Evaluating an energy efficiency behaviour-based training programme

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It all starts here ™

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COMMENTS

The reader is reminded of the following:

- The referencing style as prescribed by the *Publication Manual* (6th edition) of the American Psychological Association (APA) was followed in this dissertation.
- The dissertation is submitted in the form of a research article.

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SUMMARY

Title: Evaluating an energy efficiency behaviour-based training programme

Key terms: Greenhouse gases, energy efficiency, behaviour-based training, return on investment, Kirkpatrick's model, quasi-experimental design.

Globally, the concern amongst countries is the harmful effect of greenhouse gas emissions on the environment; the challenge therefore is for countries to implement strategies in order to reduce energy usage which is the main cause of greenhouse gas emissions, in order to ensure environmental sustainability. In South Africa, the challenge is intensified to ensure security of electricity energy supply due to the current high demand for electricity. Moreover, there has been a steep increase in electricity costs in the last five years which forces the mining industry in South Africa to look for ways to reduce energy usage in order to sustain financial viability.

Energy efficiency achieved through change of human behaviour has been identified as an essential strategy that greatly reduces energy usage with minimal financial investments. However, not a single study was found in South Africa which quantified the amount of electricity that can be saved through behavioural change interventions. Previous research postulated that behaviour was affected by individual factors such as values, beliefs and norms as well as social factors such as cultural and social norms. This study proposed an energy efficiency behaviour-based training intervention assessed as per Kirkpatrick's model to change employee behaviour towards saving energy at the mine in Limpopo province. Furthermore, Kirkpatrick's model was complemented with Phillips' model in order to quantify the return on investment (ROI) of implementing energy efficiency behaviour-based training.

The primary objective of this study, therefore, was to investigate whether energy efficiency behaviour-based training impacts positively on the electricity consumption at a mine in Limpopo, South Africa. A quasi-experimental research design was employed; this was to allow the effect of the training intervention to be isolated from other factors that may not be related to training. The results showed that employees' energy awareness correlated with energy saving behaviour; however, there were no significant changes to electricity consumption as a result, meaning that the training intervention did not significantly change

employees' overall behaviour towards energy savings. Finally, recommendations for the organisation and future research were made.

OPSOMMING

Titel: Evaluering van ‘n energiedoeltreffendheid optrede-gebaseerde opleidingsprogram

Sleutelterme: Kweekhuisgasse, energiedoeltreffendheid, optrede-gebaseerde opleiding, opbrengs op belegging, Kirkpatrick se model, kwasi-eksperimentele ontwerp.

Lande wêreldwyd ervaar kommer oor die skadelike uitwerking van kweekhuisgas-emissies op die omgewing; die uitdaging is dus vir lande om strategieë te implementeer om energieverbruik, die hoofoorsaak van kweekhuisgas-emissies, te verminder sodat omgewingsvolhoubaarheid verseker kan word. Die uitdaging in Suid-Afrika om ‘n betroubare elektrisiteitsbron te voorsien is groter as gevolg van die huidige hoë aanvraag na elektrisiteit. Verder was daar ‘n skerp verhoging in elektrisiteitskostes oor die afgelope vyf jaar wat die myn-industrie in Suid-Afrika gedwing het om maniere te vind om energieverbruik te verminder, sodat finansiële lewensvatbaarheid volhou kan word.

‘n Belangrike strategie, met minimale finansiële insette, om energieverbruik aansienlik te verminder, is geïdentifiseer as energiedoeltreffendheid wat deur verandering in menslike optrede teweeggebring word. Geen studie in Suid-Afrika kon egter gevind word wat die moontlike besparing van elektrisiteit deur optrede-veranderende intervensies kwantifiseer nie. Vorige navorsing het gevind dat optrede beïnvloed word deur individuele faktore soos waardes, oortuigings en norme, asook deur sosiale faktore soos kulturele en sosiale norme. Hierdie studie stel ‘n energiedoeltreffendheid optrede-gebaseerde opleidingsintervensie voor, soos deur Kirkpatrick se model geëvalueer, om werknemeroptrede in terme van energie-besparing by ‘n myn in die Limpopo-provinsie te verander. Kirkpatrick se model is verder gekomplementeer deur Phillips se model om die opbrengs op belegging van die implementering van energiedoeltreffendheidsoptrede-gebaseerde opleiding te kwantifiseer.

Die primêre doelwit van hierdie studie was dus ‘n ondersoek na die moontlikheid dat energiedoeltreffendheidsoptrede-gebaseerde opleiding die elektrisiteitsverbruik by ‘n myn in Limpopo, Suid-Afrika, positief sal beïnvloed. ‘n Kwasi-eksperimentele navorsingsontwerp is gebruik om die uitwerking van die opleidingsintervensie te isoleer van ander faktore wat moontlik nie verwant daaraan is nie. Die resultate het gewys dat die werknemers se bewustheid van energie aansienlik verbeter het as gevolg van die energiedoeltreffendheids-optrede-gebaseerde opleiding. Die resultate het egter geen noemenswaardige veranderinge in elektrisiteitsverbruik getoon nie; met ander woorde, die opleidingsintervensie het nie die

werknemers se algemene optrede teenoor energiebesparing verander nie. Daar is ten slotte aanbevelings gemaak vir die organisasie, asook vir toekomstige navorsing.

CHAPTER 1

INTRODUCTION

This mini-dissertation is about evaluating an energy efficiency behaviour-based training programme at a mine in South Africa.

Chapter 1 contains the background and motivation of the research, the problem statement, research objectives, research methodology, ethical considerations, and the division of chapters.

1.1 BACKGROUND AND MOTIVATION OF THE RESEARCH

Globally, the rise in world population and increased migration of people to big cities have caused an annual increase in demand for primary energy and electricity energy. In particular, the demand for primary energy has been rising by 1.3% per year and the demand for electricity has been rising by 2.3% per year up until 2012 (World Energy Council, 2013). Most recently, according to Dudley (2016), this figure has since dropped to 1.1% due to the weak economic environment. According to Pegels (2010), most of the greenhouse gas emissions originated from the energy sector due to continual growth in demands for energy. The great concern globally is the need to reduce greenhouse gas emissions which are detrimental to the climate in order to ensure sustainability; since 70% of global oil and gas reserves are located in just a few countries, there is a driving trend towards cleaner technology and higher efficiency in the use of energy. Various countries have made energy efficiency a policy in order to motivate industries and people to become energy conscious; moreover, renewable energy technologies have become the new means of power generation as substitute for power generation with greenhouse gas emissions (World Energy Council, 2013).

South Africa is not immune to the global challenge; there has been a growing demand for electricity over the last few years. From 2002 to 2009, the number of households with electricity increased by 8.2%, which led to an increase in demand (Statssa.gov.za, 2012). Eskom, the power utility company responsible for 95% of the power generation in South Africa, has been experiencing supply shortages during peak times with subsequent rolling blackouts in the country. Eskom has embarked on increasing the energy supply capacity by building two new coal power plants; moreover, Eskom has established energy saving incentives whereby customers who use energy efficiency technologies were given rebates for replacing old technology with new efficient technology. Eskom has been calling on all consumers and industries to save 10% of electricity in order to meet the supply requirements (Eskom.co.za, 2014).

Rising electricity costs and concern for greenhouse gas emissions have been a driving force in South Africa where businesses have been looking for energy efficient means to stay competitive (Engineeringnews.co.za, 2013). Baker (2011) warned that until 2008, South Africa has had an era of

cheap electricity, due to high availability of coal reserves. According to Kosmo (1987), electricity, natural gas, and coal subsidies have led to inefficient use of energy by industries due to energy being so inexpensive. In the mining industry, in particular, costs of electricity have increased by 19.4% since 2008, which is not favourable for the industry that is currently suffering a decline in commodity prices, resulting in low profitability and job losses (Engineeringnews.co.za, 2016). The goals towards saving energy and securing the supply of electricity by Eskom have become crucial in the mining industry, in order for mining companies to stay profitable and to avoid further job losses in South Africa. Therefore, this study is undertaken at a mine in South Africa's Limpopo province to study factors that influence the behaviour of employees towards being more energy efficient; thereby contributing to electricity cost savings.

StatsSA's (2014) general household survey data reveals that consumers were likely to support electricity savings initiatives as follows:

- 84.5% of household consumers used electricity for cooking, whilst the balance used other methods such as gas stoves; and
- 27% were willing to switch off their geysers whilst not being used; 85.3% were willing to switch off lights whilst leaving their houses.

These statistics indicate that some consumers are more inclined towards saving energy, whilst others are not; therefore, the aim of the research is to unpack why some people save energy, while others do not. By focusing on factors that drive human behaviour towards participating in saving initiatives, this study makes recommendations on how organisations can facilitate an environment where members develop habits of saving energy.

1.2 PROBLEM STATEMENT

South Africa, being a developing country, receives significant contributions to the country's gross domestic product (GDP) from mining and manufacturing industries which are energy intensive by nature. The historically low electricity prices and lack of public awareness about the consequences of high energy usage in South Africa have contributed to a lack of energy efficiency behaviour amongst users, since there has been no apparent incentive to save energy (Inglesi-Lotz & Pouris, 2012). South Africa Department of Minerals and Energy (2005) emphasised the fact that the previous era of cheap electricity in South Africa has caused industries to regard energy efficiency as a low priority in their businesses.

Industrial development worldwide is necessary to drive economic growth; however, greenhouse gas emissions which are detrimental to climate change are increasing. The increase in more consumption of energy has been explained by the theory of rebound effect which posits that the more

the consumer benefits from savings derived from use of less energy, the more the consumer continues to use energy as a result of their increased buying power (European Environmental Agency, EEA, 2013). According to EEA (2013), the EU member states were not on track to reduce primary energy by 20% by 2020; therefore, in an effort to reduce energy, the European Union adopted the energy efficiency directive in December 2012. South Africa is also facing the same challenges whereby the historical era of low energy prices have led the country towards being more energy intensive (EEA, 2013). Therefore, internationally, the common goal is to reduce greenhouse gas emissions to ensure sustainable economic development (Inglesi-Lotz & Pouris, 2012).

Energy efficiency has been recognised as the essential mitigation strategy in formulating energy policies that will lead to a reduction in greenhouse gas emissions (Abdelaziz, Saidur, & Mekhilef, 2011). South Africa Department of Minerals and Energy (2005) explains that energy efficiency is doing the same job - such as producing the same product - but using less energy and is therefore regarded as the best strategy to reduce greenhouse gas emissions. In European countries, the EU suggests that there have been considerable improvements in energy efficiency through the use of different strategies, including the implementation of energy efficiency policies. In particular, a reduction of energy through replacing current infrastructure by more efficient technology has yielded savings of up to 27% in the residential sector and 30% in the services sector (Lopes, Antunes, & Martins, 2012). These authors warned that even though energy behaviours contribute in a major way to energy usage in buildings, the quantification of potential energy savings through behavioural changes is often overlooked. In line with Lopes et al. (2012), Varone and Aebischer (2001) substantiate that the potential of energy savings related to end users' efficient use of energy remains unexploited.

Research in social and environmental psychology has been mainly focused on the residential sector, reviewing the effectiveness of interventions aimed at encouraging households to reduce their energy consumption (Abrahamse, Steg, Vlek, & Rothengatter, 2005). Research pertaining to energy saving behaviour in the residential sector is predominantly based on individual factors influencing behaviours, with the focus on the psychological theoretical framework aimed at environmental concerns. In particular, values, attitudes, and norms - called the value-belief-norm (VBN) theory - propose causal relationships between personality, beliefs, responsibility, and attitude. In literature, 38 studies were reviewed and characterised according to the following questions (Abrahamse et al., 2005):

- To what extent did the intervention result in behavioural change?
- Were underlying behavioural factors examined and could they be attributed to behavioural changes? and
- Were the changes in behaviours sustained?

The various studies included antecedents of behaviour such as commitment, information, goal setting, mass media, modelling, feedback, and rewards. There were considerable improvements in the change of participants' behaviour through various interventions, but the behaviours were not sustained for long. Table 1 shows the difference in the change of participants' energy saving behaviour over a short period during intervention and the corresponding results after one or two years on follow-up.

Table 1

Examples of Studies Conducted in the Residential Sector

Author	Intervention	Targeted behaviour	Effect during intervention (percentage decrease) indicated	Long term effect on follow-up (percentage decrease) indicated
McDougall et al. (1982–1983)	Information (tailoring)	Various behaviours related to heating	Not reported	No difference in number of energy saving activities
Staats et al. (2004)	Information Individual feedback Comparative feedback	Gas and water usage Electricity and gas usage Waste, food, transport usage	Gas use: decreased by 20.5% Electricity use: decreased by 4.6% Water use: 2.8%, Waste: 32.1%	After 2 years, savings not maintained Gas usage decreased by 16.9% Electricity usage decreased by 7.6%, Water usage decreased: 6.7%, Waste: 32.1%
Van Houwelingen and Van Raaij (1989)	Feedback Goal setting (10%) Self-monitoring Information	Gas usage	Continuous feedback: 12.3% Monthly feedback: 7.7% Self-monitoring: 5.1% Information: 4.3%	After one year, gas usage increased for all groups, compared to baseline
Winett et al. (1985)	Information	Gas and electricity usage	Exposure to TV programmes resulted in electricity savings of 10%	After one year, saving was not maintained

Note. Adapted from Abrahamse et al. (2005).

