating potential use against staphylococcal infections involving the bacteria under study.

2. Materials and methods

2.1 Selection of plants and collection of plant material

Plant material was collected from the veld at Gochas (Altitude: 1139m; GPS coordinates: 24°47'S, 18°49'E), located in the Karas Region, southern Namibia in February 2015. The two plants were selected based on indigenous knowledge of local people about their medicinal value in the traditional setting. Voucher specimens were prepared and submitted to the herbarium at the National Botanical Research Institute (NBRI) in Windhoek for scientific identification of the plants. Plants were identified as the shrubs *Aptosimum albomarginatum* (Marloth & Engl.) and *Dicoma schinzii* (O. Hoffm.).

2.2 Plant parts and extracts used

Plant parts used were *A. albomarginatum* roots and *D. schinzii* roots and leaves. Crude methanolic extracts were prepared at the Biomedical Research Laboratory, Biological Sciences Department at the University of Namibia.

2.3 Preparation of crude extracts

To prepare crude methanolic extracts for bioassays, the maceration methods of Njateng et al. (2013) were followed, with some modifications. Plant material from the different plant parts was macerated in methanol (Skylabs, Johannesburg, SA). Flasks containing the extracts were parafilmed, placed in a cupboard and left to stand for three days with occasional swirling. After three days, the extracts were gravitationally filtered through Whatman 110mm filter papers. The extracts were rotary evaporated in round bottom flasks at reduced pressure (91mbar) and temperature (45°C) to evaporate the methanol, and to dry and concentrate them. To avoid thermal decomposition of compounds in the plant material, the temperature set for the rotary evaporator (Heidolph, Schwabach, Germany) did not exceed 45°C. The flasks were labeled, sealed with parafilm and frozen at -86°C for a few hours. Thereafter, the frozen extracts were connected to an Alpha 1-2 LD Plus freeze-dryer (Christ®,Osterode, Germany) for two to four days to further dry and concentrate them. Dried extracts were scraped off with a spatula, weighed and stored in labeled 50-ml centrifuge tubes (Greiner Bio-One, Kremsmünster, Austria) at -86°C for further use.

2.4 Phytochemical screening for flavonoids, saponins and anthraquinones

Antibacterial and anti-biofilm activity of plant extracts may be attributed to the presence of secondary metabolites such as flavonoids, saponins and anthraquinones. These compounds were screened for using thin layer chromatography (TLC) (Wagner & Bladt, 1996) on TLC gel 60 F_{254} aluminium sheets 20 x 20cm (Merck, Darmstadt, Germany). Five 2-ml Eppendorf tubes (Eppendorf, Germany) containing methanol were used, three for plant extracts and two for phytochemical standards (positive controls). Plant extracts and phytochemical standards were added to the respective tubes for spotting the TLC plates. Mobile phases (solvents) were prepared according to the ratios given in Table 1. Spraying reagents for confirmation of compounds belonging to the two

phytochemical classes were also prepared (Table 1). The developed TLC plates were viewed at visible and under UV light at 366nm (blue light, long wavelength). A pencil was used to trace around the most prominent spots/bands and observed colours were recorded. Chromatograms were placed on paper towels in a fume hood and sprayed with the appropriate spraying reagents. These were dried in the fume hood, and viewed again under UV light. Any colour changes and new spots/bands were circled and recorded. As described by Maobe et al. (2012) distances travelled by the solvents and the spots/bands were measured with a ruler and used to calculate retention factor (R_f) values: R_f = distance travelled by compound / distance travelled by solvent.

Table 1 Mobile phases (solvents), controls and spraying reagents used for TLC, adapted from Wagner and Bladt (1996).

Phytochemical class and standards (controls) used	Mobile phase	Spraying reagent and expected result
Flavonoids Control: Quercetin dihydrate (97%)	Ethyl acetate : Formic acid : Acetic acid : Water 100 : 11 : 11 : 27	1.0% Antimony (III) chloride in chloroform. Dark yellow, orange, green, or blue fluorescent spots at 366nm (intensified by spraying). Also detectable in visible light. Quercetin is orange-yellow or yellow-green. Flavonoid extracts often contain coumarins, which form blue, light blue or green fluorescent zones.
Saponins Control: Saponin	Butanol : Ethyl acetate : Acetic acid : Water 10.8 : 3.6 : 0.2 : 2.7	Vanillin-sulphuric acid reagent; sprayed plates heated at 110°C for 5-10 minutes. Blue, blue-violet, red, or yellow-brown zones in visible light. With some exceptions, saponins are not detectable under UV light and need spraying reagents.

