

Affordances of engagement strategies in chemistry: Learning the periodic table

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DECLARATION OF AUTHENTICITY

I, **Grace Djan**, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.



Handtekening / Signature

02/02/2022

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DEDICATION

I dedicate this work to my father, Rt Rev Felix Doni-Kwame and My late mother Mrs Martha Doni-Kwame (aka auntie Martha Barnes). I thank them for the solid foundation they laid in my life.

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ABSTRACT

This study examined the impact of music, context-based inquiry and computer simulation as engagement strategies to determine the affordances of the engagement strategies in chemistry which could be realised by determining the effects/impact of the engagement strategies on the four components of engagement, affective, agentic/authentic, behaviour and cognitive engagement, to improve teaching and learning the first twenty elements of the Periodic Table (PT). Develop a set of guidelines relevant to the application of engagement strategies in the South African school chemistry curriculum. The need to develop this set of guidelines stems from research that engagement in the classroom is fundamental for effective learning. But creating engagement in chemistry classrooms is one of the crucial problems facing the teachers. Moreover, learners struggle to learn the names and symbols of the elements and understand the PT, which is central to understanding chemistry.

Research results show that the application of multiple intelligence theory (MIT) was found suitable and effective to help learners struggling to learn. While constructivism learning theory (CLT) has been associated with the development and history of the PT. Both theories emphasise the learner as a unique individual that needs attention and a strategy that suits the unique intelligence and characteristics to engage in learning. This study is embedded within a MIT and CLT.

A sequential explanatory mixed method design was followed in collecting and generating data in this study. The focus was on gathering quantitative data first with the aid of a questionnaire (pre and post-tests) followed by qualitative data collection using semi-structured interviews, focus group interviews and lesson observation. The participants of the study were teachers and not learners because promoting engagement heavily relies on the teacher in the classroom. A large class size is associated with a decrease in engagement and hence teacher participants per intervention was thirty.

Quantitative data generated was analysed with statistics procedure to determine the reliability and validity of the constructs. In contrast, the qualitative data was analysed by thematic means and descriptive statistics was used to describe the data. The findings and conclusions from this study reveal that all sets of questions on the strategies proved to have been answered consistently with a high Cronbach's alpha value between 0.85 and 0.9. The quantitative and qualitative results revealed that the affordances of the implemented engagement strategies, music, context-based inquiry and computer simulation, had a positive, but varied impact on the four components of engagement (behavioural, emotional, cognitive, and agentic/authentic engagement) in learning the first 20 elements of the Periodic Table. Furthermore, the engagement

strategies music, context-based inquiry, and computer simulation and the single combined strategy referred to as "MUCBCS" affordances increases affective, agentic/authentic(AGAU), behavioural, and cognitive engagement by focusing and placing the learner at the centre of learning chemistry within the classroom. The affordances of the engagement strategies with varying effects on the four components of engagement improved teaching and learning the first twenty elements of the PT.

Keywords: Affordances, Periodic Table, Learning, Engagement Strategies, Chemistry, Music, Context-based inquiry, Computer simulation, Engagement components.

OPSOMMING

Hierdie navorsingstudie het die impak van musiek, konteksgebaseerde ondersoek en rekenaarsimulasie as strategieë vir leerderbetrokkenheid bestudeer om hul affordansies in chemie te bepaal. Hierdie doelstelling was bereik deur die effekte van die strategieë op die vier betrokkenheidskomponente, naamlik affektiewe, outentieke, gedrags en kognitiewe betrokkenheid in die bevordering van onderrig en leer van die eerste twintig elemente van die Perioieke Tabel (PT), te bevorder. Die studie het uitgedaag op 'n stel riglyne vir die toepassing van die strategieë in die Suid-Afrikaanse chemie leerplan. Die behoefte vir hierdie stel riglyne volg uit navorsing wat toon dat betrokkenheid essensieel vir effektiewe leer is. Tog is die verkryging van betrokkenheid in chemie klaskamers een van die deurslaggewende probleme wat onderwysers in die oë staan. Wat meer is, die leerders sukkel om selfs die basiese te leer, soos die name en simbole van die elemente, om die PT te begryp wat sentraal is tot die verstaan van chemie.

Twee teorieë het as raamwerk vir die studie gedien, naamlik meervoudige intelligensieteorie (MIT) en die konstruktivistiese leerteorie (CLT). Navorsingsliteratuur wys dat toepassings van MIT en CLT geskik en effektiw is om leerders wat sukkel te help. Beide teorieë beklemtoon die leerder as 'n unieke individu wat aandag en 'n gepaste strategie benodig vir haar unieke intellegensies, eienskappe en agtergrondkennis. Daarom is hierdie studie in MIT en CLT ingebed.

'n Sekwensiële verduidelikende gemengde metode-ontwerp was gevolg om in hierdie studie data te versamel en te genereer. Die fokus was dus daarop gerig om eers kwantitatiewe data met behulp van 'n vraelys (voor- en na-toetse) te verkry, gevolg deur kwalitatiewe datainsameling deur middel van semi-gestruktureerde onderhoude, fokus-groep onderhoude, werksblaaie en leswaarneming. Die deelnemers aan die studie was onderwysers en nie leerders nie, omdat die bevordering van betrokkenheid in die klaskamer op die onderwyser berus en hulle insette m.b.t. affordansies van die strategieë in die praktyk as onontbeerlik beskou was. 'n Groot klasgroep word geassosieer met 'n afname in betrokkenheid. Daarom het minder as dertig onderwysers per intervensie deelgeneem, met 'n totaal van 50 deelnemers.

Die kwantitatiewe data was geanaliseer met statistiese prosedures om die betroubaarheid en geldigheid van die konstrakte en die impak van die intervensie te bepaal. Die kwalitatiewe analiese was tematies gedoen. Beskrywende statistiek was gebruik om die data te beskryf. Die bevindings van die empiriese studie het getoon dat al die stelle vrae (d.i. konstrakte) oor die strategieë konsistent beantwoord was met 'n hoë Cronbach Alpha waarde van tussen 0.85 en 0.90. Beide die kwantitatiewe en kwalitatiewe resultate het getoon dat die affordansies van die

geïmplimenteerde strategieë musiek, konteksgebaseerde ondersoek en rekenaarsimulasie, positiewe maar verskillende impakte op die vier komponente van betrokkenheid (gedrag, affektief, kognitief en outentiek) in die leer van die eerste 20 elemente van die PT gehad het. Verder het die individuele strategieë musiek (MU), konteksgebaseerde ondersoek (CB) en rekenaarsimulasies (CS) sowel as die gekombineerde enkel strategie waarna verwys word as "MUCBCS", toename in leerders se affektiewe, outentieke (AGAU), gedrags en kognitiewe betrokkenheid bewerkstelling deur te fokus en die leerder in die sentrum van klaskamerleer van chemie te stel. Gevolglik behoort akademiese prestasies in die PT sowel as chemie te verbeter.

Sleutelwoorde: Affordansies, Periodieke Tabel, Leer, Betrokkenheidstrategieë, Chemie, Musiek, Konteksgebaseerde ondersoek, Rekenaarsimulasie, Betrokkenheidskomponente

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CHAPTER 1 BACKGROUND OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

The introduction of a new curriculum, outcome-based education (OBE), was declared by the then Minister of Education in 1995 (DoE, 1997), which was later known as curriculum 2005. It was revised and renamed the Revised National Curriculum Statement (RNCS) for GET (Zewotir & North, 2011) and the National Curriculum Statements for the FET (Lombard, 2010). The first set of learners taught according to the new curricula from grade 1 to 12 ended in 2008. They entered tertiary, but their test results revealed that they were inadequately prepared for tertiary education, they cannot apply pre-knowledge, they lacked conceptual understanding of fundamental concepts (Potgieter & Davidowitz, 2010; Nel & Kistner, 2009).

As a result, the blame shift began. The grade 12 educators blamed the lower grade educators, and they intent to blame primary school educators for producing learners with no solid foundation who cannot read and write (Matoti, 2010). The recent implementation of the South African curriculum review referred to as Curriculum and Assessment Policy Statement (CAPS), has occurred without adequate training of teachers (Nkosi, 2012).

The inadequate training of teachers on CAPS content contributed to learners poor performance in physical sciences which is a significant problem in South Africa (Petrus, 2018). Therefore, learners poor performance could be attributed to lack of adequately trained teachers, inadequate preparedness of teachers to teach new curriculum content, inadequate preparedness of learners for tertiary education, inability to apply pre-knowledge, lack of conceptual understanding of fundamental concepts (Potgieter & Davidowitz, 2010; Nel & Kistner, 2009) lack of practical work and challenging content in the CAPS document (Petrus, 2018).

Enhancing school learners' science learning is a major goal of science education research. There is a continuous struggle to develop more effective, pedagogically, and scientifically sound strategies to assist learners in understanding science concepts (Gafoor *et al.*, 2012). It has generally been accepted that teachers should engage learners in classroom activities to help them learn better. Specific forms of engagement have been examined, investigated, and recorded in literature extensively. However, limited knowledge of the combination of different forms of engagement exists presently. Furthermore, simultaneous relationship instead of predictive relationships between engagement and achievement has been extensively examined (see chapter 3).

Educational stakeholders have made attempts to find ways of improving learners' performance in chemistry in general, with specific reference to learning the Periodic Table (abbreviated to PT in the thesis). Some educationists and researchers have focused on identifying appropriate teaching methodology (Bello *et al.*, 2016; Keraro *et al.*, 2007; Kibett & Kathuri, 2005; Prince, 2004) or improving on teachers' mastery of content and provision of instructional materials (Udeani & Adeyemo, 2011). Despite all these efforts, students' performance in chemistry is still below expectation.

Researchers who aim to improve the quality of teaching and learning often focus their attention on learner engagement (Trowler, 2010). Creating an active learning environment is essential for engaging learners and the focus is on learners' activities during the learning process (Prince, 2004). A sound body of literature (Maroco *et al.*, 2016; Zepke & Leach, 2010; Trowler, 2010; Fredricks, 2011; Reeve & Tseng, 2011) has confirmed that engagement has a positive influence on learners' success and development (Trowler, 2010, Marco *et al.*, 2016).

Given the limitations and achievement benefits of engagement strategies, it is pertinent to consider factors that could be responsible for enhancing engagement to improve achievement in chemistry, especially in learning the PT. Therefore, it was deemed relevant to investigate the affordances and use of music, context-based inquiry and computer simulation as engagement strategies to enhance engagement in learning the PT. The study was guided by multiple intelligence (MIT) and constructivist learning theories (CLT) to achieve this.

MIT points out individual differences in learning, which implies that a variety of opportunities should be provided for learners to use their abilities, interests, ambitions and learn to construct their understanding of new knowledge (Beceren, 2010). Learners' potential and skills can be developed through the exposure of different ways (in this study different engagement strategies) and a variety of appropriate experiences (various learning activities) (Beceren, 2010; Gardner, 1983). Hence the need to provide a variety of activities through engagement strategies appropriate for learners. Since MIT emphasises how individuals learn due to individual differences (e.g., visual, verbal, musical, kinaesthetic), variation in teaching strategies is required to accommodate differences in learning styles (Gardner & Blythe, 1990). Furthermore, an MIT-based classroom provides an opportunity for each learner to use their learning style to construct their own understanding of new knowledge (Stanciu *et al.*, 2011).

Additionally, CLT is a learning theory that supports learners in constructing their understanding of new knowledge (Barkley *et al.*, 2005:28). Like MIT, it also highlights the learner's active involvement in acquiring the new knowledge (Jacobs, 2004) and emphasises that the learner is the focus and not the teaching target. The teacher then becomes the designer of the environment,

the guide for learning and the academic consultant who creates a favourable learning environment for the learners (Jia, 2010).

The present study aims to identify the affordances of using the engagement strategies (context-based inquiry, music, and computer simulation) to learn the first twenty elements of the PT which fits well with an MIT and constructivist classroom, because it creates opportunities for the individual learner to use different ways of learning and processing information. Consequently, CLT and MIT formed the theoretical framework within which the engagement strategies are investigated in the study to answer the research problems.

Very few studies have been conducted on the combination of music, context-based inquiry and computer simulation as learning engagement strategy. The identified research problem areas and motivation for this study is presented in the following section.