From Table 1, it is observed that the interventions focused mainly on changing individual level behaviours by providing information and feedback in order to change attitudes and abilities that are in line with psychological perspectives. According to the results, it is clear that individuals' attitudes and knowledge are positively linked to energy savings. However, since low energy utilisation results had not been maintained, it was recommended that thorough research is needed into determinants of energy usage behaviour (Abrahamse et al., 2005).

Furthermore, Linden, Carlson-Kanyama, and Eriksson (2006) took a broader look at policy practice measures towards lowering energy behaviour, based on empirical evidence from households in Sweden. They found that households were oblivious of energy usage and some were saving because of time-related factors, such as using a microwave for faster cooking compared to the more time-consuming conventional stove, as opposed to energy conservation. One observation was that consumers who had metering and feedback on the consumption of energy were more energy efficient than those who had not. Studies within the residential sector also revealed that real-time feedback was effective in influencing households to reduce energy; moreover, the use of comparative feedback where pricing schemes were matched influenced households towards saving energy (e.g., Carrico, & Riemer, 2011; Darby, 2006). In particular, a study conducted by Darby (2006) revealed that direct feedback to household occupants on their use of energy resulted in savings of energy between 5-15%. These factors influencing effectiveness of feedback to users were also related to the reinforcement theory advocated by Skinner (as cited by Sinding & Waldstrøm, 2014), namely that behaviour is controlled by consequences in that people will repeat those behaviours that produce positive consequences and let go of behaviours that produce negative consequences (Sinding & Waldstrøm, 2014). However, as per Table 1, the intervention of feedback was not proven to be sustainable.

Lopes et al. (2012) suggest that energy behaviours are complex and are not only influenced by individual factors, but also by contextual factors. Contextual factors include social science theories towards understanding behaviour. It is argued that social norms also play a crucial part in shaping energy behaviours. Stephenson, Barton, Carrington, Gnoth, Lawson, and Thorsnes (2010) argue that the prevalence of social and environmental psychology which supports knowledge, attitudes, value-belief norms, habits, and external characteristics has a major influence on energy behaviour. Furthermore, these authors argue that sociological theories on social constructs, organisational behaviour, embeddedness, social-technical systems, and decision making in cultural and social contexts influence energy behaviour.

Sociology being a science of how society is viewed, provides different perspectives with which to explain and predict the social world; sociological theories consist of interrelated concepts and principles of sociology (Knox, Mooney, & Schacht, 2007). Three major sociological theory perspectives include functionalist perspectives, conflict perspectives, and interactionalist perspectives. (Knox et al., 2007). The functional perspective posits that the members of society are mutually dependent on one another like an organism; the conflict perspective argues that the difference in

economic classes of society is beneficial in advancing industrialisation in the world; and the interactionist perspective asserts that human behaviour is influenced by definitions and meanings through interaction with others, i.e. individual's behaviour is influenced by how others view and interact with the individual. (Knox et al., 2007).

Implications for organisations are that a social environment, in which energy saving behaviour is promoted, influences individuals to save energy; thus, as reiterated by Steg and Vlek (2009), social norms strengthen individual behaviour. The combination of individual factors and social norms influencing behaviour was researched by Steg and Vlek (2009), who highlighted behavioural interventions that are effective when systematically planned, implemented, and evaluated. They proposed a framework comprising four key issues: (a) recognising behaviour to be changed; (b) assessment of underlying behavioural factors; (c) design and implementation of interventions to change behaviour in order to reduce the environmental impact; and (d) evaluation of the extent to which interventions changed behaviour. These authors reiterate that this framework is effective because it is aimed at targeting identified individual behaviours and removing barriers for change. Furthermore, a focus on removing barriers for change suggests that behavioural intervention strategies can be reinforced if social support and role models are provided to strengthen social norms.

Social norms fall within the ambit of the social practice theory, and Sahakian and Wilhite (2013) describe stages of the latter theory as comprising three pillars, namely people and the knowledge they embody, both physically and mentally; things or the objects and infrastructures that influence and are influenced by everyday life; and socially grounded contexts, a wide category that includes everything from social norms and values to institutions and legal frameworks. Within this framework, it is suggested that change might occur by identifying opportunities and spaces for learning within a practice – or the agentive aspects of a practice. The social practice theory, applied in environmental impact studies by scholars, first quantifies the environmental impact of behaviours and then sets priorities on which behaviours have to change first in a social setting (Sahakian & Wilhite, 2013). According to Spaargaren (2011), social practice theory has been used by an increasing number of scholars to analyse energy consumption behaviour and to avoid pitfalls or limitations presented by individual theories. Social practice theory argues that the role and responsibility to save energy must not be assigned to individuals, but must be a combination of society or agency, technology, and culture.

Consistent with Steg and Vlek (2009), Carrico and Riemer (2011) also combined individual and social factors in a workplace setting to evaluate the effectiveness of two interventions - group feedback and peer education - in reducing energy usage within the workplace. The interventions of peer education and group level feedback were proposed, taking into account the barriers and natural social setting of the workplace. The barriers in the workplace exist because employees' lack of ownership would not have a direct financial benefit in comparison with the home environment. However, the facilitating factors are that barriers are easily removed by the use of group level

feedback and peer education, as energy saving behaviour observed by peers and role models can easily be adopted by other employees, since employees have regular contact with one another. The results of the empirical study revealed that both peer education and group level feedback resulted in a significant decline in energy usage in relation to baseline. The limitation of this study, however, is that the effect thereof was not replicated in the survey data and that the actual energy (Kilowatt hours [kWh]) consumption - which is a more objective usage of energy - was not used (Carrico & Riemer, 2011).

In summary, the interventions used in the workplace discussed above centred on individual level attitudes, and also on reinforcing social norms as illustrated by Carrico and Riemer (2011). The common attribute of the interventions applied by the mentioned authors above is centred on increasing people's competency as an important element in reducing energy consumption. Therefore, the rationale of the study is in enhancing employees' competencies in order to change their behaviour. The study conducted by Carrico and Riemer (2011) proved that peer education results in a reduction of energy due to employees' behavioural changes. This study proposes that energy efficiency behaviour-based training, according to Kirkpatrick's (1998) model, will yield increased savings in energy since the model has been replicated in studies and found to be effective in employee training (Curado & Martins Teixeira, 2014; Passmore & Velez, 2012). The rationale behind choosing Kirkpatrick's model is that the model focuses on assessing behaviour through evaluating the effectiveness and impact of the training intervention. The model is the most common and popular training evaluation used by organisations for the past 30 years (Passmore & Velez, 2012). Kirkpatrick's (1998) training model identifies four categories of measurement:

- **reaction**: a measure of participants' satisfaction with the training;
- **learning**: appraises the gain in knowledge and skills after the training;
- **behaviour**: assesses changes in on-the-job behaviour displayed by participants in the workplace after training; and
- **results**: measuring changes in business results in terms of improvements coming from participants who attended training.

According to Noe (2010), as cited by Curado and Martins Teixeira (2014), organisations should establish a training evaluation routine where the value of training is determined through:

- a process of collecting data of outcomes that will determine the effectiveness of training; and
- clarifying methods of gathering information to determine the effectiveness of the training programme.

Furthermore, Curado and Martins Teixeira (2014) assert that training assessment is a powerful tool that organisations can use to show the impact and value training brings about. Moreover, Cheng and Ho (2001) proposed that the trainee's self-efficacy in organising and executing trained tasks is

related to how well the trainee will adopt the learned behaviours. However, since money spent on training does not reflect on organisations' financial statements, most organisations do not assess the tangible benefits of training programmes. The result is training budgets being cut, because there are no assessment methods and no visible benefits derived from training (Tennant, Boonkrong, & Roberts, 2002). Curado and Martins Teixeira (2014) contributed to literature on training assessment following Kirkpatrick's four levels by contemplating five training programmes in a small logistics company. The measure of return on investment (ROI) on the five training programmes indicated that studies, focusing on internal efficiencies, pay off.

A fifth level to Kirkpatrick's model has since been added by Phillips's (1996) (as cited by Passmore & Velez 2012) ROI, which forecasts the potential payoff of the proposed training before funds are committed (Passmore & Velez, 2012). According to Rowden (2005), evaluation of the ROI is done using a wide variety of measures, e.g., increased sales due to training, turnaround time savings, productivity, reduced defects, etc.

This study adopted Kirkpatrick's four-level framework and complemented it with Phillips's ROI methodology. The study sought to replicate findings from literature on the effectiveness of training assessment as per Kirkpatrick's model; it is predicted that a training intervention administered to employees will change employee behaviour towards energy savings; therefore, resulting in an overall decrease in electricity consumption (Carrico & Riemer, 2011). Finally, the study seeks to measure ROI as a result of the training intervention conducted in terms of Phillips's model. The South Africa National Standard (SANS, 2011) for energy efficiency in building, benchmarks the maximum energy demand and energy consumption for lighting in office buildings to be 17W/m2 or 42.5kWh/m as a standard for energy efficiency in buildings. The energy demand for buildings at the mine where the study is conducted is up to $70W/m^2$, which is far from achieving the energy efficiency benchmark. This study also seeks to improve offices' energy efficiency in order to strive for better building energy efficiency measures as compared to the standard benchmark.

Following the review of literature, the proposed model of the study is depicted in Figure 1.

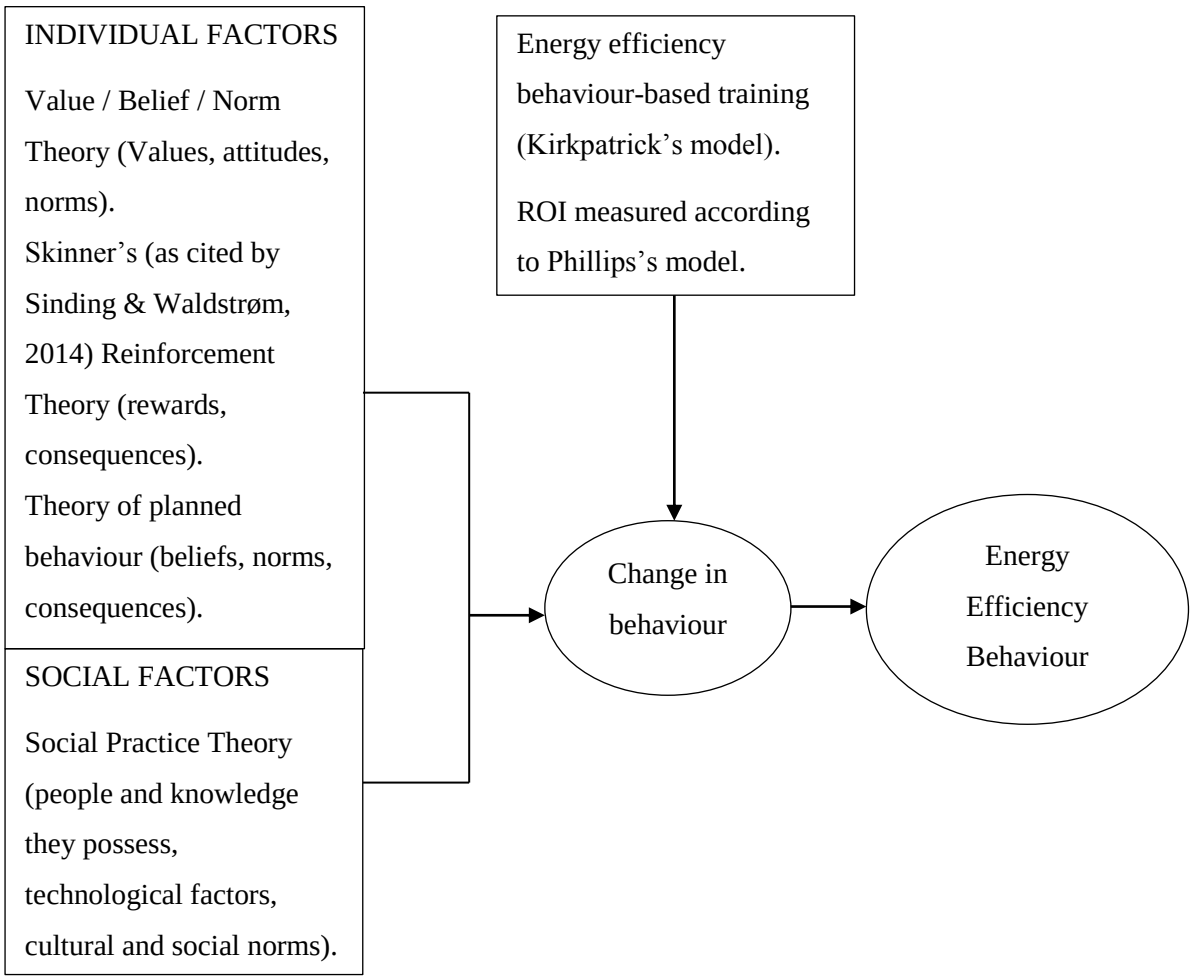


Figure 1. Model of the study.