2.5 Antibacterial and anti-biofilm activity

2.5.1 Microorganisms used

Ten *S. aureus* isolates (including one MRSA isolate) originating from nasal specimens of healthy school children aged 6-14 years in the Mariental District, Namibia, as well as commercially obtained *S. aureus* ATCC 25923 and *S. aureus* ATCC 33591 (MRSA) (Microbiologics®, St. Cloud, USA) were used in disk diffusion and microtiter plate assays with crude methanolic plant extracts.

2.5.2 Antibacterial activity

2.5.2.1 Disk diffusion assays

Disk diffusion assays based on the Kirby-Bauer technique (Harley & Prescott, 2002) were performed to determine the antibacterial effects of the different plant extracts on staphylococci. Extract concentrations of 60mg/ml, 30mg/ml, 10mg/ml, 5mg/ml, 0.5mg/ml, and 0.1mg/ml were prepared in 2-ml Eppendorf tubes (Eppendorf, Germany) each containing undiluted dimethyl sulfoxide (DMSO) (Merck, Darmstadt, Germany) and vortexed well to dissolve. A tube with only DMSO was kept to use as control. The assay was done in triplicate for each isolate. Whatman filter paper disks (110mm) were used to punch out smaller 6mm disks. The small disks were autoclaved in a screwed cap test tube before use. Bacterial-saline suspensions adjusted to 0.5 McFarland standard were swabbed onto Mueller-Hinton agar (Mast Diagnostics, Merseyside, UK) and the plates were left to dry for 5 minutes before applying the filter paper disks with a flamed tweezer onto the agar. Extracts (10µl) were pipetted onto the disks. Gentamicin (10µg) or chloramphenicol (30µg) antibiotic disks (Mast Diagnostics, Merseyside, UK) were applied as positive controls and disks containing DMSO as negative controls. Plates were incubated at 37˚C for 18-20 hours and inhibition zones measured with a ruler to the nearest millimeter. The classification by Nematollahi et al. (2011) was used to interpret results: ≤ 7mm inhibition (negative), 8-10mm (weak activity), 11-14mm (moderate activity), 15-24mm (strong activity), and ≥ 25mm (very strong activity). Results were compared with the antibiotic susceptibility profiles of isolates to see if the extracts have potential to be used as antimicrobial agents. Minimum inhibitory concentrations (MICs) were taken as the lowest concentration of extract that were able to inhibit bacterial growth on each plate.

2.5.3 Anti-biofilm activity

2.5.3.1 Microtiter plate assay for biofilm inhibition

For biofilm assays, the methods of Christensen et al. (1985), Merrit et al. (2011), and Monte et al. (2014) were used, with some modifications. Cultures were inoculated into 50-ml centrifuge tubes (Greiner Bio-One, Kremsmünster, Austria) containing brain heart infusion broth (Merck, Darmstadt, Germany) and grown to stationary phase at 37°C for 24 hours. The stationary phase cultures were then diluted 1:100 (a 0.5 McFarland standard) and some of the diluted culture was added to each of six wells in a sterile flat-bottomed 96-well microtiter plate (Thermo Fisher Scientific, Newport, UK). Figure 1 shows the plate layout. Three of these six wells were each inoculated with previously determined sub-minimum inhibitory concentrations (sub-MICs) of plant extract. Eight wells each contained sterile brain heart infusion broth only as control. After incubation, planktonic cells were removed by placing the microtiter plate upside down on towel paper and allowing for the paper to soak up any liquid. To remove remaining planktonic cells, each well was washed three times by pipetting sterile distilled water into it and inverting the plates onto towel paper. The biofilms in the wells were fixed by oven-drying the microtiter plates for 45 minutes at 60°C. Wells were stained with 0.1% crystal violet, incubated for 15 minutes at room temperature and the crystal violet discarded. Excess stain was removed by washing (pipetting) three times with sterile distilled water. Plates were air-dried for a few hours. Wells were de-stained with 33.0% glacial acetic acid (Merck, Darmstadt, Germany) for 10-15 minutes. The contents of each well was briefly mixed by pipetting and transferred to corresponding wells of a new clean microtiter plate. The optical densities (ODs) of stained biofilms were determined with a SpectraMax M2 Multi-mode Microplate Reader (Molecular Devices, China) at 595nm. Readings from the sterile brain heart infusion broth control wells were averaged and subtracted from the test readings. Test readings were averaged and standard deviations calculated. Results for biofilm formation/inhibition were interpreted using the classification by Christensen et al. (1985). The equation I% = [1 – (A595 of test / A595 of non-treated control) x 100] was used to calculate percentage inhibition (Kawsud et al., 2014). According to Manner et al. (2013) selection criteria (activity-based) for antimicrobials are as follows: Highly active (≥ 85.0% inhibition); moderately active (≥ 40.0% inhibition); inactive (< 40.0% inhibition).