1.2 PROBLEM STATEMENT AND MOTIVATION FOR THE STUDY

The status of science and mathematics education in South Africa is a great cause for concern (Kriek & Grayson, 2009; Spaull, 2013a; Spaull, 2013b). Poor performance in science contributes to negative attitudes towards science (Kriek & Grayson, 2009). Learners' attitude towards science may influence their motivation, interest and achievement in the subjects, enrolment in science courses and application for science-related jobs (Petrus, 2018; Aslan, 2017; Shrigley 1990). Despite the wide coverage of scientific topics in the typical school curriculum, Fraser-Abder (2011) argues that learners who complete high school have not developed useful scientific literacy. The lack of scientific literacy and a negative attitude towards science contribute to a decline in the number of learners who pursue science-related careers (ICSU, 2011). The standard of engagement in science education is fundamental for the future of science and technology and the ongoing development of the global knowledge of a society. Therefore, how mathematics and science are taught is important for the future well-being of a nation and people (Glenn, 2000).

Science can be taught by generating a dynamic learning environment that is essential for engaging learners (Prince, 2004). Researchers, teachers, practitioners, and policymakers are increasingly focusing on learner engagement as the key to addressing problems of low achievement, student boredom, disaffection and high dropout rates from school (Fredericks *et al.*, 2004; Christenson *et al.*, 2012). However, creating engagement is one of the most important problems teachers face (Voelkl, 1996), including chemistry teachers (Stolk *et al.*, 2012; Franco-Mariscal *et al.*, 2015).

Chemistry is a science subject offered in schools and at tertiary institutions. Literature reports the following problems facing the teaching of chemistry as a subject: content overload (Gilbert, 2006;

Pilot and Bulte, 2006), a lack of or a weak link between real world and scientific concept (Gilbert, 2006; Demircioglu *et al.*, 2009; Stolk *et al.*, 2012), learners not actively being involved in the learning process (Stolk *et al.*, 2009), and significant emphasis on memorization of facts, theories, and rules (Gilbert, 2006; Stolk *et al.*, 2012). Numerous efforts have been made to shift to meaningful learning by implementing learner-centred teaching methods (Baeten *et al.*, 2010; Struyven *et al.*, 2006; Wilson & Fowler, 2005). Meaningful learning entails that learnt facts are fully understood and the individual can make connections with other facts. A lack of awareness of giving meaning to what learners learn in class leads to poor engagement. Learners cannot subsequently retain what they have been taught (Gilbert, 2006). Therefore, teaching and learning strategies that support or encourage engagement and interest can spark a positive attitude towards learning to improve achievement and performance. This was pursued in this study conducted in learning about the PT in chemistry.

The PT is central to learning chemistry (Bayir, 2014; Mokiwa, 2017) and an important component of the South African curriculum. The content of the PT is prescribed in the CAPS (Curriculum and Assessment Policy Statement) for learners from Grades 7 to 12, both as part of Natural Sciences (GET phase-General Education and Training) and Physical Sciences (FET phase-Further Education and Training) (DBE, 2011a & b). A problem identified is that by the time learners reach secondary school level (FET), they have developed very limited knowledge of the ideas behind the PT on which to build further chemistry knowledge (Franco-Mariscal *et al.*, 2015).

Over the past years, researchers have recognized the need to increase the level of STEM (Science, Technology, Engineering and Mathematics) literacy (Maher *et al.*, 2015). Chemistry researchers and teachers should explicitly provide opportunities for learners to engage with and explore scientific concepts. Research on learning the PT indicates that it is essential to identify strategies that can promote an active learning environment (crucial for learner engagement) that links the content with learners' daily lives, where learners participate more in activities that are more challenging than in the traditional methods (Franco-Mariscal *et al.*, 2015).

As such, the engagement strategies (music, context-based inquiry and computer simulation) were investigated in this research to promote an active learning environment that achieves meaningful learning. These strategies were purposefully selected based on their perceived affordances to accommodate different learning styles and to improve learning the PT such as the names, symbols, and properties of the first twenty elements of the PT. Furthermore, different topics require different affordances.

For this reason, there is a need to investigate different strategies that can provide the required affordance. Specific content topics may require the affordances that a specific strategy can

provide (Bower, 2008). Therefore, the impact and the affordances of the engagement strategies (music, context-based inquiry and computer simulations) used to create a learning environment for effective learning of the topic was investigated. The realised affordances of the three engagement strategies applied in the study became evident from how well these strategies increase the four interrelated engagement components. For instance, conceptual knowledge (through cognitive engagement), affect (due to emotional engagement), level of active participation (observed in behavioural engagement) and contextual relations (authentic engagement).

The affordances of these engagement strategies were expected to create an environment that would allow learners to engage in active and meaningful learning of the PT, which would in turn improve achievement in chemistry. Limited literature is available on the affordances of engagement strategies, which confirms that the affordances of these strategies for communicating the topic should be investigated. The study intends to fill this gap. Therefore, the problem that the study intends to address is to what extent music, context-based inquiry, and computer simulation strategies would influence engagement in learning basic knowledge of the PT.

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1.3 RESEARCH QUESTIONS

The primary research question of this study is: What can music, context-based inquiry, and computer simulation activities afford towards increasing learner engagement within the classroom to improve academic achievement and performance on the Periodic Table?

The above primary question can be broken down into the following secondary research questions:

- (i) What is the impact of music activities on the four components of engagement (behavioural, affective, cognitive, and authentic engagement) in learning the first twenty elements of the Periodic Table?

- (ii) What is the impact of context-based inquiry activities on the components of engagement in learning the Periodic Table elements (magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen) and linking their use to everyday experiences?
- (iii) What is the impact of computer simulations on the components of engagement in learning basic concepts of the Periodic Table?
- (iv) What are the perceived and realised affordances of context-based inquiry, music and computer simulation engagement strategies in learning about the Periodic Table?
- (v) What set of guidelines is relevant for applying engagement strategies in the South African school chemistry curriculum?

1.4 RESEARCH AIM, OBJECTIVES AND HYPOTHESIS OF THE STUDY

There are five objectives and a hypothesis for the study as stated in section 1.4.2 and 1.4.3.

1.4.1 The aim of the study

The primary aim of the study is to determine the affordances of the engagement strategies music, context-based inquiry, and computer simulation impact on the four components of engagement (behavioural, affective, cognitive, and authentic engagement) in learning the first twenty elements of the Periodic Table.

1.4.2 The objectives

The objectives of the research study are to:

- (i) Investigate the impact of musical activities on the four components of engagement (behavioural, affective, cognitive, and authentic engagement) in learning the first twenty elements of the Periodic Table.
- (ii) Investigate the impact of context-based inquiry activities on the components of engagement in learning about the Periodic Table elements magnesium, lithium, phosphorous, sulphur, carbon, oxygen, and hydrogen and linking their use to everyday experiences.
- (iii) Investigate the impact of computer simulation on the components of engagement in learning basic concepts of the Periodic Table.
- (iv) Determine perceived and realized affordances of context-based inquiry, music, and computer simulation as engagement strategies in learning pertaining to the Periodic Table.

- (v) Design a set of guidelines relevant for the application of engagement strategies in the South African school chemistry curriculum.

1.4.3 The hypothesis

The hypothesis for the study is that the affordances of the engagement strategies music, context-based inquiry and computer simulation will have a positive, but varied impact on the four components of engagement (behavioural, affective, cognitive, and authentic engagement) in learning the first twenty elements of the Periodic Table.

1.4.4 The variables

- (i) The independent variables may be referred to as attribute independent variables because they were not altered during the study. None of the independent variables were manipulated to provide a stimulus to the dependent variable.
- (ii) The independent variables are the engagement strategies: music, context-based inquiry and computer simulation.
- (iii) The dependent variables are the four components of engagement: behavioural, emotional, cognitive and authentic engagement.
- (iv) The controlled variables are the participants' profession and number.
- (v) The extraneous variables are the participant variables such as the individual characteristics of each participant. These extraneous variables may affect the dependent and independent variables but cannot be controlled.

1.5 TERMINOLOGY

The key terms of the study are Periodic Table, chemistry, computer simulation, music, context-based inquiry, learning, affordances, engagement components and engagement strategy. The meanings as applied to this study are as follows.

- The Periodic Table is a chart that displays the chemical elements arranged according to their atomic numbers and is widely used in chemistry. Chemistry is a branch of science, that studies matter, material, energy and change.
- Engagement is characterized by compliance with attention and involvement (behavioural engagement), processing of knowledge and thinking (cognitive engagement), positive

affective reactions such as interest and enjoyment (affective engagement), and application of what is learned and participation in activities and team work (agentic/authentic engagement).

- Engagement strategy is a means to achieve the positive characteristics of engagement components.
- Computer simulation is a strategy that allows interaction with computer representations and manipulations of variables. It can be used to make invisible chemistry content visible, thus providing connections between sub-microscopic, macroscopic, and symbolic levels of representations in chemistry.
- Music is a strategy used in the study that involved watching chemistry-based music videos, singing along and compiling of own songs .
- Context-based inquiry is a strategy of hands on activities and discussions including transfer of knowledge between the classroom and the real world.
- Learning is the process of acquiring knowledge, skills and understanding.
- Affordances are the characteristics of a strategy that determine if and how learning occurs.

1.6 OVERVIEW OF THE RESEARCH PARADIGM

A paradigm provides a basic set of rules that guide the actions, situations and values (Guba, 1990:17; Creswell, 2011) of research about the world and determines the nature of the research study (Creswell, 2014). This research study is based on a single paradigm to provide the foundation for a mixed method design, which is found within the pragmatism emancipatory perspective. Pragmatism emphasises the research problem and the different methods to approach the problem (Rossman & Wilson, 1985) and the freedom to choose what best meet the needs and purposes of the study, since the world is viewed as an absolute unity (Creswell & Clark, 2008).

Mixed method consists of multiple philosophical positions including constructivism and post positivism suggested by some researchers. For instance, according to Creswell and Clark (2011:101) the philosophical worldview for the qualitative method is constructivism while positivism or postpositivist orientation for the quantitative method. The forced choice dichotomy between post-positivism and constructivism, metaphysical “truth” and” reality” is abandoned (Creswell & Clarke, 2011) in this study.

Hence the dichotomy, 'truth' and 'reality' is not included in the discussions and interpretations. Instead, a practical and applied research philosophy has been used to guide the methodological choices (Creswell & Clarke, 2011:44), pragmatism.

Multiple Intelligence theory is pragmatic it is practically useful and encourages how schools should value and support the learners' abilities. Since it emphasizes that every learner is a unique blend of self-motivated intelligences, it provides eight different potential pathways to learning. Hence the use of Mixed Method which provides different pathways for the study.

1.7 OVERVIEW OF THE RESEARCH DESIGN

The purpose of the study is to focus on investigating engagement to improve achievement in chemistry by using music, context-based inquiry, and computer simulation as part of teaching and learning the first twenty elements of the PT using sequential explanatory mixed method. The flow diagram in Figure 1.1 illustrates the research design. The sequential explanatory mixed method design was used to collect and analyse data for legitimate knowledge by investigating the four components of engagement to determine the impact of the intervention to answer the research questions.

1.7.1 The intervention

The intervention program was designed to promote engagement in three phases, namely: Phase 1: Application of music to learn the names and symbols of the first 20 elements of the PT; Phase 2: Linking the use of PT elements to everyday life experiences using context-based inquiry; and Phase 3: Use of a computer simulation to visualise and understand the abstract concepts of the PT. As shown in Figure 1.1, each of the three intervention phases thus implemented one of the engagement strategies.