To yield desired energy efficient behaviour, individual and social factors influencing behaviour as evident from literature can be enhanced by evaluating energy efficiency behaviour-based training as per Kirkpatrick's model. Therefore, this study explores the impact of training on energy efficiency in the workplace, through energy efficiency behaviour-based training. Furthermore, training will be correlated to savings realised, or ROI, adding to literature on the effectiveness of a training programme regarding energy efficiency behaviour.

The following research questions were formulated based on the research problem:

- Does energy efficiency behaviour-based training evaluated as per Kirkpatrick's model influence the behaviour of employees at the mine?
- What effect does energy efficiency behaviour-based training have on actual energy saving at the mine?
- What is the return on investment (ROI) of implementing energy efficiency behaviour-based training at the mine?

1.3 RESEARCH OBJECTIVES

The primary objective of the study is to investigate whether energy efficiency behaviour-based training impacts positively on electricity consumption at a mine in Limpopo, South Africa.

The specific objectives of this research are to:

- ascertain whether energy efficiency behaviour-based training, evaluated as per Kirkpatrick's model, influences behaviour of employees at the mine;
- study the relationship between energy efficiency behaviour-based training and actual energy saving; and
- determine the return on investment (ROI) of implementing energy efficiency behaviour-based training at the mine.

1.4 RESEARCH METHODOLOGY

1.4.1 Research Approach

The research approach chosen is that of a quantitative study and the design is quasi-experimental. According to Campbell and Stanley (1963), a quasi-experimental design becomes useful in settings where the researcher has little control over the selection of participants into groups, contrary to true experiments where the researcher can randomly choose participants into groups to ensure homogeneity between the different groups measured. These authors warned that homogeneity between groups is critical to guard against threats of internal and external validity which may deter the influence of intervention effects in the experiment. In the quasi-experimental design, the pre-existing groups must be chosen and assigned into an experimental and a control group, prior to an energy efficiency-based training intervention; comparison of experimental data must be done pre- and post- the intervention (Welman, Kruger, & Mitchell, 2005). The two groups must have similar characteristics as far as possible, but the intervention must only be applied to the experimental group. The control group enabled the impact of extraneous variables to be quantified and isolated from the impact of an energy efficiency training intervention; this helped to ascertain the impact of the intervention on the experimental group only (Kumar, 2011).

The pre-test and post-test non-equivalent peer control group design is illustrated in Figure 2 (Neale & Liebert, 1986).

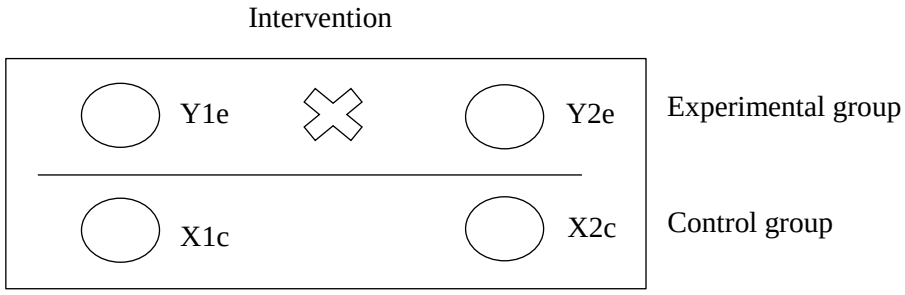


Figure 2. The quasi-experimental design.

To calculate the impact of the training intervention using the quasi-experimental design, the following equations will be used:

$$Ye = Y2e - Y1e$$

$$Xc = X2c - X1c$$

$$Impact\ of\ energy\ efficiecy\ behaviour - based\ training\ = (Y2e - Y1e) - (X2c - X1c)$$

Where:

$$Y2e = \ the\ post\text{–}test\ electricity\ consumption\ \ of\ the\ experimental\ group$$

$$Y1e = the\ pre\text{–}test\ electricity\ consumption\ of\ the\ control\ group$$

$$X2c = \ \ the\ post\text{–}test\ electricity\ consumption\ \ of\ the\ control\ group$$

$$X1c = the\ pre\text{–}test\ electricity\ consumption\ of\ the\ control\ group$$

$$Ye = Total\ change\ in\ the\ electricity\ consumption\ of\ the\ experimental\ group, in\ other\ words\ Ye\ is$$

$$(impact\ of\ energy\ efficiency\ behaviour\text{–}based\ training\ intervention) \pm (impact\ of\ extraneous\ variable) \pm (impact\ of\ change\ variable\ in\ the\ experimental\ group).$$

$$Xc = Total\ change\ in\ electricity\ consumption\ of\ the\ control\ group, \begin{pmatrix} impact\ of\ extraneous \\ variable \end{pmatrix} \pm (impact\ of\ change\ variable\ in\ control\ group)$$

$$Impact\ of\ energy\ efficiecy\ behaviour\text{–}based\ training = (Y2e - Y1e) - (X2c - X1c), in\ other\ words\ it\ is\ ([Impact\ of\ energy\ efficiency\ training\ intervention] \pm [impact\ of\ extraneous\ variable\ in\ experimental\ group] \pm [impact\ of\ change\ variable\ in\ experimental\ group]) - ([impact\ of\ extraneous\ variable\ in\ control\ group] \pm [impact\ of\ change\ variable\ in\ control\ group]).$$

This research seeks to measure the change in energy consumption as a result of employees' and management's behavioural change towards energy efficiency due to the effectiveness of the training intervention. The baseline of energy consumption was determined by measuring the energy consumption of both groups independently before the intervention, and further consumption was taken one week after training to measure or verify changes. Moreover, the experimental group's training was evaluated with Kirkpatrick's model and each step of this model was measured as follows (Passmore & Velez, 2012):

- **reaction**: measured using a questionnaire survey where participants' feedback on training was analysed;
- **learning**: a questionnaire on energy impact and energy saving was administered before the training to address the possible learning deficiencies in the training intervention;
- **behaviour**: observations by the researcher via a board game participation by employees to determine the extent of changes in behaviour; and
- **results**: comparison of electricity consumption in the area of the two groups measured before training and after training.

A quasi-experimental design is often used in a setting where pre-existing natural groups have already been formed by the institution; some groups receive treatment whilst others do not receive treatment (Neale & Liebert, 1986). The pre-existing groups chosen were two different departments in the mine, utilising separate buildings and workshops. The two groups had similar organogram structures and similar ways of working, i.e., each group comprised a superintendent, supervisor, and number of employees. Only one department chosen as the experimental group was administered training for the purpose of this research. Since only the experimental group was administered a training intervention, this approach was useful to determine the effectiveness of the intervention as well as the outcome (Welman et al., 2005). This research approach was preferred, because in the mine there had already been pre-existing groups and also this approach focused on the outcome or results of the intervention which was in line with Kirkpatrick's model chosen for this study.

1.4.2 Research Participants

The research population comprised employees from a mine; two existing groups from different sections in the mine were chosen and one of the groups was administered intervention training on energy efficiency behaviour. Both groups had office space areas where the energy consumption was measured separately. According to Kumar (2011), socio-economic demographics of the study population play an important role. In this study, the educational level, age structure, and socio-economic status of both population groups were quantified to assess the homogeneity between the two groups.

Both the control group and the experimental group in this non-equivalent control group design were subjected to separate measurements of electricity consumption; data had been measured at their respective workshops before the training intervention was administered to the experimental group. The results of changes in electricity consumption between the two groups were compared pre- and post-intervention. Moreover, training deficiencies of both groups were analysed using a questionnaire before training in order to address the identified gaps in the training administered to the experimental group. Neale and Liebert (1986) warned that there are two threats to internal validity with non-equivalent control group designs, namely:

- Selection maturation

  Groups develop at a different rate on any dimension correlated with the dependent variable. Selection maturation as a result of a group's behaviour that gradually changes had been eliminated, since the two groups were measured against their own baseline. There is currently no other intervention at the mine that could possibly influence maturation of the two groups and therefore threat of selection maturation is low.
- Local history

  This refers to threat to internal validity whenever some experience related to the dependent variable has occurred more to one group than the other. The threat due to local historical events was low, since the two groups in the mine fall under the same organisation and under the same senior management. Therefore, it is argued that the previous experience with regard to behaviour in energy consumption will be similar in both groups.

Since two departments with the same settings and traits in the mine environment have been chosen, it is expected that the instrument will be valid and reliable. To ensure that the threat of selection maturation to internal validity does not influence the outcome of the dependent variable, the two groups chosen included people from departments with similar skills and experience. Over and above the characteristics of the two groups, the socio-economic demographic information was used to verify the homogeneity between the two groups.

1.4.3 Research Procedure

The electricity power consumption of both groups was taken for a week before the intervention to be able to compare the similarity of trends in electricity usage at different times of the day. Similarly, after the intervention, average electricity consumption readings were taken for a period of one week to establish any changes to electricity usage at different time zones. Portable power meters were installed at the two different locations where the two groups were based; the meters measured the energy in kWh. The power meters enabled the uploading of data from power meters to computer, where the data was exported to Microsoft Excel. The graph of energy versus time is illustrated in Figure 3.

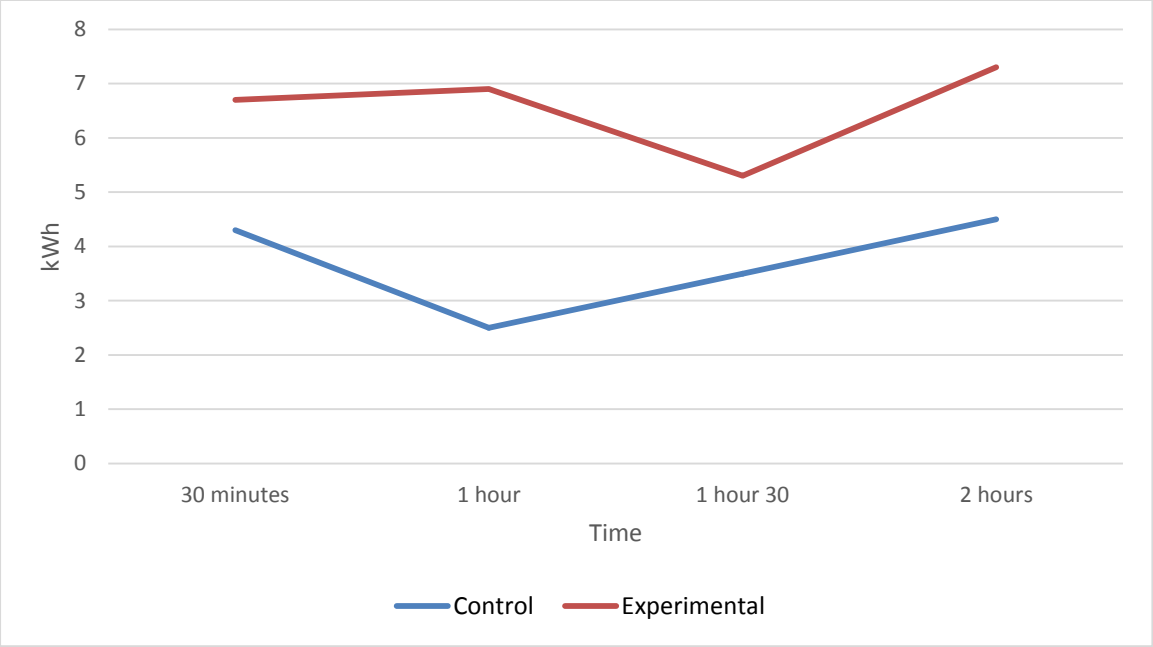


Figure 3. Graph of energy consumption measurement example.

From the illustrated example graph, the average consumption of the control group and experimental group over a period of a week was determined and the difference calculated.

It is evident from literature that an individual's behaviour can be changed by enhancing his or her beliefs in consequences of his or her actions as per Skinner's theory of reinforcement (as cited by Sinding & Waldstrøm, 2014); also social theory advocates that behaviour can be changed by enhancing the knowledge that people possess (Sahakian & Wilhite, 2013). This study proposes that energy efficiency behaviour-based training will change people's behaviour; therefore, the change in behaviour of employees as a result of training was also measured using a five-point Likert-type attitudinal scale. According to Tittle and Hill (1967), the Likert attitudinal scale is the best method to predict behaviour, providing intensity of the attitude an individual possesses. Therefore, the five-point Likert-type scale questionnaire was administered to employees in both the control and experimental groups to determine the intensity of their attitudes towards energy efficiency behavioural practices.

1.4.4 Measuring Instruments

The following measuring instruments were utilised in this study:

Biographical questionnaire. Demographic characteristics pertaining to gender, age, qualifications, and number of years' experience at the mine were measured.

Attitudinal Scale. An energy saving questionnaire adopted from Eskom's guide to energy awareness was utilised (Eskom, 2014). The scale consisted of ten items and applied a five-point Likert-scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The general attitude towards saving energy was reflected in one item ("Energy efficiency is very important to me"); the levels of awareness of the environmental impact from energy usage were reflected in these items ("Greenhouse

gas from fossil fuels impacts negatively on the environment", "Reduction in the use of energy is critical to achieve environmental sustainability", and "South Africa should introduce more renewable energy sources"). The energy saving behavioural practice was reflected in these items, e.g., "I always switch off the lights when I vacate the office", "I always switch off the air conditioner when vacating the office", "I only boil as much water as needed for coffee or tea", "I set the temperature of my air conditioner above 22 degrees". A similar scale used to measure the energy saving behaviour of 4 102 United States residents was reported with a Cronbach alpha reliability coefficient ranging from 0.62 in 2002, 0.63 in 2004, 0.61 in 2006, and 0.60 in 2008 and 2010, indicating internal reliability for this scale (McClaren, 2015).