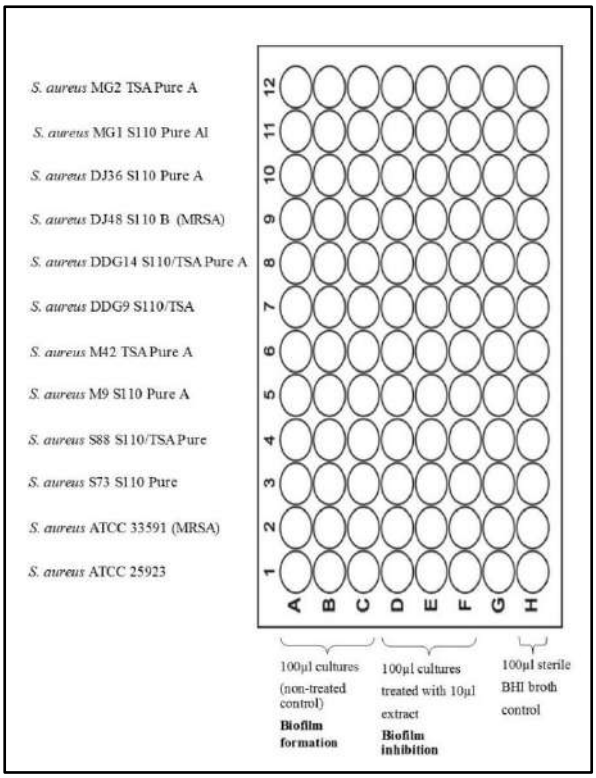

Figure 1 Schematic representation of the plate layout.

2.5.3.2 Microtiter plate assay for biofilm eradication

Stationary-phase cultures were diluted 1:100 and some diluted culture was added to each of six wells of a sterile flat-bottomed 96-well microtiter plate. Eight wells each contained sterile brain heart infusion broth only as control. The plates were parafilmed at the lids to prevent them from drying out and incubated at 37°C for 24 hours. After incubation, planktonic cells were removed by decanting onto towel paper. To remove remaining planktonic cells, each well was washed three times by pipetting sterile distilled water into it and inverting the plate onto towel paper. Three wells with the grown biofilms were inoculated with extract (just below MIC) and sterile distilled water. The remaining wells were filled with sterile distilled water and plates were incubated at room temperature for another 24 hours. After the second incubation and removal of liquid in the wells, the same steps for fixing, staining and de-staining were followed as for the inhibition assay. The equation E% = [1- (A_{595} of test / A_{595} of non-treated control) x 100] (Kawsud et al., 2014) was used to calculate percentage eradication. The classification of activity for inhibition by Manner et al. (2013) was also used to interpret eradication results.

3. Results and Discussion

3.1 Phytochemical screening

Thin layer chromatography indicated the presence of flavonoids and saponins in all of the plant extracts, whereas anthraquinones were not detected (See Tables 2 and 3). For *A. albomarginatum* roots, one flavonoid spot of R_f 0.92 was observed. Close to our results, Hussain et al. (2011) detected a blue flavonoid spot with a R_f value of 0.94 at UV 365nm for methanolic extract of *Figonia critica*. In the present study, three saponin spots (R_f values 0.15, 0.49 and 0.94) were obtained. After derivatization with vanillin-sulphuric acid reagent and heating at 105°C, Priya et al. (2014) obtained a purple saponin spot with R_f 0.94 from chloroform extract of *Milagathi chooranam*. In this work, for *D. schinzii* roots, four flavonoid spots of R_f values 0.08, 0.28, 0.57 and 0.97 were present. Two saponin spots with R_f values 0.71 and 0.96 were observed. With *D. schinzii* leaves, there were four flavonoid spots (R_f 0.43, 0.59, 0.69 and 0.96) and three saponin spots (R_f 0.50, 0.71 and 0.96). Using TLC, Olivier (2012) detected steroids, terpenoids, bitter principles, saponins and flavonoids in *Dicoma* species, including *D. schinzii.*