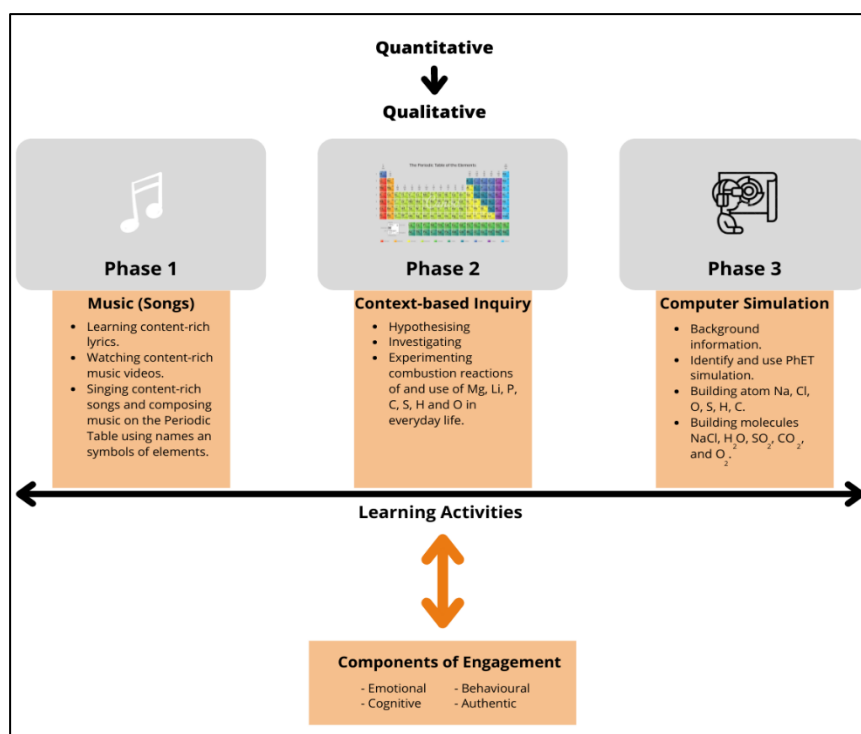


Figure 1-1: A flow diagram providing an overview of the research design

The three phases of the intervention were repeated in two workshops during the study. The first phase used music (songs) to learn the names, symbols, atomic number and atomic mass of the first 20 elements of the PT in the correct order. This was followed by the second phase, which utilized content-based inquiry to learn about the combustion and uses of selected elements on the PT (see figure 1.1). During the third phase, computer simulations were used to aid participants in understanding how atoms of different elements are made up and how molecules are formed by specific combinations of atoms as determined by their relative positions on the PT.

The characteristics of the tasks per phase were considered when compiling the intervention activities. These task characteristics associated with the conceptual modelling of engagement are age appropriateness, degree to which a task is interesting, degree to which a task is challenging, ability to connect to the real world, flexibility, opportunities for autonomy, variation and active involvement (Fredricks, 2013). This implied that the structure of each task should be clear, with consistent rules and expectations, feedback and unambiguous routines and procedures to increase engagement and the time that can be spent on the task. All eight task characteristics mentioned were considered while compiling the intervention activities which were implemented in three phases.

The multiphase model applied in this study employed a sequential explanatory design that allows the researcher to combine elements of quantitative and qualitative empirical methods sequentially

for depth of understanding, corroborating, and validating the data (Johnson *et al.*, 2007; Teddlie & Tashakkori, 2010).

The sequential explanatory mixed method design applied include:

- quantitative and qualitative methods in defining the research questions,
- methods of data collection,
- analysis procedure and inferences.

1.7.2 Data collection

The focus on gathering quantitative) data first with the aid of a questionnaire that served as pre and post-test, followed by qualitative data collection using semi-structured individual interviews, focus group interview, worksheets, case study and lesson observation. Notably stated, quantitative method confirms the objectivity and reliability of the study (Teddlie & Tashakkori, 2009:209; Djan, 2014) while qualitative research was to produce ample, detailed, and valid data that provide a comprehensive knowledge of the context (Creswell, 2012:237-239; Djan, 2014).

Research participants were natural science teachers from grade 4 to 9 and physical science teachers from grade 10 to 12. The teachers that participated came from 29 schools in the North-West Province and a total of 50 teachers participated in the study.

Data collection and analysis techniques are summarized in the diagram below: Figure 1.2 represents a visual presentation process of collecting and analysing data from the sequential explanatory mixed method.

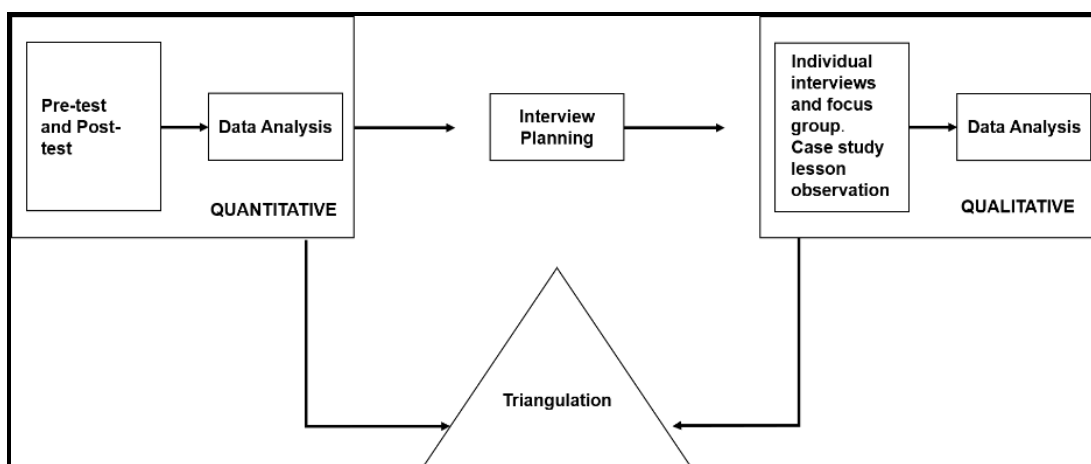


Figure 1-2: A visual presentation process of the process of collecting and analysing data

(Source: Author's compilation)

1.7.3 Data analysis

The quantitative data obtained from the questionnaires were processed statistically by the North-West University's Statistical Consultation Service to determine if the intervention had a significant effect on the engagement components. Descriptive statistics like frequencies and means was used to describe the data. To assure construct validity, a factor analyses was completed and reliability of constructs was assured by calculating Cronbach alpha values.

Thematic analysis was systematically used to identify, organise, and record patterns in the given data set from the worksheets, individual interviews, focus group interviews, and lesson observation. Grouping of themes, subthemes from the data was analysed and reported, bringing meaning to the mutual shared experiences.

1.8 ETHICS CONSIDERATIONS

Ethics clarification number NWU-00532-19-S2 was obtained from the North-West University, Potchefstroom where the researcher was enrolled. Science teachers from the Northwest province were invited to volunteer and participate in the research study. For ethical reasons, the participants were notified about what will be done and what will be expected from them during the workshops. The researcher sent letters to the principals of the schools and the Department of Basic Education (DBE). Permission was granted and the date and time as stated in the pre-notification letter were approved. See Appendix B and C for the permission letters from the North-West University, Department of Basic Education, school principals and consent forms for participants and parents. Incentives were used to motivate the potential participants (teachers) and maximise the response rate. A good response rate is important to attain respondents that match the demographic traits of the population (Thomas, 2004:123). The researcher and team cordially adhered to ethical issues listed below.

- (i) Voluntary participation: Participants participated voluntarily, and the researcher
- (ii) created an atmosphere where they felt free to refrain from being in the study. Participants' responses were treated without any prejudice and they were free to withdraw from the process at any time without providing any reason(s).
- (iii) Informed consent: Permission from the Department of Basic Education of the North-West Province, school principals, participants and parents of learners was obtained ~~prior to~~ before the study. A description of all study features that might influence the teachers or learners' willingness to participate was given to the prospective participants.

- (iv) Right to privacy and confidentiality: The researcher respected the privacy of the participants and the participants remained anonymous. The information was kept confidential and only be used for research purposes. The researcher respected the right of the participants to decline or accept feedback. The research methods and details of the intervention were explained to participants thoroughly to ensure full disclosure.
- (v) Potential risks: No risk to participants was foreseen due to the nature of the research study. The research did not interfere with teachers' or learners' school curriculum time and the researcher ensured that the benefits were maximised.
- (vi) Potential benefits: The researcher provided teachers with the opportunity to reflect on their teaching practices. They would also be able to transfer what they had learned during the intervention to other topics in the GET and FET phase to improve teaching and learning.

1.9 OVERVIEW OF STUDY OUTLINE

Chapter 1 (*Background of the study*): This chapter provided the study background, awareness of the research problem, the motivation, research questions, hypothesis, and objective of the study. The purpose and scope were stipulated in the research problem statement. An overview of the theoretical framework and research design were given.

Chapter 2 (*Learning and learning theories*): A literature study related to the theoretical background and framework for the empirical study was reported. It included information on learning, constructivist learning theory, and multiple intelligence theory.

Chapter 3 (*Periodic Table, strategies, engagement and affordances*): Prior literature surveyed included problems addressed and learning strategies that have already been developed to solve similar problems. Empirical research studies and findings relevant to the problem at hand were studied and discussed. Literature on affordances, engagement, engagement components, music, context-based inquiry and computer simulations was also included.

Chapter 4 (*Research Methodology*): The research process and design are described. Clear motivations for selecting the research design and methods appropriate to the empirical study are provided. Research objectives and questions were the main influence for the methods selected. The research methodology is described in detail.

Chapter 5 (*Results*): This chapter presents the quantitative and qualitative results and offers an interpretative discussion of both. The data were analysed and presented in tables and graphs and the results obtained for each strategy (phase) were described.

Chapter 6 (*Interpretation and discussion of the results*): What the results mean and how they relate to findings from the literature study are explained and discussed.

Chapter 7 (*Conclusion and recommendations*): This chapter explains how the results answers the research questions in the context of the theoretical framework. The researcher provided a summary and conclusion of the study. Recommendations, limitations and contributions are also provided.

1.10 SUMMARY

In this chapter the researcher introduced the research reported in the thesis. This included the background of the study, the problem statement and motivation of the study, followed by the research questions. The aim, objectives and hypothesis were stated. An overview of the research design and study outlines were provided as well as ethical considerations. The next chapter deals with a literature study related to key concepts.

CHAPTER 2 LEARNING AND LEARNING THEORIES

2.1 INTRODUCTION

This chapter reports on a literature study that forms part of the theoretical framework of the empirical research problems. Much research, studies, theories, strategies on teaching and learning have been reported in the literature by psychologists, educationists, researchers, and authors of different professions. Some of these strategies, and theories related to this study, are discussed in the sections and subsections that follow.

Chapter 2 comprises detailed discussions on selected learning theories such as multiple intelligence theory (MIT) and constructivist learning theory (CLT) which form the theoretical framework guiding this study. MIT is the learning theory that guides the teaching and learning process as it points out individual differences in learning by offering a variety of opportunities for learners to use their abilities, interests, and ambitions to practice, learn and construct their understanding of new knowledge (Beceren, 2010; Ucak *et al.*, 2006:61). In addition, constructivist learning theory allows learners to create their understanding of new knowledge by highlighting the learner's active involvement in acquiring this new knowledge with emphasis on the learner as the subject and not the object of teaching (Jia, 2010; Barkley *et al.* 2005:28; Jacobs,2004). These learning theories describe how the learners gain, obtain, process, and retain knowledge during learning.

2.2 LEARNING

Learning is how individuals consciously self-organize their cognitive structures (Jia, 2010). Learners are total, unique beings with unique physical, cognitive, emotional, social, and moral dimensions that contribute towards the learning process (Du Plessis *et al.*, 2007:3, 4). Learning can be enhanced when learners are made aware of different ways of learning and are allowed to experiment with a variety of strategies to find out which strategies work best for them.

Learning is the process of gaining new knowledge, values, behaviour, skills, and preferences credited to experiences that cause changes in the improvement of learners' knowledge, behaviour, skills, values, attitude, and performance is elaborated further.

Hornby (2006:894) perceived learning as "an act of gaining knowledge". According to Caine and Caine (2006) gaining knowledge is a continuous process that involves memorization, behavioural changes and development of skills for meaningful learning. Therefore, learning is a series of actions to gain knowledge and skills using different strategies. Learners actively employ different learning strategies to gain understanding (du Plessis *et al.*, 2007:4) making learning an active

rather than a passive process (Von Glasersfeld, 1998). Learning that involves the active participation of learners using different learning strategies can be referred to as active learning. Active learning is therefore fusing of the different teaching strategies that engage the learner in meaningful learning experiences that involve critical thinking (Prince, 2004:1), development of skills and values (Bonwell & Eison, 1991:5-13) that contribute towards learner improvement and achievement (Cross *et al.*, 2008: 842-858).

From the study of a technology-infused approach to learning science, examining learners' learning experiences and academic achievement, Nueva and Calica (2018) deduced that there is no major relationship between learning experiences and learner achievement. They highlight the vital role of teacher interventions in improving learners' understanding of scientific concepts. They further emphasised the importance of well-planned lesson plans to include a variety of learning activities that promote learners' engagement (Nueva & Calica, 2018:122-124).