According to Kumar (2011), questionnaires are convenient and inexpensive methods of gathering research data; they provide greater anonymity. Since anonymity is crucial in a workplace, questionnaires were administered to the experimental group in the evaluation of the energy efficiency training intervention programme in the following manner:

Reaction Scale. An attitudinal Likert-scale questionnaire (Kirkpatrick, 1998) was administered after the intervention to evaluate participants' satisfaction with the training. Participants were required to respond using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) on five items, namely training programme objectives (e.g., "I understood the learning objectives, I will be able to apply what I have learnt at work"), course material (e.g., "The learning material was presented in an interesting manner"), facilitator knowledge (e.g., "The instructor was well prepared"), content relevance (e.g., "The board game enhanced my engagement and participation in the training "), and facility (e.g., "The facilities and schedule were suitable"). Participants were also afforded an opportunity to comment on how the training can be improved. The reliability of the Kirkpatrick reaction scale was reported by Steensma and Groeneveld (2010) with a Cronbach alpha reliability coefficient of .84.

Behaviour. An energy awareness board game from Energy Training Foundation (Energytrainingfoundation.co.za., 2016) was used to observe change in behaviour of the employees as they participated in a competitive energy awareness game against fellow employees. The energy efficiency awareness board game is an entertaining and interactive game formed on the basis of energy saving fundamentals. The board game teaches people how to balance risk and reward whereby the energy expenses risk is managed against the reward from energy savings activities. The expenses include geysers, appliances, stoves, kettles, etc. The rewards come once the expenses – such as geysers – have been upgraded into an energy efficient product such as purchasing a solar geyser. Greater rewards are reaped when a player chooses to purchase a house and upgrades the house by installing LED lights, heat pumps, and solar water geysers.

1.4.5 Statistical Analysis

The raw data was analysed using SPSS 23 (IBM Corporation, 2015). A *t*-test was used to compare means between samples and/or within sample(s), which provides information on the significance of any calculated differences. Due to the fact that in this study the sample consisted of 30 participants or fewer (experimental group), the parametric *t*-test could not be utilised. There are, however, alternative non-parametric tests available for such cases, and these were used in this study. In order to compare means between the pre- and post-experimental groups on electricity consumption, the Wilcoxon signed rank test (in place of the dependent *t*-test) was used, because the data was collected from the same group, albeit on separate occasions. The comparison for electricity use between the control and experimental groups was done with the Mann-Whitney test, which has been established as the relevant substitute for the independent *t*-test (Field, 2013). The Wilcoxon signed rank test is used to compare one group's scores; in this case, the experimental group's scores were evaluated using this test. Mann-Whitney test is used to compare the scores of two or more groups; in this case, the experimental group and control group utilised the independent type Mann-Whitney Test.

1.5 ETHICAL CONSIDERATIONS

Ethical clearance was received from the university to conduct this research (EMS15/03/31-1/35). Thereafter, permission was obtained from the organisation's management to conduct the research at the specific mine. The purpose of the research was then explained to all participants. The roles and responsibilities of all parties involved were clarified, and it was emphasised that participants partook voluntarily, ensuring their anonymity throughout the research. Participants were also assured that they could decide at any stage to withdraw from the research, without penalty, and that the information obtained via the research would be used for research purposes only. Confidentiality was assured to all participants before completing the questionnaires and before taking part in the board game.

Moreover, participants were required to sign an informed consent form that included the following: purpose and procedures of the research, possible risks (if any) as a result of participation, potential benefits to the organisation and participants, confidentiality, withdrawal without prejudice, name and contact details of student and supervisor should questions arise, and, finally, an agreement clause for participation.

1.6 CHAPTER DIVISION

The study has been divided into three chapters which are schematically presented in Figure 4.

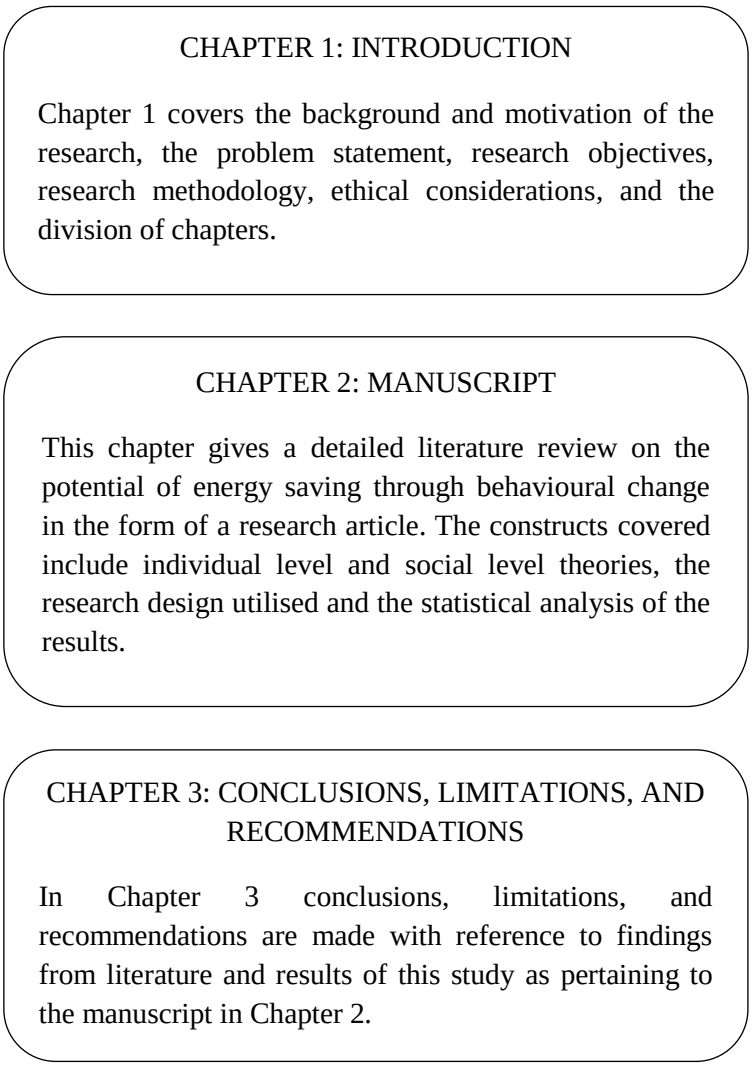


Figure 4. Lay-out of the study.

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CHAPTER 2

MANUSCRIPT

Evaluating an energy efficiency behaviour-based training programme

ABSTRACT

The challenge facing countries around the world is to reduce the energy demand to lessen the impact of carbon emissions on the environment. In South Africa, the challenge in the mining industry is escalated by the high cost of electricity due to increases in the electricity tariffs in the recent past. Following a quasi-experimental research design, the aim of the study was to investigate whether energy efficiency behaviour-based training changes the behaviour of employees towards energy saving at a mine in the Limpopo province in South Africa. Kirkpatrick's training model and Phillips's ROI principle had been administered to a total sample (N = 56) of 31 participants in an experimental group and 25 in a control group, comprising employees in two different sections at the mine. Findings indicated that the energy efficiency behaviour-based training intervention - due to various reasons - did not significantly change employee behaviour towards saving energy.

Key terms: Energy efficiency, behaviour, behaviour-based training, return on investment, Kirkpatrick's model, quasi-experimental design.

Globally, there is great concern that the increase in greenhouse gas emissions is detrimental to the climate and does not support the goal of environmental sustainability (World Energy Council, 2013). The great concern is the negative consequences resulting from climate change whereby the global temperature keeps rising. The rise in temperature leads to devastating droughts and adverse weather patterns. Moreover, the sources related to acid rain are as a result of carbon emissions into the atmosphere. Acid rain destroys agricultural plantations that threaten basic food supply resources around the world. The paradigm shift towards reduction of carbon emissions by different countries is the aim of developing initiatives, namely:

1. Initiatives that protect the essential needs of human beings (food, water, etc.).
2. Energy efficiency technologies.
3. Renewable energy technologies.
4. End users' efficient use of energy.

The Kyoto protocol, which is the international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC), confirms the binding commitments that countries have set internationally to reduce emissions with set targets (United Nations, 1997). The Kyoto protocol binds countries to the commitment set to reduce carbon dioxide emissions by at least 5% below the levels which were measured in 1990, with the first commitment period from 2008 to 2012 (United Nations, 1997). The second commitment, called the 'Doha Amendment', was adopted in December 2012, where the member states and Iceland committed to reduce the greenhouse gas emissions in years 2013 to 2020 by at least 20% below the levels which had been measured in 1990, (European Commission, 2013). To meet the Kyoto protocol commitments, the European Union (EU) member states resolved to issue energy efficiency directives (European Union Directive, 2009) that force the member states to implement policies and procedures to improve end users' efficient use of energy, application of energy efficient technology, and to promote renewable energy as the source of electrical energy by member states. The European Union Directive (2009) recognised that at least 70% of the energy requirements that result in emissions of greenhouse gases come from end users' inefficient use of energy, and therefore the energy efficiency directive's focus was on implementing strategies that encouraged end users to save energy. In particular, the directive presumes that strategies aimed at changing consumers' behaviour are cost effective and will ensure long term energy saving benefits.

In South Africa the challenge has been escalating through the growing demand for electricity in the past few years (Eskom.co.za, 2014). Moreover, there has been a steep increase in electricity costs over the last decade to accelerate the development of new power stations. Therefore, in South Africa the challenges to save energy do not only lead to reduction in greenhouse emissions, but are also essential in electricity cost reduction for industries and companies to stay financially competitive (Odendaal, 2013). The mining industry, as a principal producer of wealth in South Africa, consumes about 15% of Eskom's annual electricity power output. The gold mining sector consumes 47% of the

industry's total electricity, followed by the platinum mines at 33%, with the rest of the mines consuming 20%. By applying efficiency results in the following areas, the mining industry can save vast amounts of energy: materials handling (23%); processing (19%); compressed air (17%); pumping (14%); fans (7%); industrial cooling (15%); and lighting (5%) (Eskom.co.za, 2014). In the mining industry, the rise in electricity costs affects profitability of the mines negatively and as a result some mines have resorted to restructuring operations, leading to job losses (Kilian, 2016).

Energy efficiency has been adopted by many countries as one of the quickest and most cost effective strategies to counteract the threat of global warming (Hepbasli, Ozdamar, & Ozalp, 2001). South Africa Department of Minerals and Energy (2005) adopted the national energy efficiency strategy in order to implement no cost and low cost strategies to ensure industries and government institutions adhere to energy efficiency measures with set targets aimed at reducing the energy demand of 12% by 2015. Energy efficiency is the ability to produce the same output with less energy through installation of more efficient technology and through changing behavioural patterns prone to wasting energy (Lopes, Antunes, & Martins, 2012). According to Lopes et al. (2012), the potential of energy savings through behavioural change remains untapped. There are a few studies that endeavoured to quantify the amount of energy that a low cost intervention towards changing behaviour saves. Therefore, this study explores factors that are aimed at changing behaviour in order for people to participate in using energy efficiently. In particular, this study advocates the implementation of an energy-efficiency based training programme in order to change people's behaviour. This study adds to the aforementioned literature gaps by utilising a quasi-experimental design in measuring how much energy consumption is achieved through a training intervention based on Kirkpatrick's model (Kirkpatrick, 1998).

Energy Efficiency

Energy efficiency refers to the use of less energy to produce the same amount of services or required output (Patterson, 1996). For example, energy for lighting can be reduced by using lamps that consume less energy, yet giving the same lighting output. Globally, energy efficiency remains one of the leading strategies that have been used to reduce energy consumption by end users amidst current climate change concerns (Abdelaziz, Saidur, & Mekhilef, 2011).

In South Africa, the Government, together with Eskom, embarked on Demand Side Management (DSM) strategies in order to accelerate the reduction of energy use by 3000kW of peak load by 2012 (Pelzer, Mathews, Roux, & Kleingeld, 2008). DSM is described as actions that are used to change patterns of consumers' energy usage. In the United States, DSM has been implemented since 1985 by utility companies and has yielded electricity savings of up to 29GW of peak load (Pelzer et al., 2008). Notably, in South Africa, DSM yielded significant savings when 40 million compact fluorescent lights (CFLs) were rolled out to industries and households for free, in exchange for old inefficient incandescent lamps. This initiative yielded savings of up to 1759MW. Moreover,

Eskom, together with the National Energy Regulator of South Africa (NERSA), encouraged industries, households, and the commercial sector to become involved in energy saving projects whereby funding was subsidised according to the potential energy savings. Based on international benchmarking and proven technologies, the energy efficiency technologies to replace old inefficient equipment that was approved for rebate, comprised the following:

1. Energy efficient lighting technologies: The old technology consisted of high wattage magnetic ballasts with standard fluorescent tubes; these are being replaced with electronic ballasts and energy efficient fluorescent tubes, saving up to 40% of energy. Replacing fluorescent lights with light emitting diodes (LED) fluorescent lights, yields even higher savings. More than one and a half decades ago, retrofit lighting projects that had been carried out in Eskom's Megawatt Park headquarters had already indicated savings of up to 26% in total lighting energy by replacing old fluorescent lights with energy efficient lights (De Villiers, 2000).
2. Heat pumps for water heating: The old geysers contained resistance elements to heat water, which consumed high amounts of electricity. By replacing these with heat pumps, the electricity consumption can be reduced by up to 67% (De Villiers, 2000).
3. Solar water heating: Solar water heaters consist of solar panels mounted on the roof of the building to heat water. This technology is considered with a backup source of heating when solar radiation is insufficient, normally at night time (Eskom.co.za, 2014).
4. Shower heads: Replacement of shower heads with the latest technology; energy efficient shower heads use less water and therefore require less energy (Eskom.co.za, 2014).