Table 2 Screening for flavonoid compounds in plant extracts based on R_f values and colour changes on chromatograms before and after spraying with 1.0% antimony (III) chloride reagent.

	Compound number and R_f in brackets	Colour before spraying	Colour after spraying	Identification
Extract 1: ***A. albomarginatum*** **roots**	1. (0.92)	Light fluorescent blue at UV 366nm	Yellow in visible light	Flavonoid
Extract 2: ***D. schinzii*** **roots**	1. (0.08) 2. (0.28) 3. (0.57) 4. (0.97)	Light fluorescent blue at UV 366nm Light fluorescent blue at UV 366nm Light fluorescent blue at UV 366nm Light fluorescent blue at UV 366nm	Became colourless Became colourless Stayed the same Yellow in visible light	Flavonoid Flavonoid Flavonoid Flavonoid
Extract 3: ***D. schinzii*** **leaves**	1. (0.43) 2. (0.59) 3. (0.69) 4. (0.96)	Light fluorescent blue at UV 366nm Light fluorescent blue at UV 366nm Fluorescent yellow at UV 366nm and yellow in visible light Light fluorescent blue, pink and orange mixture at UV 366nm	Yellow in visible light Stayed the same Stayed the same Yellow in visible light	Flavonoid Flavonoid Flavonoid Flavonoid
Control/standard: Quercetin dihydrate (97%)	1. (0.97)	Fluorescent yellow-green at UV 366nm and yellow-green in visible light	Brighter yellow-green	Quercetin dihydrate (flavonol)

Table 3 Screening for saponin compounds in plant extracts based on R_f values and colour changes on chromatograms before and after spraying with vanillin-sulphuric acid reagent.

	Compound number and R_f in brackets	Colour before spraying	Colour after spraying	Identification
Extract 1: ***A. albomarginatum*** **roots**	1. (0.15) 2. (0.49) 3. (0.94)	Colourless Colourless Light fluorescent blue at UV 366nm	Purple in visible light Purple-brown in visible light Purple-brown in visible light	Saponin Saponin Saponin

Extract 2: *D. schinzii* roots	1. (0.71)	Colourless	Purple-brown in visible light	Saponin
	2. (0.96)	Light fluorescent blue at UV 366nm	Purple-brown in visible light	Saponin
Extract 3: *D. schinzii* leaves	1. (0.50)	Yellow-brown in visible light	Stayed the same	Saponin
	2. (0.71)	Yellow-brown in visible light	Stayed the same	Saponin
	3. (0.96)	Fluorescent orange-pink mixture at UV 366nm	Green at UV 366nm and purple in visible light	Saponin
Control/standard: Saponin	1. (0.1)	Colourless	Red in visible light	Saponin

3.2 Antibacterial activity

3.2.1 *Aptosimum albomarginatum* root extract

Using disk diffusion assays, at the highest (60mg/ml) concentration, *A. albomarginatum* root extract was moderately active against five nasal *S. aureus* isolates (one MRSA isolate and the two *S. aureus* reference strains ATCC 25923 and ATCC 33591). The largest inhibition zone (13.67 ± 0.58mm) was observed against *S. aureus* DJ36 S110 A. This isolate was obtained from the nose of a 9-year-old boy. Based on inhibition zone size, the root extract was not more effective than the antibiotic control gentamicin (GM) 10µg, that had an average inhibition zone of 23.33mm. As observed in this study and other studies (Kamonwannasit et al., 2013; Carranza et al., 2015) flavonoids and saponins may play a role in the root extract's antibacterial activity.