These studies seems imperative for the teacher to explore different learning strategies that maximize engagement. However, different learning theories govern different learning strategies, as discussed in the following section.

2.3 LEARNING THEORIES

Learning theories are sets of organised principles and frameworks describing and explaining how individuals acquire, absorb, process, retain and recall knowledge during learning. In addition, understanding and acquisition of a world view or change is influenced by cognitive, emotional, environmental and behavioural factors. Learning theories related to behaviourism, cognitivism, humanism, connectivism and constructivism are briefly discussed in sections 2.3.1 to 2.3.5.

2.3.1 Behaviourism

Behaviourism was among the first learning theories to be compiled. It was mainly connected with the work of Thorndike (1913), Watson (1913) and Ivan Pavlov (1927). The behaviourist view involves external factors such as rewards, punishment, positive and negative reinforcement. These are practical means of modifying learning and behaviour (Skinner, 1985; Scott *et al.*, 2021)

Behaviourism operates on a principle of "stimulus-response". Skinner's experimental study in the 1930s on reflexes led to the notion that a response to stimulus takes place within an organism (Watrin & Darwich, 2012). For instance, when a learner is shown the equation " $C + O_2$ " and the answer given is CO_2 , then the equation is the stimuli, and the correct answer is the associated response. This view of learning is promoted by repetition and positive reinforcement. Learning is therefore considered as a transformation in the behaviour of the learner.

Watson (1913, 1924), one of the pioneers and advocates of behaviourism, believed that the “environment” plays a more significant role in learning than genetics. In support of Watson’s view, Rakos (2013) emphasises that any child can learn anything and can become anything you want them to be by creating the environment for learning that will lead to achieving that goal.

The factors that influence learning are thus perceived to be the arrangement of stimuli, reinforcement and the environment. Although both learner behaviour and environmental factors are considered, the environment, according to the behaviourist, is the most important and should receive the most significant emphasis (Ertmer & Newby, 2013).

As noted, learning occurs when there is a behaviour change, thus new behaviour which is observable and measurable is acquired. Neither thinking, mental processes and reasoning activities nor the role of memory is emphasised as part of the learning process by behaviourists (Ertmer & Newby, 2013).

However, Fauziati (2016) and Budiman (2017) have applied the behavioural learning theory in language teaching. Creating a conducive environment with repetitions, mastering basic concepts before progressing to more complex ones, and reinforcement as presented by behaviourism were found vital to learning. Positive reinforcement in rewards or informative feedback presented to learners could guide them to respond favourably to a stimulus.

Although Budiman (2017) found that behaviourism is useful in teaching and learning activities, this theory lacks attention to memory and thinking, which other educationalists consider as vital to learning. The study of cognition led to the development of alternative learning theories, including humanism, cognitivism, constructivism and connectivism.

2.3.2 Humanism

The humanism theory rejects the behaviourist perspective of reinforcing the stimulus-response behaviour, which is based on animal research and the theory regards this as dehumanising. Humanism, also referred to as the humanistic learning theory or humanistic psychology, emerged as a response to the limitations in Skinner’s behaviourism theory as identified by Sigmund Freud’s psychoanalytic theory (McLeod, 2020; Kamran & Kayvan, 2010; Hollis, 1991).

Abraham Maslow, a humanist, created what he believed to be a psychological hierarchy of needs. At the bottom of the hierarchy are physiological needs like safety, love and belonging, and at the top of the hierarchy are self-esteem and self-actualisation. Fulfilment of the need at the very top of the pyramid symbolises meaning (Weiner, 1980). Humanism asserts that learning requires the teacher to provide an environment for the learner to experiment and develop hence experiential

learning governs humanism (Wu *et al.*, 2012:1154-1160; Hollis, 1991). However, for the learner to grow, there is also the need for an environment that provides them with acceptance and being listened to and understood. This means that the learner must be allowed to talk and to be listened to in the classroom.

Yang *et al.* (2018) argue that the humanistic learning theory focus on learners' experience and internal feelings to understand their psychological behaviour, dignity, ideals and interests. Teachers should pay special attention to the learners' perceptions, emotions, beliefs and intentions (Yang *et al.*, 2018).

To summarise, it can be contended that humanism is the study of the whole person and the uniqueness of the individual. Providing an ideal environment for learner centeredness and reaching out to every learner is proposed. Therefore, individual learning is promoted by role modelling, experiences, exploring and observing others. This implies that learning from the humanist point of view can be described as a natural and a personal process to fulfil one's potential and self-actualisation. It is a holistic approach.

2.3.3 Cognitivism

Cognitivism view learning as the development of cognitive pathways for understanding physical responses to experiences. Jean Piaget (1977) developed the cognitive learning theory, called the theory of thought.

Cognitivism is characterised by thought, understanding the structure of knowledge and the internal environment instead of the behaviourist external environment (Torre *et al.*, 2006). It stresses cognitive processes rather than external observable behaviour. According to the cognitivist, learning takes place in the learners' internal environment and cognitive structures using cognitive tools such as insight, information processing, perceptions and memory to facilitate learning by assigning meaning to events (Torre *et al.*, 2006).

Cognitive development, however, takes place through social settings and interactions. Knowledge and skills are acquired through interaction with others who already have the skills and knowledge (Hakvoort, 2002). In other words, to obtain knowledge, the individual depends on the persons in possession of the knowledge such as teachers, peers or parents, for guidance and support (Anastasiou *et al.*, 2015). Learning does not depend solely on the level of cognitive development of a child but upon the representation and strategies used to process information (Anastasiou *et al.*, 2015; Berg, 1999).

Stanković *et al.* (2018) content that the conditions to develop learners' cognitive abilities; include active participation in the learning process, interacting with adult teachers, information with clear instruction, and teaching materials with clear and quick identification of goals.

A general idea about the application of cognitive theory in the classroom, is the active participation and learner cognition in the classroom and interaction with the teacher. This relates to the findings of Stanković *et al.* (2018) by comparing cognitive learning theories to multimedia teaching and learning. They assert that the application of multimedia in the teaching process increases students' active participation, facilitating interactive learning and improving success.

2.3.4 Connectivism

Connectivism is a theory of learning in the digital age based on the concept that information is processed by forming connections. Since technology is growing very fast, a severe consideration for a new paradigm of teaching and learning to match up with the fast-moving technological environment and complexity of information available on the internet was considered essential (Downes, 2008; Siemens, 2005; Brown & Adler, 2008).

The connectivism theory affirms that knowledge forms connections between networks by actions and experiences (Kop & Hill 2008). Learning is the "ability to construct and traverse these networks" (Downes, 2008). Siemens (2006) suggests that "learning is the network" which, according to Kop and Hill (2008), is a relationship between the external and the internal physical environment.

Downes (2008, 2019), Kop and Hill (2008) assert that connectivism theory can guide teaching and learning as the digital age progresses. The learner connects to a learning community by receiving and giving information (Kop & Hill 2008), in an area of similar interest that allows for interaction, sharing and thinking together through networking (Siemens, 2004).

The internet and technology have altered essence of learning from teacher-centred to learner-centred (Foroughi, 2015). Connectivism, a proposed learning theory for the digital age, views learning as continuously creating, updating connections with other networks and different knowledge sources (Foroughi, 2015). Importantly, Kop and Hill (2008) emphasised that cognition and emotions are important to the learning process as perceived by connectivism. Finally, Simens (2013) argues that connectivism offers awareness to learning skills and activities that are necessary for learners to succeed in the modern digital age because learning and knowledge include interacting with different media and not just an individual activity.

Utecht and Keller (2019) argue that we are in the new digital era where the internet creates easy access to information and knowledge. Factors such as how quickly one can learn, unlearn and relearn information in today's digital world are of optimum importance in acquiring knowledge. Connectivism embraces the change to a "just-in-time" learning environment (Utecht & Keller, 2019). The ability to enjoy immediate production and arrival of information and knowledge in a learning environment represents immense engagement potential for educators and their learners (Utecht & Keller, 2019:11). This implies that a learning environment with easy access will produce immediate and continuous information with ease due to the present availability of the internet. This interaction enhances learning engagement.

Verhagen (2006) criticises connectivism because connectivism does not display any new principles that do not already exist in other present learning theories. Furthermore, Verhagen is unconvinced that learning can fit in non-human appliances. Hence the constructivist approach is more acceptable, as it views learning as the building of knowledge and experiences created by the learner (Djan, 2014; Driver *et al.*, 1986; Barkley *et al.*, 2005).

2.3.5 Constructivism

Constructivism is a learning philosophy (Jia, 2010) where learners construct their own knowledge by giving meaning to new knowledge (Barkley *et al.*, 2005:28). They create their understanding based on their experiences and link further information to their experiences to construct their own meaning. Therefore, exposure to activities that promote existing and new experiences is used to construct knowledge.

2.4 THE CONSTRUCTIVIST LEARNING THEORY

The constructivist learning theory is seen as an educational theory, which is the main view to inform pedagogy. There are many books informing teachers, educators and all other stakeholders about constructivist research findings and ideas that guide teachers on what method to teach science from a constructivist point of view.

The purpose of teaching is to ensure that learning takes place. Therefore, teaching should involve the process through which learners acquire knowledge. The constructivist teaching and learning theory has much to offer towards the acquisition of knowledge by learners (Fernando & Marikar, 2017).

Von Glasersfeld (1998), mentioned that teachers must consider the learners as active participants in the learning process while acting as facilitators. Jacobs (2004) also highlights the importance of active involvement in acquiring new knowledge. The teacher is then the designer of the

environment, facilitator of the learning process and an academic consultant who creates a favourable learning environment for learners (Jia, 2010). Opportunities created for the learner to experience interactive activities create a positive affect (Jia, 2010). Constructivists thus believe that learning is affected by the context, teaching, learning, learners' beliefs and attitudes (Olusegun, 2015; Sjoberg, 2007).

Akpan and Beard (2016: 396) explored constructivist strategies to improve the academic performance of learners with special needs. After the exploration, they made the following conclusions regarding constructivism: Constructivism is a model to guide how learners learn and how learning occurs. The learner is always active and is the central focus, i.e., instruction is learner-centred.

Basic concepts on constructivist learning theory relate to knowledge, the learner, the teacher and teaching. These concepts are discussed briefly under sections 2.4.1, 2.4.2 and 2.4.3.

2.4.1 Knowledge

According to constructivism, knowledge is gained by the active participation of the learner. In support of the above statement, Doolittle and Hicks (2003) state that knowledge is the product of active use of thought processes by the individual satisfying specific goals (Doolittle & Hicks, 2003:78). This implies that knowledge is created by building personal interpretation based on individual experiences and the relevance of knowing.

According to Novodversky (1997:242), the constructivist learning theory is based on three premises, namely, learners construct knowledge in their minds, secondly, learners bring their prior knowledge and experiences to class, and lastly, learning is a lifelong process. Consequently, Jacobs (2004:46) views constructive theory as learners' ability to actively acquire and construct their knowledge.

The diverse types of constructivism which include social, radical and cognitive address the nature of knowledge and knowing differently (Steffe & Gale, 1995; Moshman, 1982). Cognitive constructivism differs from radical and social constructivism as it holds the idea that reality or truth can be known as it exists in the individual's external environment (Prawat,1996; Doolittle & Hicks, 2003). While radical and social constructivism knowledge is internal or social nature respectively (Doolittle & Hicks, 2003). From the cognitive point of view, knowledge is objective. Acquiring knowledge means constructing and reconstructing of mental structures (Moshman, 1982; Doolittle & Hicks, 2003). These three types of constructivism are elaborated upon in section 2.5.

Knowledge in terms of the constructivist learning theory encompasses the active and creative involvement, change in knowledge acquired and understandings resulting from experiences that arise from given context (Doolittle & Hicks, 2003:77-79) such as the science context. Knowledge is therefore linked to the context of learning and the experiences that the learners bring (Ertmer & Newby,1993). In addition, knowledge is built-in social contexts that are heavily influenced by prior learner experience (Akpan & Beard 2016:397). In this case, the learner is the focus of learning and the recipient of knowledge.

2.4.2 Learner

The learner is the constructor of knowledge and the core target of learning as viewed by the constructivist (Olusegun, 2015:66; Doolittle & Hicks, 2003:78; Bereiter, 1994). The individual learner makes sense and constructs knowledge based on their experiences within their own context. Sjoberg (2007) emphatically mentions that the learner should actively construct knowledge, which underscores the fundamental idea of a constructivist approach to learning.