South Africa Department of Minerals and Energy (2005) advised that the technological initiatives described above contributed to significant energy savings; however, there are barriers that prevent institutions and consumers from saving energy, such as lack of understanding of energy efficiency by consumers, and also institutions not committing to initial capital expenditure to replace old inefficient equipment. In a foreword statement, the Minister of Minerals and Energy stated that "perhaps the most difficult area for implementation is the changing of people's behaviour in promotion of public awareness about costs and benefits of energy efficiency" (South Africa Department of Minerals and Energy, 2005, p. 4). Therefore, this research focuses on exploring the potential energy saving that can be realised through interventions that change people's behaviour towards energy saving.

The rationale of the study context being a mine is that there have been a number of interventions aimed at energy efficiency through replacing old inefficient equipment with new technology, but there have not been interventions aimed at changing employee behaviour. From observations by the researcher in the office blocks, there are many instances where employees leave lights and air conditioners on while not being in the office. Therefore, it is expected that the intervention to change behaviour will yield more electricity consumption savings at the mine.

Energy Saving Behaviour

According to Lopes et al. (2012), energy saving behavioural factors are understood by scholars as having a higher potential towards saving energy, compared to the more popular technological means; however, the potential remains untapped. Energy saving behaviour research is centred mostly in the residential sectors where the factors affecting behaviour are described as falling under either an individual context or a social context (Lopes et al., 2012).

Individual factors. According to Steg and Vlek (2009), factors affecting the environmental behaviour of individuals are aimed at changing individual motivations comprising weighing of costs and benefits, moral and normative concerns, and consequences of behaviour to the environment. These factors stem from the Theory of Planned Behaviour (TPB; Ajzen, 1991), which is one of the most widely cited and applied behavioural theories that have been used to understand individual behaviour (Kaiser, Hübner, & Bogner, 2005). The theory postulates that the individual's intention to perform certain behaviours is dependent on his or her perception of control, the attitude towards performing the particular act, and subjective norms. Attitude refers to the rational choice-based evaluation of the results or consequences of performing a behaviour; subjective norms refer to the perceived expectations of relevant others or normative beliefs (Kaiser et al., 2005). Therefore, the theory advocates that the intention of an individual to perform behaviour is based on perceived expected outcomes and subjective norms.

The TPB is also complemented by Skinner's reinforcement theory (as cited by Sinding & Waldstrøm, 2014), which points out that behaviour is controlled by consequences in that people will repeat those behaviours that produce positive consequences and let go of behaviours that produce negative consequences (Sinding & Waldstrøm, 2014). To test TPB and Skinner's reinforcement theory (as cited by Sinding & Waldstrøm, 2014), empirical studies undertaken by various scholars used feedback interventions in the residential sector to ascertain electricity energy savings. The observations by scholars (Carrico & Riemer, 2011; Darby, 2006; Lindén, Carlsson-Kanyama, & Eriksson, 2006) were that consumers in residential homes, who had real time feedback and metering, were more energy efficient than those who did not have feedback on usage of energy. The implications of these findings are that interventions do lead to change in behaviour towards saving energy; however, interventions alone were not proven to be sustainable (Abrahamse, Steg, Vlek, & Rothengatter, 2005).

In a quest to find sustainable behavioural interventions, various studies in environmental psychology maintain that the value-belief-norm (VBN) theory best predicts individual pro-environmental behaviour. After testing this VBN theory, Stern (2000) concludes that "personal moral norms are the main basis for individuals' general predisposition for pro-environmental action" (p. 413). Personal moral norms are activated partly by the individual's views of whether the threat by environmental degradation is of importance, and the individual's view of his or her personal

responsibility and ability to launch effective action to help solve the problem (Faiers, Cook, & Neame, 2007; Stern, 2000). Moral norms are triggered by the individual's views of whether climate change threatens his or her values (Martinsson, Lundqvist, & Sundström, 2011). Faiers et al. (2007) and Stern (2000) identified that it is the values, attitudes, and norms as described by the VBN theory which propose causal relationships between personality, beliefs, responsibility, and attitude, and pro-environmental behaviour. Empirically, 38 studies were reviewed to determine whether the results achieved actually changed behaviour, by examining underlying behavioural elements; also whether the effects were sustained. Interventions which were considered to strengthen values, beliefs, and norms included commitment, information, goal setting, mass media, modelling, and feedback.

These 38 studies revealed that there had been considerable improvements in the change of participants' behaviour through various interventions; however, the behaviours had also not been sustained for a very long time (Abrahamse et al., 2005). In a study to characterise recent trends in environmental behaviour, Lopes et al. (2012) argued that the historical individual perspectives lack examination of contextual factors that affect environmental behaviour. These authors further recommended that the influence of contextual factors, such as social factors, be explored in research. The individual perspective suggests that for each employee at the mine to change behaviour towards energy saving, employees must have high beliefs and have developed personal moral norms that high usage of energy degrades the environment. The individual perception of consequences as a result of energy saving behaviour suggests that rewards or punishment are important to change individual behaviour towards energy saving.

Social factors. Researchers in social science assert that energy usage is not only the consequence of individual choices, but also results from social contexts (Lopes et al., 2012). Shove (2010) argued that it is evident that energy usage behaviour is to a certain degree influenced by social norms, based on cultural and economic factors. Shove (2010) argues that people take part in pro-environmental behaviour as a result of social practice in the environment in which they live; they adopt habits that are practised socially in that space. The implication of social practice is that behavioural change needs to be approached by changing the practice itself in a social space, and not only the individual factors. Sahakian and Wilhite (2013) describe stages of social practice theory as follows: to identify actual practices and their related practices, while acknowledging the presence of three pillars in any agency, namely people and the knowledge they possess, both practically and mentally; tangible things and infrastructures that affect daily life; and socially rooted and grounded contexts, including institutional values and legal frameworks.

Social practices propose that change of behaviours might occur when opportunities rooted in the social environment have been identified and addressed. Social practice considers the environmental impact of different practices when prioritising which practices need to be changed. Social practice theory also pays attention to the importance of people and the knowledge they possess

as one of the three pillars. Social factors suggest that employees in the mine can easily change their behaviour if the practice of energy saving in the mine is adopted by employees as a collective.

Behaviour-Based Training

According to Carrico and Riemer (2011), a few studies evaluated the effectiveness of energy efficiency interventions in the workplace. Therefore, these authors explored saving opportunities by applying feedback interventions as part of consequence strategies, and also by applying group level feedback together with peer education to reinforce the knowledge. Their study made use of both individual factors in the form of feedback, and also peer education, which also appeal to the enhancement of social norms. Barriers in the work environment were identified as being employees' lack of ownership, as there is no direct financial benefit as opposed to the home environment (Carrico & Riemer, 2011). However, these authors found that these barriers are easily removed using group level feedback and peer education, as energy saving behaviour observed by peers and role models can easily be adopted by other employees as a result of regular contact with one another. The results of Carrico and Riemer's empirical study proved that more significant savings are achieved through group level feedback and peer education than just feedback alone.

According to Abrahamse et al. (2005), studies in the residential sector revealed energy is saved by modifying behaviours through interventions aimed at antecedents and consequences as per individual factors; similarly, energy is saved in the work environment through interventions aimed at reinforcement of social norms in alignment with energy saving practices. Therefore, this study suggests that social norms and individual factors can be reinforced through training interventions, resulting in sustainable energy savings. This study explores the impact of energy efficiency behaviour-based training on the reduction of energy consumption.

Employee training can be evaluated using Kirkpatrick's (1998) model as a measuring instrument, as this model has proven to be successful in evaluating training interventions over the last 30 years (Passmore & Velez, 2012). In this study, a fifth principle has been added from Phillips's (1996) model, namely return on investment (ROI; Curado, & Martins Teixeira, 2014).

According to Kirkpatrick (1998), the reasons for evaluating a training programme are threefold, namely to:

1. determine how to improve future programmes;
2. determine whether or not to continue with the training programme; and
3. justify the existence of the training programme budget to top management.

Kirkpatrick (1998) described the four-level framework of the training model as comprising reaction, learning, behaviour, and results.

Reaction. The perceptions of the learners' reaction to training are used to measure the effectiveness of the training programme. The measurement instruments require participants to rate the facility, training material, training instructors, etc. The comments from the participants are important as both positive and negative comments are used to improve the training programmes; positive comments encourage participants to attend the training programmes, while negative comments are used to address the gaps in the training and to gain support from the organisation.

Learning. The focus is on the learner's understanding of the concepts and principles that have been taught, and whether these have been grasped by the learner. In this level, the skills, knowledge, and attitudes of the participants are measured before and after the training. The goal of this level is to increase participants' knowledge and attitude.

Behaviour. This level assesses changes in the job behaviour displayed by participants at the workplace after training. Measuring behavioural change is necessary; not only to see the behavioural change, but also to understand reasons or barriers should the behaviour not change.

Results. This stage measures changes in business results such as improved sales, reduction of costs, and improved quality in terms of improvements coming from participants that attended training. It is important that the results are measured before and after the training.

Many organisations have benefited from Kirkpatrick's model and the framework is still relevant in the 21st century. A number of scholars, such as Passmore and Velez (2012), and Curado, and Martins Teixeira (2014) postulate that Kirkpatrick's training evaluation method is an effective training tool. Tennant, Boonkrong, and Roberts (2002) insist that the training budget must be clearly justified in terms of monetary benefits in order to avoid training budgets being cut by organisations. According to Passmore and Velez (2012), Kirkpatrick's four-level framework is better complemented by Phillips's ROI in order to justify the payback of training before budgets are committed. Phillips's ROI has since been added as a fifth level to Kirkpatrick's model to measure ROI. Therefore, this study adopts Kirkpatrick's four-level framework and complements it with Phillips's ROI methodology to assess whether energy efficiency behaviour-based training administered to employees will change employee behaviour towards energy savings and result in overall savings in electricity consumption.

Return on Investment

Passmore and Velez (2012) assert that the current economic dispensation and globalisation require companies to constantly be competitive. It is for these reasons that human resource departments in companies are also faced with the challenge to show return on investment in their human capital. In the competitive business environment, there has recently been strong emphasis on evaluating the value of human resource interventions, such as training programmes, and whether they improve employee performance which is critical to business improvements (Passmore & Velez, 2012). Company executives often question the benefits associated with continuous investments in

training programmes; therefore, it has become imperative that the training expenses are justified in contribution to the bottom line (Curado & Martins Teixeira, 2014).

Passmore and Velez (2012) argue that the major limitation of Kirkpatrick's training evaluation model is the lack of consideration of monetary value that training initiatives produce, i.e., lack of focus on business ROI. Therefore, a fifth level was added to Kirkpatrick's four level framework, namely Phillips's Return on Investment (ROI; Phillips, 1996). Phillips pointed out that the results that are achieved through Kirkpatrick's model can be converted into tangible monetary benefits, whereby the benefits can be compared to costs of the training programme. Phillips suggested that data of the results, such as productivity improvements, higher sales, and improved quality, must be collected and converted into monetary terms after the training programme in order to calculate the ROI.

Different approaches are used in the calculation of monetary benefits; one such approach is called benefit/cost ratio (BCR), where the benefits are divided by the cost. To find the ROI, the total costs are subtracted from the benefits to find the nett benefits, which are then divided by the costs to estimate the ROI. For example, if a training programme produces benefits of R100 at a cost of R20, the ROI is the cost of R20 subtracted from the total benefits of R100 (R100-R20) = R80 nett benefit, divided by the cost (R20) which equals 400% ROI. This means that for every R1 invested in the training programme, there was a return of R4 in nett benefits. Phillips (1996) also warned that while this method is effective in calculating the ROI, careful attention should be paid to identify the other variables, other than the training initiatives, that could have contributed to the results, such as age, work experience, economic changes, etc. Phillips suggested that these extraneous variables be measured by comparing the results of the control group to the results of the experimental group.

Board Game Training Intervention

The energy saving awareness board game from Energy Training Foundation (EnTF; Energytrainingfoundation.co.za, 2016) was used to train the experimental group. The aim of the training was to ensure that employees grasp the energy awareness tips and ways to save energy as they play against one another. The board game allows all employees to take part in the training and to interact with one another as they participate. The game is played is follows:

1. Maximum five players on one board game; each player receives R 3 000 Rentos money.
2. Each player takes a turn to pick a MOVEMENT CARD and reads out loud on the energy saving tip for learning purposes. The MOVEMENT CARD will tell the player how many positions to move forward. Energy saving tips are for learning purposes and include tips such as switching off the lights and appliances when vacating the office.
3. A player can either land on a house or an expense. If a player lands on a house, there is an option to buy that house, if it has not been bought yet. The price for the house is indicated on the HOUSE CARD. The player can also increase the energy efficiency of the house by buying an energy efficient lights token (X1), heat pumps (X2), or a solar

geyser (X3). The advantage of increasing efficiency in the house purchased is that the next time another player lands on that particular house, he or she pays the owner an amount indicated on the HOUSE CARD.