3.2.2 *Dicoma schinzii* root extract

By disk diffusion assay, at the highest (60mg/ml) concentration, *D. schinzii* root extract was moderately active against six nasal isolates and the two reference strains, as depicted in Figure 2. This extract displayed weak activity against MRSA. The largest inhibition zone (14.0 ± 0mm) was observed against *S. aureus* M9 S110 Pure A, isolated from the nose of a 7-year-old girl. The root extract was not more effective than the control antibiotics chloramphenicol (C) 30µg or gentamicin (GM) 10µg, that had average inhibition zones of 23.5mm and 18.84mm, respectively. Flavonoids and saponins in the roots may have antibacterial properties.

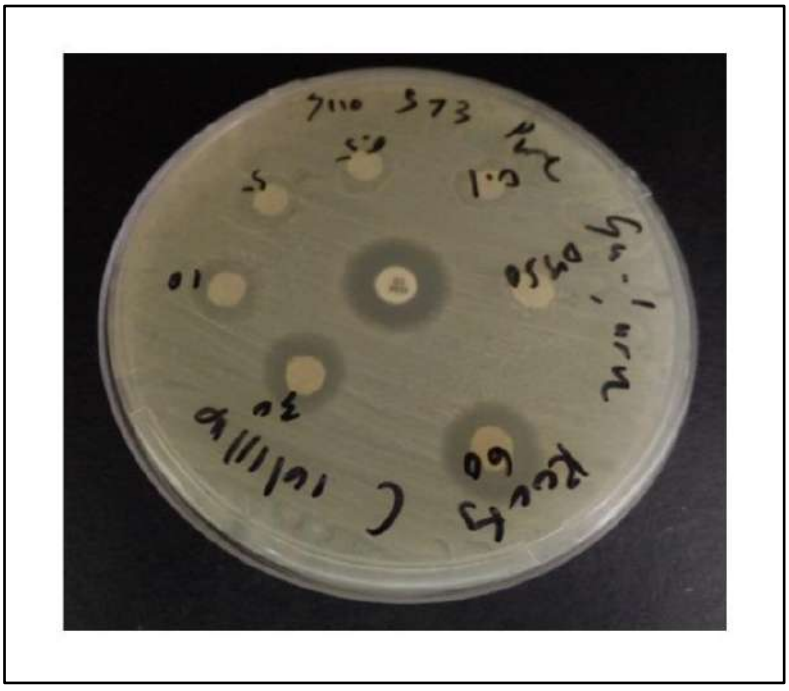

Figure 2 Moderate antibacterial activity of *D. schinzii* root extract at 60mg/ml and 30mg/ml concentrations, with inhibition zones of 13.1 ± 1.0mm and 11.67 ± 0.58mm, respectively.

3.2.3 *Dicoma schinzii* leaf extract

According to disk diffusion assays, at 60mg/ml, *D. schinzii* leaf extract was moderately active against only two *S. aureus* nasal isolates, with an average inhibition zone of 12.33 ± 0.58mm for each of them. This activity may partly be attributed to the presence of flavonoid and saponin compounds in the leaves. The extract showed very weak activity against the MRSA strain ATCC 33591. It was less active than the antibiotic control chloramphenicol (C) 30µg, that inhibited bacterial growth by an average of 17.89mm.

3.4 Anti-biofilm activity

3.4.1 Biofilm inhibition

As shown with the microtiter plate assay, overall, *A. albomarginatum* root extract was the best biofilm inhibition agent, with highly active inhibition (86.0%) observed in *S. aureus* ATCC 33591 (MRSA), and moderate activity in four other nasal isolates (Figure 3).

Flavonoids and saponins were detected in the plant's roots (Tables 2 and 3) and leaves. These secondary metabolites may play a role in its activity. Manner et al. (2013) observed 10 commercially bought flavonoids to be highly active, causing more than 85.0% biofilm inhibition and eradication against the clinical strains *S. aureus* ATCC 25923 and the Newman strain. Kamonwannasit et al. (2013) found that *Aquilaria crassna* leaf extract, containing flavonoids and saponins, could inhibit biofilm formation in *Staphylococcus epidermidis*. They explained that destruction of the bacterial cell wall by the plant extract prevents bacteria from growing and creating primary biofilm structures. In our study, *Dicoma schinzii* leaf extract moderately inhibited biofilm formation in two nasal isolates and the reference strain ATCC 25923. *Dicoma schinzii* roots were classified inactive against staphylococci in this study.