Jacobs (2004:46) describes the constructivist theory as emphasising learners' active participation in building and gaining knowledge. However, learners must be helped by their teachers to build meaningful knowledge. Therefore, the learner must be the centre of learning which implies that the learner must participate actively in the learning process. Learners use their previous experience to reconstruct new knowledge. For this reason, teaching must stimulate learners in the construction process.

2.4.3 The teacher and teaching

Teachers play a vital role in facilitating discussion and critical thinking as part of their teaching strategy. Research findings indicate that the learner is the active participant in the teaching and learning process (Olusegun, 2015; Doolittle & Hicks, 2003; Jacobs, 2004; Von Glasersfeld, 1998; Bereiter, 1994). Hence, teaching as facilitation of learning must consider the learner as an active participant (Von Glasersfeld, 1998). The teacher possesses expert knowledge on a topic and should facilitate active learning. Given this, Fernando and Marikar (2017:111) contend that teaching involves the transmission of knowledge and facilitating learning. However, according to Jia (2010), the role of the teacher changes from the transmitter of knowledge to the helper who guides learners to take the initiative to construct meaning. Teachers, therefore, as the experts become the designers, guides, and academic consultants of the learning environment (Jia, 2010).

According to the constructivist theory teaching means knowing and understanding the learner's pre-existing knowledge, guiding the activity and encouraging the learner to use creative strategies to develop more knowledge and reflect on how their understanding changes (Olusegun, 2015;

Tam, 2000). Constructivist learning theory is especially valuable in teaching complex skills e.g among others, problem solving, critical thinking, decision making, etc. (Tam, 2000). The constructivist learning theory attests that creating a suitable learning environment and exposing the learner to the material to be studied give rise to meaning (Olusegun, 2015; Tam 2000).

2.5 CATEGORIES OF CONSTRUCTIVISM

The three categories of constructivism are social, cognitive and radical, but the main direction of constructivism in learning have been social and cognitive constructivism.

2.5.1 Cognitive constructivism

Cognitive constructivism embraces the outward disposition of knowledge, and the fact that reality can be experienced outside the individual. Knowledge is an indication of how the world truly works, and the importance of knowledge is defined by its communication with the real world (Doolittle & Hicks, 2003; Prawat & Floden, 1994). The cognitive constructivist teacher may therefore use discovery learning including problem solving with the aim to develop critical thinking as well as problem-solving skills.

2.5.2 Social constructivism

Social constructivism embraces the social nature of knowledge and shares the world view that no individual may come to know way facts (Doolittle & Hicks 2003:79) without social interaction. Social constructivism highlights social interaction as the basis of knowledge (Larochelle *et al.*, 1998; Prawat & Floden,1994). Doolittle and Hicks (2003:80) placed special emphasizes on how learner's interaction with their peers and other learners help them construct scientific knowledge themselves under a changing social environment. In a social constructivist classroom, cooperative inquiry approach might be used in teaching and learning.

2.5.3 Radical constructivism

Von Glasersfeld (1996,1998) has been the leading representative of radical constructivism. Since he did not have a large group of followers, many perceived cognitive and social constructivism as the two main categories of constructivism. However, the theoretical core of Von Glasersfeld's original radical constructivism includes the concept that knowledge cannot be passively obtained which is one of the main principles of constructivism.

Radical constructivism places emphasis on the internal nature of knowledge. While an external reality may exist, the true nature of this fact is unknown (Doolittle & Hicks 2003).

According to radical constructivism, a teacher must be aware of the experience and, pre-existing conceptual structures of learners and understand how they interact with others. Hence, the teacher's key role is to be a leader who provides an appropriate learning environment for learners to construct knowledge. On the contrary, knowledge constructions are limited, restricted, and validated by resources that they interact (Doolittle & Hicks 2003).

2.6 PRINCIPLES OF CONSTRUCTIVISM APPLIED IN LEARNING STRATEGIES

Learning under the constructivist premise can be classified under subheadings: cooperative learning/collaborative, inquiry-based, problem-based and technology-based learning. These techniques present learners with tasks, contests and opportunities to explore. Constructivism presents learners with challenges to think about and produce solutions, and promote active participation of learners (Prince, 2004; Wilke, 2003; Bonwell & Eison, 1991).

In the 1990s, Ebert-May, Brewer, Allred, Bonwell and Eison dynamically discoursed active learning. They promoted the use of active learning to achieve effective understanding instead of lecturing. Bonwell and Eison (1991:4-7) promoted active learning as an approach to instruction, and in 2003, Wilke identified the benefits of active learning from his studies..

The outcomes of studies on the effect of active learning indicate that these strategies improve students' content achievement as well as their motivation, expectancy, affect and self-efficacy (Wilke, 2003:219-220). Active learning strategies are reported to promote confidence in the learner's own ability to do science. This confidence produces a significant increase in their science self-efficacy (Wilke, 2003). Bonwell and Sutherland (1996) maintain that active learning is beneficial because it promotes effective learning

According to Prince (2004:1) active learning combines variety of learning methods to engage learners in meaningful activities. Cooperative, inquiry-based, problem-based and technology-based learning are classified as active learning methods because they highlight the development of skills and values (Bonwell & Eison, 1991:5-13) which improves learners' academic success and performance (Wilke, 2003:218). The following sub-sections deal with these strategies.

2.6.1 Collaborative /Cooperative learning

Constructivism supports collaboration by sharing group projects and exchanging ideas. Collaborative and cooperative learning, according to Barkley *et al.*, (2005:5), have similar meaning and these terms are therefore interchangeable. Both methods emphasis the use of small groups in learning.

Cooperative learning can be defined as a social constructivism approach that provides learners opportunity to work in small groups (Johnson *et al.*, 1994; Slavin, 2014) and maintain their interdependence in a group (Gawe, 2004:209). Each member of the group is encouraged to succeed.

Various research findings (Slavin, 1989, 2013, 2014) conclude that cooperative learning can be an effective strategy for increasing learner achievement, promote socialisation (Gillies, 2014), produce positive effect for struggling learners (Slavin *et al.*, 2014), and has significant possibility to improve science learning (Slavin *et al.*, 2013).

2.6.2 Inquiry-based learning

Inquiry-based learning is constructivism approach used by scientists to answer questions of interest (Lederman, 2009:2) and that is why scientific concepts are best taught using the inquiry-based approach. It stimulates excitement (Shamsudin *et al.*, 2013).

Yilmaz (2008:167-171) confirms that constructivists believe that the purpose of learning is to let learners discover. This means learners discover values, facts and meaning which are regarded as universally valid using inquiry-based learning. As mentioned earlier, science is best taught using an inquiry-based approach. Science is a process that requires learners to competently find solutions to solve problems. Therefore problem-based learning is also considered ideal for learning science.

2.6.3 Problem-based learning

Human beings are faced with a range of problems in their daily lives and there is a dire need for solutions from different avenues. From this premise learners must be prepared by exposing them to real-life problems in their learning environment (Tandogan & Akinoglu, 2007:71).

Problem-based learning is a constructivist theory where learners are actively involved in constructing knowledge. Learning starts by creating real-world problems that motivate learners to identify concepts, theories and principles then solving the problem using problem-based learning (Duch *et al.*, 2001:6). In support, Barkley (2005:169) states that essential motivating strategy include providing learners with challenging tasks and problems to solve. However, it is difficult to assess learning because it requires voluminous material, and it is time-consuming especially when a problem is introduced in class for the first time.

The problem-based approach promotes practical communication skills, critical thinking and working efficiently in groups (Duch *et al.*, 2001:7). It produces an active problem solver and

focuses more on learning than teaching (Tandoğan & Akinoğlu, 2007:72), where learners have more control over their knowledge.

2.6.4 Technology-based learning

Technology-based learning (TBL) integrates instructional technology that uses electronic technology in the learning environment to aid learners to learn (Koller et al., 2006:4). The purpose of technology-based learning is to increase interconnection between and among learners through various technology-based activities (Lippincott, 2002). This includes using various media such as video, audio, power points, Google Classroom, the internet, and other computer-based learning programmes.

Technology-based learning (TBL) provides greater accessibility for learning anytime anywhere matching the learners' needs (Koller *et al.*, 2006:6). With the rapid development of new technologies, TBL has generated significant enthusiasm among learners in larger or smaller groups (Wang & Hannafin, 2005:5-6). It emphasises the advantages of discovery learning, offering the prospect of enhancing better understanding and retention of complex and abstract content (Koller *et al.*, 2006:8).

Contrary to the perceived advantages, technology-based learning (TBL) has its own challenges. Examples are a low computer literacy rate, lack of access to computers, and a lack of affordability by learners' parents among low-income groups (Koller et al., 2006).

Groff and Mouza (2008) maintain that generating efficient learning environments the with technology is a challenge for teachers and technology-based learning activities (Harris *et al.*, 2009). Harris *et al.* (2009) argue that integrating technology in technology-based learning lacks emphasis on content and pedagogy. Therefore, the search for strategies to assist the teacher and enhance learning continues to be necessary in our present technological and digital world (Harris *et al.*, 2009; Groff & Mouza, 2008).

It is essential to understand that technology-based learning encompasses different media. This implies that the learner will require different learning strategies, intelligence, styles to attain the maximum benefit of TBL and discovery learning in the light of the constructivist learning theory, providing opportunities to exert their individual differences in the learning process.

2.7 MULTIPLE INTELLIGENCE THEORY

Multiple intelligence theory (MIT) is a learning theory that promotes individual differences (Becerem, 2010; Sulaiman *et al.*, 2010) and guides the teaching and learning process (Ucak *et al.*, 2006:61). It requires a variety of opportunities for learners to use their different abilities, interests

and ambitions in practice to construct their own understanding of new knowledge (Beceren, 2010; Ucak *et al.*, 2006:61). This principle is supported by Gardner's (1983, 1993, 1998) theory of multiple intelligence (MIT) that comprises eight intelligences. It implies that learners have varied ways to learn but do so at different levels of the eight types of intelligence. It is worthy of mentioning that many authors and researchers such as Matthews (1988), Klein (1997), Barrington (2004) and Takahashi (2013) have interpreted, analysed, reviewed and studied the MIT, hence there is a variety of views and explanations of the theory. Since learners exhibit these different types of intelligence, it is important to place equal attention on each of them and emphasise each of them in schools (Al-Sabbah *et al.*, 2011).

Howard Gardner's eight types of intelligence include linguistic intelligence (words are effectively used verbally or in written form), logical-mathematical intelligence (effective use of numbers), spatial intelligence (involving accurate perception of visual-spatial application), bodily-kinesthetics intelligence (expert use of one's body) (Al-Sabbah *et al.*, 2011; Dickinson *et al.*, 1996; Gardner, 1983). The rest of the Multiple intelligences consist of musical intelligence (ability to express ideas in music), interpersonal intelligence (interaction and understanding among individuals), intrapersonal intelligence (mainly self-knowledge) and naturalist intelligence (used in flora and fauna) (Al-Sabbah *et al.*, 2011; Dickinson *et al.*, 1996; Gardner, 1983).

The distinct types of intelligence surmount and defeat the challenge that other learners can learn the exact same content in the same way (Takahashi, 2013; Lane, 2000; Gardner & Hatch, 1998). Therefore, a uniform, general strategy cannot assess student learning (Lane, 2000; Gardner & Hatch, 1998). This implies that providing diverse opportunities for learners to learn and be tested caters for the different ways learners learn. In addition, multiple learning style capabilities are more significant than learning through only one style. However, the diversity of learners' knowledge, skills and learning abilities remain difficult for any educator to overcome (Johnson, 2016:57).

Some authors labelled the visual-spatial, musical-rhythmic, verbal-linguistic, logical-mathematical, bodily-kinaesthetic, intrapersonal, interpersonal and naturalistic intelligence as learning styles. They show diverse ways in which learners process information to different degrees due to their different personalities. Gardner (1983, 1995) argues that even though learners explore the world by using these intelligences, everyone does so at various levels. No two people precisely display the same intellectual strengths and weaknesses profile. For instance, an individual may have a higher ability to use musical, intrapersonal, linguistic, musical and bodily-kinaesthetics intelligence as an effective learning style than spatial, naturalistic and logical-mathematical intelligence.