4. If a player lands on an expense, such as water or electricity, the player could buy the EXPENSE CARD by investing in an energy consumption meter, for instance. The next time another player lands on that expense position, he or she pays the player who had bought the EXPENSE CARD.
5. Once a player has run out of money, he or she is out of the game.
6. The aim is to invest in initial energy saving, so that the player reaps the rewards as soon as possible.

RESEARCH METHOD

Research Design

A quasi-experimental quantitative research design was followed. In a quasi-experimental design the research has limited control over the selection of participants in a group (Campbell & Stanley, 1963). The aim of the research was firstly to ascertain whether energy efficiency behaviour-based training, evaluated as per Kirkpatrick's model, influences behaviour; and secondly, if resulting behavioural changes lead to a decrease in electricity consumption. This approach was twofold, utilising the following, namely:

1. A questionnaire-based approach was used to gather data from the experimental group and the control group in order to assess their awareness with regard to energy efficiency, also their energy savings behavioural practices in view of customising the training to target those behaviours that prevent employees from saving electricity at the mine.
2. A quasi-experimental design was used to measure changes in electricity consumption between the experimental group to which energy efficiency behaviour-based training was administered, and the control group, to which no training was administered. The electricity readings of the experimental group and the control group were measured using a power meter located in the office blocks where the experimental group resides, and another power meter to measure electricity readings for the control group's electricity consumption in the workshop. The electricity readings were taken for a period of seven days before training commenced and seven days after training had been completed.

Participants

The sample comprised employees totalling 56 (N = 56); 25 from the control group (n = 25) and 31 (n = 31) from the experimental group, from a mine in the Limpopo province, South Africa. The two groups from the sample were characterised in the following manner:

1. The experimental group (n = 31) consisted of employees from the administration building which houses procurement, security, clinic, projects, and human resources.
2. The control group (n = 25) consisted of employees from technical services workshops and training workshops.

Descriptive statistics were used to present the demographic data. According to Levine, Stephan, and Szabat (2013), descriptive statistics present quantitative data in a simpler format, by describing central tendencies where the extent - to which all the data values group around a central value - is described. Moreover, the amount of dispersion or scattering of values is easily described by variation values.

Table 1 represents the frequency distribution of participants according to gender, age, qualifications, and number of years' working experience at the mine. As shown, from a total of 56 employees in the sample, 53.6% were male and 46.4% were female. The majority of the participants fell between the ages of 31-40 years (32.1%), followed by 20-30 years (30.4%), 51-60 years (23.2%) and finally 41-50 years (14.3%). The participants with less than one year of experience were 23%, whilst most of the participants had between 1 to 10 years' (46.4%) experience. Most of the participants (37.5%) had diplomas, followed by Matric (35.7%), with only 1.8% holding a master's degree.

Table 1

Characteristics of Participants (N = 56)

Item	Category	Frequency	Percentage
Gender	Male	30	53.6
	Female	26	46.4
Years' experience	0-1 year	13	23.2
	1-5 year(s)	12	21.4
	5-10 years	14	25.0
	10-15 years	9	16.1
	15-20 years	2	3.6
	20+ years	6	10.7
Qualification	Matric/Grade 12	20	35.7
	Certificate	4	7.1
	Diploma	21	37.5
	Degree	8	14.3
	Honours degree	2	3.6
	Master's degree	1	1.8
Age	20-30 years	17	30.4
	31-40 years	18	32.1
	41-50 years	8	14.3
	51-60 years	13	23.2

Measuring Instruments

The following measuring instruments were utilised in this study:

Biographical questionnaire. Demographic characteristics pertaining to gender, age, qualifications, and number of years' experience at the mine were measured.

Attitudinal scale. An energy saving questionnaire adopted from Eskom's guide to energy awareness was utilised (Eskom.co.za, 2014). The scale comprised ten items and applied a five-point Likert-scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The general attitude towards saving energy was reflected in one item ("Energy efficiency is very important to me"); the levels of awareness of environmental impact from energy usage were reflected in these items ("Greenhouse gas from fossil fuels impacts negatively on the environment", "Reduction in the use of energy is critical to achieve environmental sustainability", and "South Africa should introduce more renewable energy sources"). The energy saving behavioural practice was reflected in these items, e.g., "I always switch off the lights when I vacate the office", "I always switch off the air conditioner when vacating the office", "I only boil as much water as needed for coffee or tea", "I set the temperature of my air conditioner above 22 degrees". A similar scale was used to measure the energy saving behaviour of

4 102 United States residents, reporting a Cronbach alpha reliability coefficient ranging from 0.62 in 2002, 0.63 in 2004, 0.61 in 2006, and 0.60 in 2008 and 2010, indicating internal reliability for this scale (McClaren, 2015).

Reactionaries training evaluation. The survey battery on training effectiveness followed Kirkpatrick's (1975) evaluation, which proposes four levels of training evaluation, namely:

Level 1: Reaction. The participant's reaction to training is measured immediately after the training. Participants were required to respond to a five-point Likert-type scale ranging from 1 (*strongly disagree)* to 5 *(strongly agree).* Examples of items in the scale include: "I understood the learning objectives, I will be able to apply what I have learnt at work", "The learning material was presented in an interesting manner", "The instructor was well prepared", "The board game enhanced my engagement and participation in the training", and "The facilities and schedule were suitable". A Cronbach alpha of 0.84 was reported for this scale (Steensma & Groeneveld, 2010).

Level 2: Learning. Using a pre- and post-questionnaire approach, a measure of learning developed by participants was assessed before and after the training. The energy saving questionnaire was adopted from an Eskom guide (Eskom.co.za, 2014) towards energy awareness, whereby participants responded using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Examples of items in the scale include: "95% of primary energy sources to generate electricity are from coal", "Greenhouse gas from fossil fuels impacts negatively on the environment", "Reduction in the use of energy is critical to achieve environmental sustainability", "Energy efficiency is very important to me", and "South Africa should introduce more renewable energy sources".

Level 3: Behaviour. Using a pre- and post-questionnaire approach, behavioural change in participants was measured before and after the training. The energy saving questionnaire was adopted from an Eskom guide (Eskom.co.za, 2014) towards energy awareness; participants responded using a five-point Likert-type scale ranging from 1 *(strongly disagree)* to 5 *(strongly agree).* Examples of items in the scale include: "I always switch off the lights when I vacate the office", "I always switch off the air conditioner when vacating the office", "I only boil as much water as needed for coffee or tea", "I set the temperature of my air conditioner above 22 degrees", and "I ensure that the boardroom lights, air cons and overhead projector are switched off after the meeting".

Level 4: Results. The readings of electronic power meters, measuring power in kW, were taken before the training intervention. The power meter takes readings pertaining to power demand every 30 minutes for a period of seven days. After training had been completed, the same power meter was used to measure the power demand in kW after the training for seven days. The difference between the kW demand before the training and after the training was computed.

Reaction Scale. An attitudinal Likert-scale questionnaire (Kirkpatrick, 1975) was administered after the intervention to evaluate participants' satisfaction with the training. Participants were required to respond to a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) on five items, namely training programme objectives (e.g., "I understood the learning objectives, I will be able to apply what I have learnt at work"), course material (e.g., "The learning material was presented in an interesting manner"), facilitator knowledge (e.g., "The instructor was well prepared"), content relevance (e.g., "The board game enhanced my engagement and participation in the training"), and facility (e.g., "The facilities and schedule were suitable"). Participants were also afforded an opportunity to comment on how the training can be improved. The reliability of the Kirkpatrick reaction scale was reported by Steensma and Groeneveld (2010), with a Cronbach alpha reliability coefficient of 0.84.

Behaviour. An energy awareness board game from Energy Training Foundation (Energytrainingfoundation.co.za., 2016) was used to observe change in behaviour of the employees as they participated in a competitive energy awareness game against fellow employees. The energy efficiency awareness board game is an entertaining and interactive game formed on the basis of energy saving fundamentals. The board game teaches people how to balance risk and reward, whereby the energy expenses risk is managed against the reward from energy saving activities. The expenses include geysers, appliances, stoves, kettles, etc. The rewards come once the expenses – such as geysers – have been upgraded into an energy efficient product such as purchasing a solar geyser. Greater rewards are reaped when a player chooses to purchase a house and upgrades the house by installing LED lights, heat pumps, and solar water geysers.

RESULTS

According to Conover and Iman (1981), non-parametric statistics are used for data that does not resemble a normal distribution. Non-parametric statistics are a distribution free procedure where data is first transformed into ranks and then normal statistical analysis is applied to those ranks as parametric data (Conover & Iman, 1981). The non-parametric methods include the dependent type called Wilcoxon Signed Ranks test which is used to test one group only, and the independent type called the Mann-Whitney test which is used to compare two different groups' scores. To measure the effectiveness of training that was administered to the experimental group, the dependent type called Wilcoxon Signed Ranks test was used. The quasi-experimental results - for comparison between the experimental group and control group - utilised the independent type Mann-Whitney test.

Assessment of Energy Saving Behaviour Results before Training Intervention for Both Experimental and Control Groups

Descriptive statistics, reliability coefficients, and correlations were calculated on the energy saving behaviour questionnaire, measuring the awareness of energy impact (EI) on the environment, and current energy saving (ES) practices by participants. Correlations are the measure of strength in

linear relationships between the two variables; the correlation coefficient ranges between -1 and 1, where the closer the correlation coefficient to -1, the stronger the negative linear relationship; and the closer the correlation coefficient to 1, the stronger the positive linear relationship (Levine et al., 2013). The results are displayed in Table 2.

Table 2

Descriptive Statistics, Reliability Coefficients, and Correlations

Variable	M	SD	α	1
1. Electricity use - Impact (1-5)	4.46	0.57	0.74	-
2. Electricity use - Saving (1-5)	4.25	0.69	0.75	0.56‡**

** $p < 0.01$

‡ $r > 0.50$

The average score of energy use impact of all 56 participants was 4.46, with a standard deviation of 0.57. The average score of the energy saving practices of participants was 4.25, with variability or a standard deviation of 0.69. However, the correlation coefficient ($r > 0.50$) for the energy saving practices scores was significantly positively correlated to the energy impact scores; therefore, the more participants are aware of the impact of energy use on the environment, the more they practice energy saving behaviour. The correlation is significant at the confidence level of $p < 0.01$ (2-tailed).

Reliability estimate is the measure of consistency in the data or the degree of repeatability in measurements such that the instrument will measure the same way all the time; it indicates to what extent the scores are attributable to the true score, e.g., the reliability of 0.8 means that 80% of the data scores are attributable to truth, whilst 20% is attributable to error (Trochim, 2002). Reliability of the data was measured using Cronbach's alpha, and the results show the reliability of energy impact scores to be 0.74, with the reliability of the energy practices score at 0.75.

Assessment of Training Effectiveness on Experimental Group Only

The results on evaluation of energy efficiency behaviour-based training rendered to the experimental group (as per Kirkpatrick's model) revealed the following:

Level 1: Reaction scores. The results of the training evaluation questionnaire administered after the training programme, revealed positive feedback as shown in Table 3, namely:

1. "I understood the learning objectives, I will be able to apply what I have learnt at work" – The mean score of 4.74 indicates that the majority of participants understood the learning objectives.
2. "The learning material was presented in an interesting manner" – This item has a mean score of 4.70, which indicates that the participants were given interesting study aids.

3. "The instructor was well prepared" – Most of the participants were satisfied with the instructor as indicated by a mean score of 4.78.
4. "The board game enhanced my engagement and participation in the training", and "The facilities and schedule were suitable" – The majority of participants indicated that the board game ensured that they were engaged with the training as indicated by a mean score of 4.81.

Table 3

Descriptive Statistics for Experimental Group Training Evaluation

	N	Mean	Std. deviation
	Statistic	Statistic	Statistic
Evaluation Q1	27	4.74	.45
Evaluation Q2	27	4.70	.47
Evaluation Q3	27	4.78	.42
Evaluation Q4	27	4.81	.40
Evaluation Q5	27	4.81	.40
Evaluation total	27	4.81	.40

Level 2: Learning scores. The participants' evaluation of learning as a result of training was done by an energy saving questionnaire that was administered before the training, and again after the training. Non-parametric correlations between the different factors were calculated, with the results displayed in Table 4. The high correlation score of 0.92 shows that participants who are more aware of the impact of energy saving on the environment and towards costs saving are more prone to practice desired energy saving behaviour. A high correlation also suggests that the energy efficiency behaviour-based training increased the level of awareness and knowledge of experimental group employees. The energy saving practice measure indicates that there was a high correlation between the post energy saving practice and the total energy impact and energy saving, indicating that the behaviour of participants was significantly influenced by the training intervention during the training.