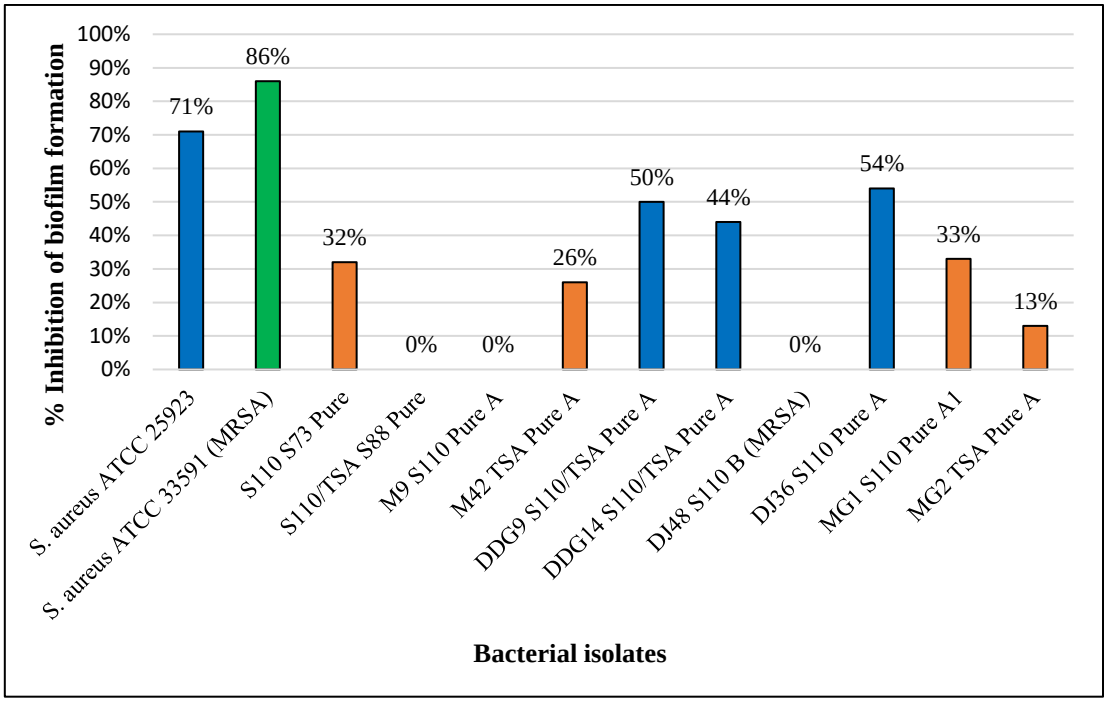

Figure 3 Percentage biofilm inhibition in microtiter plates by treatment with *A. albomarginatum* crude methanolic root extract. Classification of activity according to Christensen et al. (1985): ≥ 85.0% inhibition (highly active); ≥ 40.0% inhibition (moderately active); < 40.0% inhibition (inactive).

3.4.2 Biofilm eradication

Biofilm eradication was observed in microtiter plate assay only with *A. albomarginatum* root extract in only one *S. aureus* nasal isolate from an 11-year-old boy. It destructed the biofilm of this isolate by 40.0% (moderate activity). As stated previously, this activity may partly be attributed to the presence of flavonoid and saponin compounds in the plant's roots.

4. Conclusion

This study evaluated crude methanolic extracts from two traditional medicinal plants currently being used in Namibia for their antibacterial and anti-biofilm activity against *S. aureus* and MRSA. *Aptosimum albomarginatum* roots and *D. schinzii* roots and leaves displayed antibacterial activity, indicating potential use against staphylococcal infections. *Aptosimum albomarginatum* root extract was the best anti-biofilm agent against *S. aureus*. It was highly active in inhibiting

biofilm formation in one MRSA reference strain, and moderately active in inhibiting formation in four nasal isolates. This extract moderately eradicated the biofilm in one nasal isolate. Noteworthy is both antibacterial and anti-biofilm properties of *A. albomarginatum* root extract against MRSA. *Dicoma schinzii* leaf extract moderately inhibited biofilms in two nasal isolates and *S. aureus* ATCC 25923. Flavonoids and saponins may contribute to extracts' activity. The present work supports the traditional medicinal use of *A. albomarginatum* roots and *D. schinzii* roots and leaves as natural anti-staphylococcal agents in infections involving the bacteria under study.

Conflicts of interests
The authors declare no conflict of interest.

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