2.7.1 Naturalistic intelligence

Naturalistic intelligence is the latest addition to Gardner's MIT (Cherry, 2018; Al-Sabbah *et al.*, 2011). Naturalist Intelligence recognises plants, animals and other objects in their natural environment. It includes the ability to understand patterns related to the natural environment (Meyer, 1998:8-9; Sulaiman *et al.*, 2010:514) and observe, identify and relate to the natural environment (Sulaiman *et al.*, 2010:514). Its application involves giving learners the opportunity to observe and classify, convey information to the natural environment, explore nature, make collections of objects, study them and group them (Meyer, 1998:10-11; Cherry, 2018).

2.7.2 Logical-mathematical intelligence

Logical-mathematical intelligence is the understanding and the ability to differentiate logical numerical patterns and manage long chains of interpretation (Gardner & Hatch, 1989). logical-mathematical intelligence (LMI), as developed by Gardner and interpreted by other authors and researchers plays a vital role in cognition. According to Brauldi (1996:1), LMI is associated with scientific and mathematical thinking. According to Lane (2000:3), learners learn concepts before dealing with the details using their Logical-Mathematical Intelligence.

This intelligence empowers individuals to use and appreciate abstract relations (Cherry, 2018). It involves the ability to detect numerical patterns, handle reasoning deductively and think logically (Brauldi, 1996,1; Gardner & Hatch, 1989). Besides these LMI have the advantage of developing number and calculation skills, relationships and the capability to solve various challenges using logic.

Application of logical-mathematical intelligence in education should include activities involving classifying, sequencing, identifying patterns, solving complex computations, formulating hypotheses, conducting scientific experiments playing of numbers and other logic and bus games. (Cherry, 2018; Stanciu, Orban & Bocoşa, 2011:93; Dickinson, Campbell & Campbell, 2002; Gardner & Hatch, 1989).

The study of Al-Sabbah *et al.* (2011) aims to measure students' multiple intelligence levels and the implication on the educational system in Jordanian schools. From the interpretation of their results, they state that students scored high and positive on the LMI and linguistic intelligence, which could be attributed to the emphasis placed on practising these types of intelligence in secondary schools in Jordan. Gardner and Hatch (1998:5) claim that scientists use logical-mathematical intelligence to make discoveries and linguistic intelligence to describe and explain the finding.

2.7.3 Linguistic-verbal intelligence

Linguistic intelligence is verbal intelligence. Gardner and Hatch (1989) state that linguistic or verbal intelligence denotes manipulation of different language functions using sounds and rhythms. Linguistic-verbal intelligence allows an individual to portray the proficiency in language; using words to describe, explain and remember information (Stanciua *et al.*, 2011; Sulaiman *et al.*, 2010).

Gardner and Hatch (1998:4-5) criticise the emphasis on logical intelligence aptitude, and achievement tests. Gardner argues that MIT that grew out of an opinion that standardized tests focusing more on linguistic and logical skills are limiting and learners with other abilities are excluded and disadvantaged (Gardner, 1958: 16-18). All learners cannot express their understanding in ways with which they are comfortable. However, the MI approach includes linguistic intelligence since it enables individuals to communicate. The application of linguistic-verbal intelligence provides a variety of activities like reading, speaking, writing, asking, reporting, addressing, presenting, describing, debating, playing word games, reciting poetry and storytelling (Cherry, 2018; Stanciua *et al.*, 2011; Dickinson *et al.*, 2002; Lane, 2000; Gardner & Hatch, 1989) through the use of books, internet, computers, games, multi-media and tape recorders (Lane, 2000). Learners with linguistic-verbal intelligence demonstrate the ability to manipulate language to express themselves through poetry effectively, well developed auditory skills, sensitivity to words and meaning (Sulaiman *et al.*, 2010; Dickinson *et al.*, 2002; Lane, 2000; Gardner, 1993).

Sulaiman *et al.*, (2010) state that, among the eight types of intelligence, the highest mean was intrapersonal intelligence followed by interpersonal intelligence then logical-mathematical intelligence while linguistic-verbal intelligence has the lowest mean. This implies that the science teachers who facilitate learning and guide the learners to learn may not necessarily possess high and strong linguistic-verbal intelligence. Instead, they demonstrate high intrapersonal and interpersonal intelligence which are characteristics of cooperative learning, and this is in line with constructivism.

According to Al-Sabbah *et al.*, (2011) study on the level of students' multiple intelligence in Jordanian schools revealed a very high ability of mathematic, linguistic and bodily- kinaesthetic intelligence among the learners.

2.7.4 Bodily-kinaesthetic intelligence

Bodily-kinaesthetic intelligence is the skilful handling of objects, involving physical expression (Gardner & Hatch, 1998) and using one's mental ability to coordinate body movements (Brualdi, 1996). It involves using skills such as physical expression, coordination, excellence in sports and

learning through other physical activities (Cherry, 2018; Sulaiman *et al.*, 2010:136; Dickinson *et al.*, 2002:1). These skills do not exclude the effective use of the body with a strong sense of awareness (Lane, 2000).

Learners with bodily-kinaesthetics intelligence enjoy creating things with the hands and maintaining a high sense of memory by doing, moving, making and touching things (Cherry, 2018; Lane, 2000). They have excellent body language communication, physical, hand-eye coordination, and dexterity skills (Cherry, 2018; Dickinson *et al.*, 2002; Lane, 2000). Because they learn through hands-on and physical activities, role playing, the use of educational equipment and real objects (Lane, 2000) may be employed in the classroom to cater for bodily-kinaesthetic intelligent learners. Cherry, (2018) and Dickinson *et al.*, (2002) recommend that learners are provided with games, sports and other construction materials, the opportunity to dance, participate in play-acting and the use of different manipulative methods to solve problems.

Gardner and Hatch (1998), suggest that providing learners with regular creative movement sessions allow them to exercise their bodily-kinaesthetics intelligence at regular intervals. Brualdi (1996) maintains that bodily-kinaesthetic intelligence opposes the idea that mental and physical activities are not related. In support of that, Lazear (1999:85-86) maintains that physical movement which learners elicit bodily-kinaesthetic intelligence creates an optimum condition of mind to deal with the daily different situations.

The high score of bodily-kinaesthetic intelligence in the study of Al-Sabbah *et al.*, (2011) means that the academic system should emphasise bodily-kinaesthetics as the preferable skill. This implies that the school curriculum in Jordan and the activities used in schools will focus on these types of intelligence (bodily-kinaesthetic intelligence and mathematic-linguistic) and not on the others like natural and musical intelligence.

2.7.5 Musical-rhythmic intelligence

Music is sensitive to rhythm and sound, and musical intelligence is the capability to produce and appreciate rhythm. Hence it is referred to as musical-rhythmic intelligence. Musical-rhythmic intelligence encompasses recognising, producing and appreciating rhythm, pitch and forms of musical emotion (Gardner & Hatch, 1998; Lazear, 1999). People who possess strong musical-rhythmic intelligence become our composers and musicians. Musical intelligence entails appreciating, expressing and understanding rhythmic movements, dance, singing, playing and performing (Dickinson *et al.*, 2002:1).

Some characteristics of learners with strong musical intelligence prowess for good reasoning patterns, rhythms and sounds. Cherry (2018) and Sulaiman *et al.*, (2010) maintain that people

with musical intelligence love music, singing and play musical instruments. They can easily recognise and understand the musical structure, rhythm and notes. They can even recognise non-verbal sounds (Sulaiman *et al.*, 2010:513; Lane, 2000:3) and sign language. Musical-rhythmic intelligence is the greatest of all the eight types of intelligence since it has a conscious altering effect on the brain Lazear (1999:6).

Therefore, learners with strong musical-rhythmic intelligence may study effectively with music in the background. A number of activities including turning lessons into lyrics, speaking steadily, tapping out time, listening to CDs that teach concepts, singing, dancing, playing various instruments can be used in teaching (Dickinson *et al.*, 2002:1; Lane, 2000:1).

The practical tools to be used for teaching and learning in this type of intelligence group include CDs, musical instruments, radio, video, computer and multimedia (Dickinson *et al.*, 2002:1; Lane, 2000:1). Activities, projects and ideas that can be used in the classroom should include among others, allow learners to write their own songs and music about subject-content topics, use song, rhythm and clapping to memorise specific and relevant facts on the content (Lane, 2000).

Music and rhythms can be used to help learners learn and remember a variety of information, processes and operations in subjects Lazear (1999:118). Furthermore, music can be listened to with the whole body; it can be heard, smelled, tasted, touched and seen (Lazear,1999:116), which implies that music can be visualised.

2.7.6 Spatial-visual intelligence

Spatial intelligence involves a visual awareness of the environment and positioning the body in space (Dickinson *et al.*, 2002). Spatial-visual intelligence is the ability to create images and pictures in mind relying on the sense of sight (Lazear, 1999:4). In the words of Gardner and Hatch (1998), spatial/visual intelligence is the “capacity to observe the visual-spatial world closely and to perform transformations on one’s initial perceptions”.

Spatial-visual intelligence involves the capability to use and generate mental images, recall facts by visualising, observing and transforming visual information. Use mental images to solve problems and perform transformations on initial perceptions based on visual and spatial perception (Maphalala & Mpofu, 2017:49; Sulaiman *et al.*, 2010:516-517; Gardner & Hatch, 1998:6; Gardner, 1993). Characteristics of spatial-visual intelligence comprise easy recognition of patterns, good interpretation of pictures, graphs and charts, a love for music, a sense of enjoyment in reading, writing, drawing and painting, and visual arts (Cherry, 2018; Lane, 2000; Lazaer, 1999).

Learners with strong spatial-visual intelligence capabilities turn to the graphs, charts and pictures first when they open their textbook and prefer mind mapping. They like to draw, build puzzles, read charts and dream. They can be taught through drawing, verbal and physical imagery. Tools used in teaching include models, graphics, charts, photographs, drawings, 3-D modelling, videos, video conferencing, television, multimedia and texts with pictures/charts/graphs (Cherry, 2018; Maphalala & Mpofu, 2017; Lane, 2000). According to Gardner this intelligence is not restricted to the visual ability and denotes that spatial intelligence is also present in blind children. In support, Bruialdi (1996:1) states that spatial/visual intelligence uses mental images to solve problems, and this makes it possible for the blind to be included.

The personal intelligence (interpersonal and intrapersonal) and spatial intelligence had low scores if compared to the mathematical-linguistic and kinaesthetic intelligence according to the study of Al-Sabbah *et al.* (2011). This may be due to the little focus given to training learners about awareness of the self and others (Al-Sabbah *et al.*, 2011). The low scores of interpersonal, intrapersonal and spatial intelligences can also be attributed to the lack of maximum attention and reinforcement by the educational system in Jordanian schools (Al-Sabbah *et al.*, 2011).

2.7.7 Interpersonal intelligence

Interpersonal intelligence is the extent to which one can evaluate and respond to motivations, intentions, emotions, needs of other people and the understanding of how to work with them collaboratively (Cherry, 2018; Suliman *et al.*, 2010:513; Gardner & Moran, 2006:229; Lazaer, 1999:6-7; Gardner & Hatch, 1998:6). Therefore, it is the ability to appreciate and interact well with others (Cherry, 2018; Sulaiman *et al.*, 2010). It is worth noting that those with strong interpersonal intelligence are skilled at assessing others, use effective verbal and nonverbal communicators, understand others' perspectives, create positive relationships with others, are good group conflict resolvers, skilled at discerning and motivating others (Cherry, 2018; Sulaiman *et al.*, 2010:513; Lane, 2000; Lazaer, 1999:128-132; Gardner, 1983:240-242). People with high interpersonal intelligence use body and facial expressions to communicate.

Interpersonal intelligence may be applied in the classroom through structured problem-solving projects, storytelling, dramatic activities, multicultural books and materials, role plays, group work, discussions, pair work, debates and group projects and case studies which can be used to develop interpersonal intelligence (Cherry, 2018; Maphalala & Mpofu, 2017:51; Lazaer, 1999:7, 141-145). These group activities allow learners to communicate and relate with others, thus contributing to the development of interpersonal intelligence. Assessment of interpersonal intelligence may involve activities that require them to interact and work with other people.

Personal intelligence includes interpersonal and intrapersonal intelligence. Even though these two types of intelligence appear to be the same, Gardner never linked them, but he considered them as separate entities (Gardner & Moran, 2006).