Table 4

Non-parametric Correlations – Experimental Group Only

		Pre-train impact	Pre-train saving	Post-train impact	Post-train saving	Pre-train total	Post-train total
Pre-train saving	Correlation coefficient	.599**	1.000				
	Sig. (2-tailed)	.000	.				
	N	31	31				
Post-train impact	Correlation Coefficient	-.135	.126	1.000			
	Sig. (2-tailed)	.502	.530	.			
	N	27	27	27			
Post-train saving	Correlation Coefficient	.151	.162	.551**	1.000		
	Sig. (2-tailed)	.451	.420	.003	.		
	N	27	27	27	27		
Pre-train total	Correlation Coefficient	.803**	.789**	.014	.115	1.000	
	Sig. (2-tailed)	.000	.000	.943	.569	.	
	N	31	31	27	27	31	
Post-train Total	Correlation Coefficient	.127	.096	.575**	.920**	.094	1.000
	Sig. (2-tailed)	.527	.633	.002	.000	.643	.
	N	27	27	27	27	27	27

Level 3: Behaviour scores. No significant changes were found. Table 5 shows the results of the dependent non-parametric *t*-test, the Wilcoxon Signed Ranks test.

Table 5

Comparison of the Experimental Group's Behaviour Before and After Training

	Post-train impact – Pre-train impact	Post-train saving – Pre-train saving	Post-train total – Pre-train total
Z	-1.155	-.676	-.500
Exact significance (2-tailed)	.388	.640	.807

Because of the small size of the experimental group, a dependent non-parametric Wilcoxon Signed Ranks test was used to compare the data for the group's electricity consumption before and after the training. The aim was to ascertain if behaviour-based training evaluated as per Kirkpatrick's model had changed employee behaviour, in turn resulting in electricity consumption savings. The

results on training effectiveness show a very strong correlation between the energy impact and energy savings after the training had been administered to the experimental group, which suggests that the more employees become aware of the negative impact to the environment caused by high usage of energy, and to company's costs increases, the more they take part in energy saving behaviour. The results obtained from the training intervention's evaluation confirm findings from previous studies (e.g., Passmore & Velez, 2012), that Kirkpatrick's model was replicated in many studies to be effective in changing behaviour. Moreover, the training evaluation results of the experimental group indicated positive feedback from participants' reaction to training, as 81.5% of the participants scored 'totally agreed' to indicate their satisfaction with the training.

The comparison of the experimental group's consumption with the control group's consumption pre- and post- training intervention did not yield significant differences between the two groups' consumption. The question arises as to why there were no significant differences, even though the training showed that there were improved correlations between energy impact and energy saving behaviour of the employees. In this study, the intervention took only one week to train the experimental group and then the electricity consumption was taken immediately after training. Previous studies (e.g., Abrahamse et al., 2005) lacked quantification of electricity power consumption savings after interventions to change behaviour had been made. It was evident from these authors' study that changing human behaviour did not yield sustained lower energy consumption through a single intervention.

The fact that the previous studies did not maintain the behavioural change in participants through various interventions reveals that changing people's behaviour is not easy. Steg and Vlek (2009) maintained that although the challenge in changing people's behaviour is understanding motivational, cognitive, and structural factors that change behaviour, there is high potential that people can contribute significantly towards achieving long term environmental sustainability by adopting pro-environmental behavioural patterns. The training intervention used to measure changes in behavioural patterns showed that the more employees are made aware of energy impact, the more likely they are to practise energy saving as expected, even though the electricity consumption savings had not been realised. The results show the need to further improve the training intervention to realise savings in actual energy consumption. As depicted in Table 6, the electricity consumption readings during working hours, after hours, and for complete days were compared before and after training; no significant differences were found.

An independent non-parametric Mann-Whitney test was used to compare the experimental group's consumption to the control group's consumption, both before and after the training intervention. As shown in Table 7, the difference in electricity consumption readings between the two groups was compared for complete days before and after training, and again no significant differences were found.

Table 6

Comparison of the Experimental Group's Electricity Consumption Before and After Training

	Post-train after hours – Pre-train after hours	Post-train working hours – Pre-train working hours	Post-train 24 hours – Pre-train 24 hours
Z	-1.690	-1.859	-1.690
Exact significance (2-tailed)	.109	.078	.109

Table 7

Comparison of the Experimental and Control Groups' Electricity Consumption Before and After Training

	Post-train kW reading – Pre-train kW reading (24 hour period)
Z	-.192
Exact Significance (2-tailed)	.902

Discussion

The study aimed at ascertaining if behaviour-based training evaluated as per Kirkpatrick's model changed employee behaviour, resulting in electricity consumption savings. The results on training effectiveness show a very strong correlation between the energy impact and energy savings after the training had been administered to the experimental group, which suggest that the more employees become aware of the negative impact on the environment caused by high usage of energy and to increasing company's costs, the more they take part in energy saving behaviour. The higher correlation between energy impact and energy saving post-training as compared to pre-training confirms that the training did impact positively on employee behaviour. The results, obtained from training intervention evaluation, confirm findings from previous studies (e.g., Passmore & Velez, 2012) that Kirkpatrick's model was effective in changing behaviour. Moreover, the training evaluation results of the experimental group indicated positive feedback from participants regarding their satisfaction with the training.

The fact that there were no significant changes realised in the electricity consumption, which necessitates the provision of explanations on possible contributing factors, can possibly be ascribed to the short duration of the intervention. In this study the intervention took only one week to train the experimental group and then the electricity consumption was taken immediately after training. Previous studies (e.g., Abrahamse et al., 2005) lacked quantification of electricity power consumption savings after interventions to change behaviour, had been made. It was evident from these authors that changing human behaviour did not yield sustained lower energy consumption through a single intervention carried out in a short duration of time - less than a month to be exact. Steg and Vlek (2009) maintained that although the challenge in changing people's behaviour is towards

understanding motivational, cognitive, and structural factors that change behaviour, there is high potential that people can contribute significantly towards achieving long term environmental sustainability by adopting pro-environmental behavioural patterns. Studies in TransTheoretical Model (TTM; Prochaska, 2013) argue that adopting behaviours that are long lasting follows a progressive step-by-step process that modifies behaviour in an individual over time. In fact, the TTM recommends a minimum period of six months to change behaviour. According to Prochaska (2013), the TTM follows a five stage sequential process, namely:

1. Pre-contemplation: this process can take less than six months where the individual has not yet decided to take part in newly desired behaviour;
2. Contemplation: this process can also take less than six months where the individual is considering engaging in a new behaviour;
3. Preparation: this stage can take less than six months where the individual begins to take small steps in practising new behaviour;
4. Action: this is the stage less than six months where the individual is actively taking part in new behaviour; and
5. Maintenance: this stage takes at least six months for the individual to maintain the desired behaviour.

Prochaska (2013) argues that interventions fail because they do not consider stages to which individuals in the intervention group belong, nor do they pay attention to the time required to effect behavioural changes. According to Prochaska, individuals in early stages of pre-contemplating and contemplating will respond to awareness-raising interventions, whilst individuals - in later stages of practising desired behaviour - appeal to outcome reinforcement interventions; therefore, the author cautions that interventions should be directed at the specific needs of those individuals.

The training intervention in this study was effective in increasing the awareness of the experimental group as revealed by the results of correlations. The implication is that this training will only be effective in moving employees from contemplating stages as per the TTM model, but will not effect changes to their behaviour to move from preparation stages to maintaining behaviour. Moreover, the training intervention was only limited to a period of one week, which would not be sufficient time to allow changes in behaviour according to the TTM model.

Therefore, it is recommended that energy efficiency behaviour-based training is modified, identifying the stages of the individuals in the experimental group, and designing the training intervention to match the stage categories of the employees as per the TTM model. It is further recommended that the mine provides time not less than six months for training interventions to be done, with regular follow up and feedback sessions to allow employees to progress through the TTM change process stages in order to completely maintain energy efficiency behaviours.

The study had a few limitations. The short period of training – one week exactly – was not enough to have changed employee behaviour which might also have been impacted by the extreme climate temperatures during that specific week (an average of 32 degrees; worldweatheronline.com, 2016). The study took place at a mine in the Limpopo province in South Africa and findings may not be generalisable to other industries, for example the manufacturing industry, due to the uniqueness of the mining environment. Lastly, the research utilised a quasi-experimental design which isolated the effect of energy efficiency behaviour-based training from external variables that may have affected the results (such as the weather).

It is recommended that the mine implements an energy efficiency behaviour-based training programme based on the TTM model which is a stage by stage process towards changing behaviour according to the specific needs of the employees at the mine.

Future studies could also explore energy saving behaviour in the mining industry in order to improve the model of this study, as most of the studies in energy efficiency behaviour had been conducted in the residential sectors.

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CHAPTER 3
CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

The purpose of this chapter is to present the conclusions of the current study according to the general and specific objectives. In addition, the limitations of the study are discussed and recommendations are made for the individual, the organisation and for future research.

3.1 Conclusions

The primary objective of the study was to investigate whether energy efficiency behaviour-based training impacts positively on electricity consumption at a mine in Limpopo province, South Africa.

The **first objective** was to ascertain whether energy efficiency behaviour-based training, evaluated as per Kirkpatrick's model, influences behaviour of employees at the mine. Internationally, there is general consensus that training interventions evaluated as per Kirkpatrick's model are effective in changing participants' behaviour (Curado & Martins Teixeira, 2014; Passmore & Velez, 2012). However, in South Africa no studies could be found that exploited the change in behaviour of employees towards energy saving in the mine or in manufacturing industries as a result of training intervention as per Kirkpatrick's model.

The aim of this study was therefore to add to literature by providing guidance to mining and other organisations that wish to implement energy efficiency behaviour based-training in order to generate potential value when conducting such an intervention. The research design, namely a quasi-experimental design, that was employed for this study has been used in previous studies (Campbell & Stanley, 1963; Kleigeld, Tuijl, & Algera, 2004), where the effectiveness of training intervention was evaluated, isolating other factors not related to training itself as far as possible. In this study the effects of extraneous variables on training were tested by utilising two groups; the experimental group comprised employees from administration offices in the mine and the control group comprised employees in technical services offices in the mine. The training administered to the experimental group followed Kirkpatrick's model, where the reaction, learning, and behaviour of employees as well as business results were evaluated. The results from the study indicate the following:

Reaction. Descriptive statistics revealed that employees reacted positively to questionnaire items, which indicate that they were highly satisfied (mean of 81%) with the training intervention.

Learning. The assessment of learning by the experimental group revealed a high correlation between energy impact (EI) scores and energy saving (ES) scores. A high correlation score suggests

that training enhanced employees' awareness which in turn improved their willingness to practise energy saving behaviours. This result is consistent with previous studies (Abrahamse et al., 2005; Lopes et al. 2012) which found that reinforcing values, beliefs, and norms through awareness interventions leads to energy saving behaviour. However, the overall EI and ES scores before and after the training did not yield significant results; therefore, suggesting that although EI and ES were positively correlated, overall training did not significantly change the willingness of employees to practise energy saving behaviours. The insignificant result could be attributed to the short time period of one week during which training was administered to the experimental group. Furthermore, the energy efficiency output was measured immediately after training.

Skinner (as cited by Sinding & Waldstrøm, 2014) argued that for desired behaviour to become repetitive or habitual, it is important for the desired behaviour to be reinforced through reward or punishment after having learned what the desired behaviour is. In this study, no rewards or punishment were applied to the experimental group after training. This could explain Carrico and Riemer's (2011) assertion that the challenge in the work environment is that employees derive no direct financial benefit from saving energy, and therefore have no motivation to save. Social exchange theory (Schlechter & Strauss, 2008) explains the importance of reciprocity when there is a mutually rewarding relationship between the organisation and its employees. The reciprocal exchange between the individual and the environment implies that individual learning will strengthen when individuals positively observe desired behaviours and consequences of such behaviours in an environment. Furthermore, Cheng and Ho (2001) warned that previous interventions that had failed can be ascribed to the lack of trainees' ability and motivation and also as a result of an unconducive work environment. These scholars found that employees' motivation to learn was a key predictor of the success with which skills are transferred; however, this must be facilitated by subordinate and management support and post-training feedback interventions or relapse interventions. The fact that there was no reward for taking part in the training or for saving energy afterwards could have demotivated employees towards saving energy.

Behaviour: The behaviour of employees in the experimental group was found to correlate strongly with EI awareness scores, suggesting that strong emphasis was placed on energy awareness during training. However, the comparison score between pre- and post-energy efficiency behaviour was not significant.

The **second objective** was to study the relationship between energy efficiency behaviour-based training and actual energy saving. Assessment results of electricity consumption pre- and post-energy efficiency behaviour-based training of the experimental group were not significant, and therefore there was no relationship between energy efficiency behaviour- based training and actual energy consumption. There was also no significant differences between the control group's energy

consumption pre- and post-training intervention, which was expected since the intervention had not been administered to the control group. Abrahamse et al. (2005) assessed actual energy saved through behavioural interventions in the residential sector and found a poor savings track record, more especially after a year or two. These authors found that residential occupants saved immediately after the training, but savings had not been sustained after a period of one to two years. No studies were found where actual energy savings had been quantified following energy efficiency behavioural intervention.

Zelezny (1999) analysed eighteen educational interventions that were aimed at improving environmental behaviours in classroom settings. She found that active involvement of the participants in the classroom effectively improved behaviour as opposed to participants in traditional settings such as households and workplace settings. She also found that the duration of the intervention contributed to its success in classroom settings; the minimum duration in classroom settings was eight weeks and in traditional settings ten hours.

According to Prochaska (2013), person behaviour is changed over time by progressively following different stages as described by the TransTheoretical Model (TTM). TTM describes the stages of change behaviour as comprising pre-contemplation, contemplation, preparation, action, and maintenance. During the pre-contemplation stage, an individual has no intention of changing his or her behaviour; during the contemplating stage, the individual is thinking about starting to change his or her behaviour which can usually take up to six months; during the preparation stage, the individual has started taking steps to change his or her behaviour, but has not yet met desired behavioural changes; during the action stage the individual has recently - during the past six months - just started practising desired behaviours; and finally, the maintenance stage is where the individual has been practising desired behaviour for six months or longer. Therefore, the TTM postulates that change is a process that unfolds over time, following six sequential stages. TTM posits that for individuals to move from one stage to another, there are three mediating processes, namely, self-efficacy for change, decision balance of perceived pros and cons on outcomes of practising behaviour, and ten change processes.

Self-efficacy describes the confidence that an individual has in performing the behaviour successfully in difficult situations, without reverting back to old behaviour (Marshall & Biddle, 2001). Decision balance refers to the individual assessing behaviour outcomes in terms of pros and cons; and change process refers to individual processes used to modify individual feelings, perceptions, and behaviour (Marshall & Biddle, 2001). The ten change processes, namely consciousness raising, dramatic relief, environmental re-evaluation, self-re-evaluation, social liberation, counter conditioning, stimulus control, self-liberation, contingency management, and helping relationships have received the most empirical support in literature (Proshaska, 2013).

Empirical research in TTM studies (Marshall & Biddle, 2001; Proshaska, 2013) reveals that there is a relationship between stages of change and the ten processes of change, in that the first five processes (experiential processes) were more influential in individuals moving from the pre-contemplation to contemplation stages; and the second five processes (behavioural processes) were more influential in moving individuals from the preparation to action and maintenance stages. In particular, contingency management focuses more on positive reinforcement such as providing incentives for desired behaviour and not on punishment of behaviour; this assists individuals to progress from preparation stage to maintenance stage (Proshaska, 2013).

Therefore, practical implications towards designing interventions are that if the targeted population falls within the pre-contemplation to contemplation stage, interventions that enhance consciousness raising and dramatic relief should be applied. Also, if the targeted population falls within the preparation, action and maintenance stages, interventions that are aimed at enhancing behavioural processes should be applied. There is also a growing trend in TTM studies (Marshall & Biddle, 2001; Proshaska, 2013) for tailored made interventions that match the individual stage category according to relevant change processes, namely TTM-tailored communications intervention, i.e. individuals in conception stages would receive messages on raising consciousness, and individuals in action and maintenance stages would receive messages on behavioural outcomes. TTM-tailored communications had been applied in 35 studies on smoking cessation, whereby significant greater effect sizes were found when the interventions had been tailor made for each stage's participants (Noar, Benac, & Harris, 2007). The high success rates in TTM interventions in the health sector suggest that TTM can be applied to the mining industry where employees' stages in change behaviour are first determined in order for subsequent interventions to be tailored. Employees then move across these stages towards developing the desired energy saving behaviours.

Other successful studies (Hermann, Ibarra, & Hopkins, 2010; Tuncel, Lotlikar, Salem, & Daraiseh, 2006) were on behaviour-based safety (BBS); their success attributable to factors such as reward and incentives, participation by employees, behaviour-based safety training and interpersonal feedback. Tuncel et al. (2006) concluded that the critical success on behaviour-based safety is centred on the triad of personal trust, employee participation and work environment with training intervention in the middle of the triad as a facilitator. These authors assert that the work environment must support the practice of BBS, with managers also supporting employees and with rewards and incentives in place; moreover, employees' participation and trust are also crucial for successful intervention. The success of BBS suggests a culture change for work environments to support the learned behaviours in order for the behaviours to be sustainable.

According to Sinding and Waldstrøm (2014), culture is the basic pattern of assumptions about how people in organisations perceive, think, and act and is revealed through evidence of shared

things, shared sayings, shared behaviour, and shared emotions. These authors maintain that culture is embedded in the company's history that was shaped by owners and had been further reinforced by management. According to change management principles, leaders should primarily use embedding mechanisms, which include promoting what leaders are attentive to, leader measure and control, role modelling, teaching, coaching, and allocation of rewards. Tuncel et al. (2006) warned that rewards and incentives are useful to motivate employees, but should not be the only motivating factor why employees participate.

Deci and Ryan (2000) have demonstrated that individuals' internal/intrinsic motivation increases when three basic psychological needs are met, namely the needs for autonomy, competence, and relatedness. Self-determination Theory (SDT) (Deci & Ryan, 2008) is specifically framed in terms of social and environmental factors that facilitate versus undermine intrinsic motivation. According to Deci and Ryan (2008), for basic needs to be satisfied, the environment must support intrinsic motivation and facilitate internalisation and integration of extrinsic motivation. The implication from SDT theory is that, for individuals to be self-motivated, organisations must support their autonomy, encouraging individuals to initiate actions, develop self-efficacy through training, and show genuine interest in individuals to relate to the significant others. The BBS intervention placed more emphasis on constantly providing feedback on observed behaviour, which was identified as the critical success factor (Tuncel et al., 2006). This suggests that for successful energy efficiency behaviour-based training interventions to be effective, the organisation must create an environment where employees are motivated through regular feedback which appeals to their intrinsic motivation and offer rewards which appeal to their external motivation.

When the training intervention took place, the ambient temperature at the mine was on average 32 degrees with high maximums of 41 degrees (worldweatheronline.com, 2016); a fact that also contributed to participants' unwillingness to change their behaviour. These extreme temperatures could explain employees' lack of motivation to switch off the air conditioners when out of office. This suggests that the weather conditions must also be taken into account before and after the training intervention to isolate the effect of the weather on the training intervention.

According to Ölander and Thøgersen (2014), another area in behavioural research that places more emphasis on altering the environment towards supporting behavioural change is the theory of nudging. Nudging is described as the alteration of change architecture that modifies people's behaviours in a predictable way without the influence of rewards, incentives or punishment (Thaler & Sunstein, 2008). These scholars assert that nudging does not only depend on people's cognitive or rational processes in making behavioural decisions, but rather relates to subtle, automated and subconscious processes towards changing behaviour. Examples of nudging include providing information on the number of people choosing healthy food towards making healthy eating behaviour

a salient norm; redesigning or changing the layout of buildings to cue physical activity; or making cycling more attractive and visible as a means of transport (Ölander & Thøgersen, 2014).

The study in Denmark, reviewed by Olander and Thøgersen (2014), revealed that using eco-labelling to nudge consumers had proven to significantly change consumers' buying behaviour towards buying more eco-labelled products. These scholars suggest that the identified barriers towards making decisions to change behaviours must be removed, namely when choice to change behaviour is difficult, when choice is not frequently practised, and when feedback is poor, by altering the contextual nature of the environment towards making it more amicable and by designing cues that trigger change in behaviour. Olander and Thøgersen also advise that social nudging is used to trigger automated behaviour where the desired behaviours are shared by other employees. The applicability of nudging to the mining context is that although training intervention goes a long way towards improving the awareness of employees, nudging may encourage adopting newly learned behaviour through altering the work context to one which makes it easier for employees to subconsciously practise energy saving behaviour.

The **third objective** was to determine the return on investment (ROI) of implementing energy efficiency behaviour-based training at the mine, according to Phillips's (1996) principle. The ROI could not be determined since there was no significant reduction in electricity consumption as a result of energy efficiency behaviour-based training. However, previous energy saving studies (Abrahamse et al., 2005; Lopes et al., 2012) in the residential sector have proved that potential energy savings ranging from 5% to 10% can be achieved through changing behaviour. In the control group, for example, a 10% saving in consumption of electricity would result in achievement of the following ROI:

Power and Energy Saving

Average power demand measured pre- and post-training intervention in kW: 393kW

Monthly energy consumption: 282 960 kWh

Yearly energy consumption: 3 395 520 kWh

Yearly energy consumption saving: 339 520 kWh (assuming 10% energy savings)

Total yearly costs saving: R237 664 (0.7 cents per kWh tariff used based on 2016/2017 Eskom tariffs; Eskom.co.za, 2014).

Training Costs

Total cost of training for a year: R70 000 (based on estimated labour cost for facilitator and training material).

ROI

Nett benefits = total yearly savings – cost of training for a year = R237 664 - R70 000

ROI = Nett benefits / cost of training = R167 664/R70 000

ROI = 239.52%

The results indicate that for every R1 invested in the training programme, there is a potential return of R2.39 in nett benefits. The potential ROI of 239.52% that can be realised by investing in energy efficiency behaviour-based training suggests that mines must consider investing in such training to realise financial savings.

3.2 LIMITATIONS

The study had a few limitations, although these did not curb the contribution of this study towards providing guidelines and paving the way for energy saving behaviour in the mining industry specifically.

The major limitation is the time duration of the energy efficiency behaviour-based training programme administered to the experimental group; the training took place over a one-week period. This might have influenced the results to a certain extent, since the results had been measured a week after the training.

The study was limited to employees at a mining organisation in the Limpopo province. The results of the study may not be generalised to other industries such as manufacturing, because of the uniqueness of the mining environment. The high summer temperature during a week's training in October 2016 could have been a curbing factor towards motivating employees to switch off their offices' air conditioners.

As a result of the deficit of previous South African studies on this specific topic, the study had to rely on research conducted in European countries in the residential sectors. The levels of individual and social factors as predictors of energy saving behaviour as described by these studies (Abrahamse et al., 2005; Lopes et al., 2012) in residential sectors may not be generalisable to the mining environment.

The research employed a quasi-experimental design; the limitation is the extent to which the effect of other variables other than the energy efficiency behaviour-based training was properly isolated. The possibility of external factors (such as the weather) beyond the researcher's control may not be completely ruled out. Moreover, the total sample size (N = 56) for both the experimental group

and the control group did not allow the use of normal distribution statistical analysis; instead non-parametric statistical analysis was done.

Finally, the influence of an energy efficiency behaviour-based training intervention evaluated as per Kirkpatrick's model has not been studied before in the South African mining industry; therefore the training intervention may not have been specifically designed for employee behaviours in a mining context.

3.3 RECOMMENDATIONS

The following recommendations are made:

3.3.1 Recommendations for the Individual

Concerning the aspect of energy awareness, the training intervention highly improved the awareness of energy impact and therefore it recommended that the energy efficiency behaviour-based training in this study be used to enhance individual energy saving awareness.

In terms of employees' change of behaviour, it is recommended that the energy efficiency behaviour-based training intervention be improved as follows:

- Intervention should follow five stages of changing behaviours sequentially as per TTM change processes.
- Intervention is to be tailored designed according to the category of stages in which the employees are grouped according to the TTM stages; the stage distribution of employees should first be determined, then the employees in pre-contemplation and contemplation stages should receive training that raises consciousness and self-efficacy; similarly, employees in the preparation, action, and maintenance stages should receive training that raises behavioural outcomes such as stimulus control and contingency management.

It is also recommended that rewards and incentives be included in energy efficiency behaviour-based training in order to increase the likelihood that employees will repeat desired energy efficiency behaviour. The critical success factor in the behaviour-based safety programmes points to the use of constant feedback to employees to encourage desired behaviour; it is recommended that - after training - feedback is given regularly in order to prevent employee relapses and to allow more frequent participation in training to satisfy employees' basic psychological needs for autonomy, competence and relatedness.

Finally, it is recommended that the training intervention applies the principle of nudging in order for employees to subconsciously adopt energy efficiency behaviour.

3.3.2 Recommendations for the Organisation

It is recommended that the mine implements energy efficiency behaviour-based training following the TTM processes to successfully influence all employees towards adopting energy saving behaviour by facilitating training that will be tailor made to move employees from one stage to another until the desired behaviour has been achieved. It is further recommended that the mine implements reward systems that will motivate employees to save energy as employees graduate towards the maintenance stage of the TTM change process. Moreover, it is recommended that, through change management principles, leaders and managers become role models in energy efficiency behaviour in order that energy saving behaviour becomes part and parcel of the mining culture. It is also recommended that the working environment in the mining areas where energy saving behaviour takes place be altered to support nudging; where contexts support and facilitate the decisions to practise energy saving behaviours. Finally, the potential return on investment indicates that the mine should invest in energy-efficiency training interventions aimed at electricity energy consumption in order to not only save costs, but most of all to contribute to environmental sustainability.

3.3.3 Recommendations for Future Research

It is recommended that future research utilises a larger sample in order to determine the generalisation of the findings in the mining industry. The energy efficiency behaviour-based training model of this study included individual and social factors affecting energy saving behaviour in studies done in the residential sector (Abrahamse et al., 2005; Lopes et al., 2012). It is recommended that future research explores energy saving behaviour in the mining industry in order to improve the model of this study. It is also recommended that the impact of nudging on employees in the mining industry be researched further in order to establish if nudging does affect energy saving behaviour.

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