2.7.8 Intrapersonal intelligence

Intrapersonal intelligence is the capacity of an individual to examine and acknowledge their own feelings, emotions, motivation (Sulaiman *et al.*, 2010:513-514; Dickinson *et al.*, 2002; Brualdi, 1996:1; Gardner, 1983:240-241) to draw accurate self-knowledge to guide behaviour, strength, weakness, desire and intelligence (Gardner & Hatch, 1998). This behaviour allows the person to be conscious of the self (Lazaer, 1999:7). Cherry (2018), Dickinson *et al.* (2002:1), Lane (2000:3) and Lazaer (1999:7) assert that intrapersonal intelligence involves understanding, control and work with one's feeling and thoughts deliberately, and have capacities to experience wholeness and unity.

Learners with strong intrapersonal intelligence are good at introspection, analysing strengths and weaknesses and self-awareness. They enjoy investigating theories and ideas, evidently understand and are conscious of their emotions and motivations (Cherry, 2018; Maphalala & Mpofu, 2017; Dickinson *et al.*, 2002; Lane, 2000; Lazaer, 1999). They also have strong confidence, very opinionated, enjoy self-reflection, analysis and the ability to evaluate their strengths (Cherry, 2018; Ozier, 2016; Lazaer, 1999). However, these learners tend to shy away from others (Lane, 2000). Teaching through assessments, self-study and self-analysis is important because these learners are the most self-driven (Lane, 2000:3).

According to Maphalala and Mpofu (2017) and Dickinson *et al.* (2002) intrapersonal intelligence may be applied in the classroom through reading, imaginative activities, journal writing, reflection as well as speaking into tape recorders. Lane (2002) maintains that books, creative materials, diaries and privacy time are tools that can be used to develop intrapersonal intelligence. The teacher can use this trait to determine content learners struggle to understand and to develop strategies to assist them in overcoming any barriers.

2.8 LEARNING IMPLICATION OF MULTIPLE INTELLIGENCES THEORY

Analysing the application of all eight types of intelligence and their characteristics in class as discussed in the preceding paragraphs, it can be demanded that there is interrelation between them. None of the eight types of intelligence namely, bodily-kinaesthetic, visual-spatial, naturalistic, verbal-linguistic, logical-mathematical, musical-rhythmic, interpersonal and intrapersonal can be treated in isolation from each other.

The Multiple intelligence approach is learner-centred and caters for the individual learner. According to Gardner (1995:16-17), the MI approach focuses on the learner. It recognises learners having different intelligences of different strengths that are to be considered and developed to maximise learning opportunities for each learner.

Therefore, schools should provide multiple materials to cater for the individual learner with its unique individual strength of intelligence. The Multiple intelligence approach also favours multiple means of assessment beyond the standard use of “language-logic instruments only”. Thus, catering for all learners.

2.8.1 Application in specific subjects

The study of Maphalala and Mpofu (2017) clearly shows that the MIT was considered in developing the senior phase subjects in some aspects of the curricula of South Africa. This implies that each subject included developing one or more of the eight intelligences. Maphalala and Mpofu (2017) argue that each type of intelligence is considered in various senior phase (grades 7-9) subjects in the Curriculum and Assessment Policy Statement (CAPS). For example, life orientation addresses the concept of self-image, reflection on positive individual qualities and relationship with self, family, and friends (Maphalala & Mpofu, 2017; DBE, 2011a). In the face of this statement, it is evident that intrapersonal intelligence is strongly favoured. But the activities used in their study enhanced only the development of interpersonal, verbal-linguistic, and bodily-kinaesthetics.

Maphalala and Mpofu (2017) maintain that visual-spatial intelligence is addressed under the visual arts component of the creative arts subject in the South African senior phase curriculum. Creative arts as a subject incorporate visual, musical, kinaesthetics intelligences and create opportunities for social, emotional, and intellectual development (Maphalala & Mpofu, 2017). The first and second additional subjects accommodate verbal-linguistic intelligence. The classification of living things in natural sciences supports the development of naturalistic intelligence. Logical Mathematics features in mathematics, natural sciences, technology and physical sciences.

Maphalala and Mpofu have successfully outlined and associated subjects of the South African curriculum with the eight multiple intelligences of Gardner. This implies that the content and context of these subjects are to some extent identified with MIT. Further research into its implementation in natural and physical sciences will be ideal.

2.8.2 Differentiated instruction

Ozier (2016) states that differentiated instruction is one of the most extensively used pedagogical procedures reflecting Gardner's MI impact. According to Tomlinson and Imbeau (2014:6-7), differentiated instruction promotes an atmosphere in which each learner comes to understand, and value their capacity, worth and capability of handling a meaning-rich curriculum. Therefore, teaching and learning strategies should accommodate diverse skills, abilities, multiple intelligences, individual learning styles, availability of a variety of methodology/tools/resources and a flexible classroom environment (Tomlinson & Imbeau, 2014).

Furthermore, less emphasis is placed on identifying the personal learning needs and personalised instruction and learning which will boost the academic needs of individual learners (Tomlinson & Imbeau, 2014). This may be associated to the fact that teachers may not be aware of the relevant knowledge needed and how to acquire them to understand the diversity in their classroom (Currie, 2003). Therefore, Currie (2003) proposes that Gardner's MIT may be used as the first step to investigate the diversity in the classrooms. This will help teachers gain more knowledge and identify the learners' strengths and weaknesses related to the learning process.

In addition, there is an apparent correlation between the study of language and music therefore the language teachers should be aware of the importance of music related to the achievement of improved language skills (Currie, 2003).

Currie (2003) maintains that teacher's awareness of the fact that each student has their individual intelligence profile is mounting. Hence, Brualdi (1996) argues that it is of utmost importance for teachers to develop an "intelligence profile" for every learner. Knowing how the learner learns allows the teacher to assess the child's progress properly.

2.8.3 Intelligence profile

The multiple intelligence approach proposes that every learner has their unique intelligence profile. Therefore, optimum learning will occur when content is taught in the learner's dominant intelligence (Sulaiman *et al.*, 2010). So, Sulaiman *et al.* (2010) did a study that focused on examining the relationship between the intelligence profile and teaching strategies of science and mathematics teachers. The study results indicated that there is indeed a relationship between the intelligence profile and teaching strategies of mathematics and science (Sulaiman *et al.*, 2010).

Multiple Intelligence Development Assessment Scale (MIDAS) was adapted, validated and used in the Arabic setting by Al-Sabbah *et al.* (2011). So, the Arabic MIDAS version was used in the study, which was found effective in measuring students' MI in Jordan schools. Furthermore,

analysis of the results revealed that MIDAS could be used to obtain information to rate students' MI, categorise and understand their intelligences. Therefore, the MIDAS is an excellent method that a teacher can use to develop learners' profiles (Al-Sabbah *et al.*, 2011) to guide the learners to develop their strength and use various learning activities enhancing the strength of their intelligence.

The Teele Inventory of Multiple Intelligences (TIMI) can be used to identify the strengths (dominance) and weaknesses of individual intelligence and a profile for each learner of all ages and grades can be established and used by learner and teacher (Özdemir *et al.*, 2006). Science teachers must accurately identify learners' intelligence types, to integrate MIT (Özdemir *et al.*, 2006). To identify learners' intelligence types TIMI may be used to produce results for creating a learner MI profile.

Gardner believes that the eight intelligences develop at different times and degrees. Nevertheless, when an individual becomes more proficient in one, all the other eight intelligences may improve and advance (Dickinson *et al.*, 2002). The creation of learning environment and experiences that assist the identification of strengths and difficulties in each person's MI profile (Stanciu *et al.*, 2011:93) is of great necessity.

Currie (2003) designed a learner MI profile which was used in the study to identify diversity in the ESL (Early Support Learning) classroom using a MIT questionnaire to collect MI data in the classroom. Table 2.1 below is a learner multiple intelligence profile adopted from Currie (2003) that teachers in schools can use as a guide for both teachers and learners to enhance their strengths, learning and academic achievement.

Table 2-1: An example of learner multiple intelligence profile

Student Number	Linguistic	Mathematical / Logical	Visual / Spatial	Bodily - Kinesthetic	Musical	Inter - personal	Intra - personal	Naturalistic	Grand Total
1	5	1	3	1	10	4	2	2	28
2	3	6	7	2	4	6	8	1	37
Total number of points									
Summary per learner	Highest personal score + well developed areas			Average scores within each student's range			Less-developed areas		
Key	Well developed Intelligence			Average Intelligence			Under-developed Intelligence		

(Source: Currie, 2003)

Lazear (1999:119) suggests that music can be used before or during a test series to help learners lower their stress levels to maximise their ability to remember essential information. Therefore, music intelligence can be applied in all the subjects in South African school curriculums. This implies that music can also be used before a science test to reduce stress levels and maximise learning science.

Goodnough (2000:41) states that MIT serves as a framework for teaching and learning science, providing a pathway to promote active participation and learner centredness as premised on constructivism principles. Sulaiman *et al.* (2010) maintains that, to optimise science learning to ensure successful teaching and learning, a variety of teaching strategies and acknowledgment of the strength of multiple intelligence must be considered. On the contrary, Stanciu *et al.* (2011:96) contend that using a variety of strategies in the multiple intelligence approach is time consuming and difficult to enforce a traditional school system. Still, the study results of Stanciu *et al.* (2011:96) show that multiple intelligence strategies, including differentiated learning, were found suitable and effective to help underachievers and students with learning difficulties. This implies that learners with difficulties in learning science can overcome their challenges if they are exposed to multiple intelligences strategies, where activities that conform to the learners' dominant intelligence are included.

2.9 SUMMARY

Although several learning theories of essential importance have been discussed earlier, two of such theories have been selected to guide the current study. These two are multiple intelligence and constructivist learning theories. The two theories are interrelated in promoting the learner as the subject, active, central and focal learning point. Olusegun (2015) asserts that in the constructivist theory, learning is an activity that is specific to the individual learner. Consequently, Sulaiman *et al.* (2010:512-518) reflect that every individual learner has a unique intelligence profile.

For these reasons it is important to train learners to use their eight intelligences in an active learning environment to maximise learning opportunities. Therefore, teachers should reflect on their practice to apply innovative ideas during their teaching and learning planning. With a highly planned classroom activities and atmosphere, the learners should learn to excel (Olusegun, 2015).

A schematic presentation (Figure 2.1) has been developed to underscore the foregoing discussion regarding learning, learning theories, and learning strategies to promote efficacy in learning.

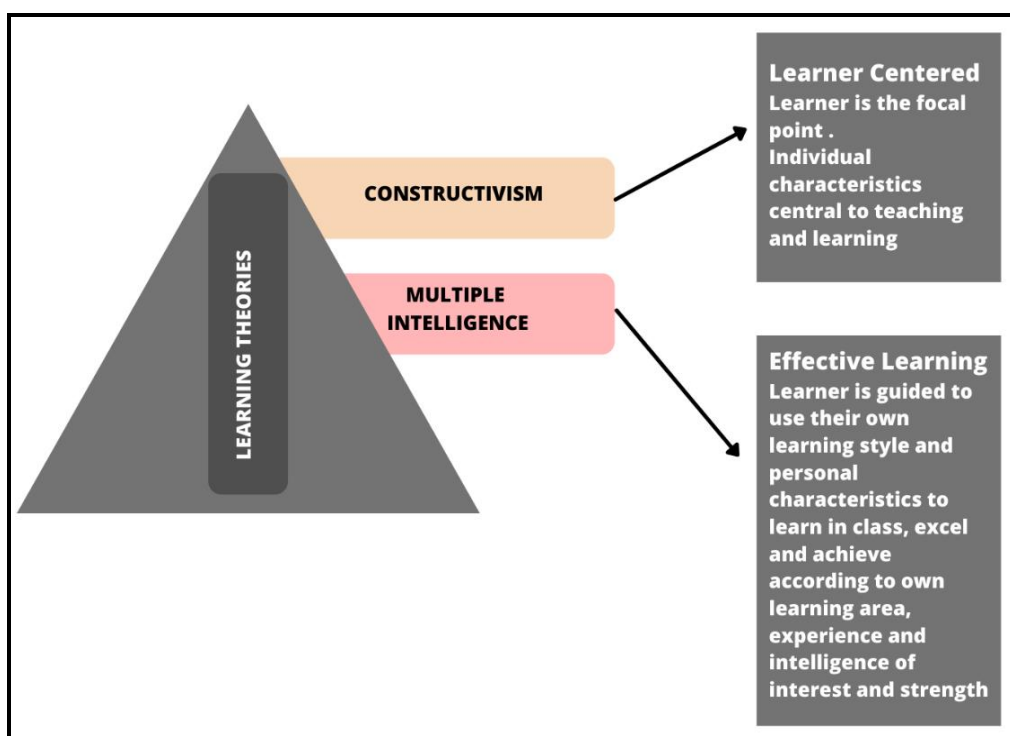


Figure 2-1: The relationship between constructivist theory and multiple intelligence theory.

(Source: Author's compilation)

The multiple intelligence approach has been reconsidered in the SA educational system and practice for the last century and provides an alternative method to effective learning. Hence it can be considered as an alternative in learning science, chemistry and the Periodic Table in schools. Constructivist approach on the other hand, has been in existence for a while and applied in our schools for building a knowledge based on learners' experience and previous knowledge. But both theories are premised on the fact that each learner is a unique individual and needs attention and a method of learning that suits their unique individuality towards mastering learning and academic achievement.

Gardner (1995) maintains that even though we all possess varying levels of each of the intelligences, no two individuals exhibit the exact MI profile. Therefore, in assessing the learner, intelligences need to be approached in their own dominant intelligence fair way instead of the usual pen and paper use of linguistic testing.

The constructivist learning theory provides a learning environment for teachers to consider learners' previous experiences and abilities. To acknowledge each uniqueness, different learning strategies is of significant importance.

It is sufficiently clear from the above discussions that different learning strategies do not have the same effect on learning engagement. It is therefore a necessity to investigate the possibility of enhancing engagement and learning of the PT. The next chapter will follow a literature study on the Periodic Table, engagement and affordances.

CHAPTER 3 THE PERIODIC TABLE, ENGAGEMENT STRATEGIES AND AFFORDANCES

3.1 INTRODUCTION

The concept and properties of chemical elements are viewed as the basic foundation of teaching chemistry (Demircioğlu *et al.*, 2009; Ben-Zvi & Gemut, 1998). As such, most studies on chemistry education research have been related to approaches and resources for teaching chemistry at various levels of education. However, not much attention has been dedicated to finding the difficulties, deficiencies in learner learning or the effects of approaches to improve teaching and studying the periodic table (PT) in chemistry (Franco-Mariscal *et al.*, 2015).

The arrangement of the elements in a systematic tabular form called the PT is the foundation that lies at the core of chemistry (Franco-Mariscal *et al.*, 2015; Scerri, 2011).

The use of different learning strategies can improve understanding concepts and properties of chemical elements and learner engagement in the science classroom. That implies that it can also enhance learner engagement regarding learning the PT. The PT is an important basis of chemistry conceptualisation in high school (Franco-Mariscal *et al.*, 2015). The PT's importance is underscored by the amount of published reviewed articles, and one of the most regularly debated topic in chemical education journals (Franco-Mariscal *et al.*, 2015). In the face of this argument music, context-based inquiry and computer simulation as learner engagement strategies are reviewed to determine its potential to enhance cognitive, affective, behaviour and authentic engagement.

Chapter 3 of this thesis comprises of a literature review to frame the study on the affordances of engagement strategies for learning about the PT. Section 3.2 provides information related to the periodic table of elements; section 3.3 learning strategies; section 3.4 engagement; section 3.5 deals with learner engagement; section 3.6 attends to factors that impact engagement; 3.7 handles engagement strategies; section 3.8 discusses affordances; and lastly section 3.9 summarizes the main points of the chapter.

3.2 THE PERIODIC TABLE OF ELEMENTS

The PT was first invented in 1869 by Dmitri Mendeleev, a Russian chemist, to display the chemical elements known at that stage (Lengler & Eppler, 2007). The year 2019 was set apart as "The International Year of the Periodic Table" for all chemists and scientists to commemorate 150 years of the PT (IUPAC, 2018).

The PT is described in many ways. It is considered a model, theory, representation, classification, and system by various scientists (Scerri, 2010; Brito *et al.*, 2005). The PT in many books has classified the elements into main group and transition elements then further divided into subgroups A and B. However, the International Union of Pure and Applied Chemistry (IUPAC) recommends that the numbering of the main groups and transition elements starts from 1 to 18, meaning the PT should consist of 18 groups. This has gained acceptance and was adopted by many authors and chemists (Lee, 1996).

The properties of the electron structure of the chemical elements have been the focus for arranging the elements in groups within the PT. Over the years, chemists have arranged the elements in groups for two reasons, connecting the electron structure to the elements' chemical properties and making the learning of the PT simpler (Lee, 1996). According to the IUPAC (2018); there are 118 elements indicated on the IUPAC's Periodic Table. It is worth mentioning that the 2016 IUPAC Periodic Table had 103 elements, but the current one (2018) has 118 elements. This implies that new elements have been discovered and added to the PT of the elements. The IUPAC(2018) version of the Periodic Table of elements indicates the 18 groups in Figure 3.1.

IUPAC Periodic Table of the Elements

												13						14		15		16		17		18									
1 H hydrogen 1.0080 ±0.0002		2																				10 Ne neon 20.180 ±0.001													
3 Li lithium 6.94 ±0.06		4 Be beryllium 9.0122 ±0.0001																				6 C carbon 12.011 ±0.002		7 N nitrogen 14.007 ±0.001		8 O oxygen 15.999 ±0.001		9 F fluorine 18.998 ±0.001							
11 Na sodium 22.990 ±0.001		12 Mg magnesium 24.305 ±0.002																				13 Al aluminium 26.982 ±0.001		14 Si silicon 28.085 ±0.001		15 P phosphorus 30.974 ±0.001		16 S sulfur 32.06 ±0.02		17 Cl chlorine 35.45 ±0.01		18 Ar argon 39.95 ±0.16			
19 K potassium 39.098 ±0.001		20 Ca calcium 40.078 ±0.004		21 Sc scandium 44.956 ±0.001		22 Ti titanium 47.867 ±0.001		23 V vanadium 50.942 ±0.001		24 Cr chromium 51.996 ±0.001		25 Mn manganese 54.938 ±0.001		26 Fe iron 55.845 ±0.002		27 Co cobalt 58.933 ±0.001		28 Ni nickel 58.693 ±0.001		29 Cu copper 63.546 ±0.003		30 Zn zinc 65.38 ±0.02		31 Ga gallium 69.723 ±0.001		32 Ge germanium 72.630 ±0.008		33 As arsenic 74.922 ±0.001		34 Se selenium 78.971 ±0.008		35 Br bromine 79.904 ±0.003		36 Kr krypton 83.798 ±0.002	
37 Rb rubidium 85.468 ±0.001		38 Sr strontium 87.62 ±0.01		39 Y yttrium 88.906 ±0.001		40 Zr zirconium 91.224 ±0.002		41 Nb niobium 92.906 ±0.001		42 Mo molybdenum 95.95 ±0.01		43 Tc technetium [97]		44 Ru ruthenium 101.07 ±0.02		45 Rh rhodium 102.91 ±0.01		46 Pd palladium 106.42 ±0.01		47 Ag silver 107.87 ±0.01		48 Cd cadmium 112.41 ±0.01		49 In indium 114.82 ±0.01		50 Sn tin 118.71 ±0.01		51 Sb antimony 121.76 ±0.01		52 Te tellurium 127.60 ±0.03		53 I iodine 126.90 ±0.01		54 Xe xenon 131.29 ±0.01	
55 Cs caesium 132.91 ±0.01		56 Ba barium 137.33 ±0.01		57-71 lanthanoids		72 Hf hafnium 178.49 ±0.01		73 Ta tantalum 180.95 ±0.01		74 W tungsten 183.84 ±0.01		75 Re rhenium 186.21 ±0.01		76 Os osmium 190.23 ±0.03		77 Ir iridium 192.22 ±0.01		78 Pt platinum 195.08 ±0.02		79 Au gold 196.97 ±0.01		80 Hg mercury 200.59 ±0.01		81 Tl thallium 204.38 ±0.01		82 Pb lead 207.2 ±1.1		83 Bi bismuth 208.98 ±0.01		84 Po polonium [209]		85 At astatine [210]		86 Rn radon [222]	
87 Fr francium [223]		88 Ra radium [226]		89-103 actinoids		104 Rf rutherfordium [267]		105 Db dubnium [268]		106 Sg seaborgium [269]		107 Bh bohrium [270]		108 Hs hassium [269]		109 Mt meitnerium [277]		110 Ds darmstadtium [281]		111 Rg roentgenium [282]		112 Cn copernicium [285]		113 Nh nihonium [286]		114 Fl flerovium [290]		115 Mc moscovium [290]		116 Lv livermorium [293]		117 Ts tennessine [294]		118 Og oganesson [294]	

57
La
lanthanum
138.91
±0.01

58
Ce
cerium
140.12
±0.01

59
Pr
praseodymium
140.91
±0.01

60
Nd
neodymium
144.24
±0.01

61
Pm
promethium
[145]

62
Sm
samarium
150.36
±0.02

63
Eu
europium
151.96
±0.01

64
Gd
gadolinium
157.25
±0.03

65
Tb
terbium
158.93
±0.01

66
Dy
dysprosium
162.50
±0.01

67
Ho
holmium
164.93
±0.01

68
Er
erbium
167.26
±0.01

69
Tm
thulium
168.93
±0.01

70
Yb
ytterbium
173.05
±0.02

71
Lu
lutetium
174.97
±0.01

89
Ac
actinium

90
Th
thorium

91
Pa
protactinium

92
U
uranium

93
Np
neptunium

94
Pu
plutonium

95
Am
americium

96
Cm
curium

97
Bk
berkelium

98
Cf
californium

99
Es
einsteinium

100
Fm
fermium

101
Md
mendelevium

102
No
nobelium

103
Lr
lawrencium

INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY



Figure 3-1: IUPAC Periodic Table of the Elements (IUPAC, 2018)

3.2.1 Nomenclature in the periodic table

3.2.1.1 Names of groups of elements

The diagram below (Figure 3.2) shows the PT with the previous and current names of the various groups, adopted from (Lee,1996; 2008). The s-block and p-blocks on the PT were labelled under group I to VII and 0 according to the number of electrons in the outer shell of the atom, while the current IUPAC numbering of the groups is from 1 to 18. Elements are grouped by their chemical and physical properties.

s-block		d-block										p-block					
I	II											III	IV	V	VI	VII	
IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA	VIIA	VIIA	IB	IIB	IIIB	IVB	VB	VIB	VII B	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg	Sc										Al	Si	P	S	Cl	Ar
K	Ca	Y	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
		La	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
			Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Figure 3-2: Periodic Table of the previous and current names of the various groups

The top row (IA-VIIB) represents the previous group naming and the last row (1-18) the current grouping. The Russian chemist Dmitri Mendeleev published several tables with different arrangements of the chemical elements from 1869 to 1905. His Memorial Table, constructed in 1934, is based on atomic numbers in which both the inert gases and the lanthanoids are correctly placed (Laing, 2008). The IUPAC Periodic Table of Elements (Figure 3.1) is organised according to the element's atomic numbers.

3.2.1.2 Comparing the atomic numbers and the groups of the first thirty elements of the Periodic Table of Elements

Table 3.1 displays the name, symbol, atomic number, and groups of the first 30 elements.

Table 3-1: Comparing the atomic numbers and groups on the Periodic Table

NAME OF ELEMENT	SYMBOL	ATOMIC NUMBER	GROUP	DESCRIPTION
Hydrogen	H	1	1	Non-metal
Helium	He	2	18	Noble gas
Lithium	Li	3	4	Alkali metal
Beryllium	Be	4	2	Alkaline earth metal
Boron	B	5	13	Metalloid
Carbon	C	6	14	Non-metal
Nitrogen	N	7	15	Non-metal
Oxygen	O	8	16	Non-metal
Fluorine	F	9	17	Halogen
Neon	Ne	10	18	Noble gas
Sodium	Na	11	1	Alkali metal
Magnesium	Mg	12	2	Alkaline earth metal
Aluminium	Al	13	13	Metal
Silicon	Si	14	14	Metalloid
Phosphorus	P	15	15	Non-metal
Sulphur	S	16	16	Non-metal
Chlorine	Cl	17	17	Halogen
Argon	Ar	18	18	Noble gas
Potassium	K	19	1	Alkali metal
Calcium	Ca	20	2	Alkaline earth metal
Scandium	Sc	21	3	Transition metal
Titanium	Ti	22	4	Transition metal
Vanadium	V	23	5	Transition metal
Chromium	Cr	24	6	Transition metal
Manganese	Mn	25	7	Transition metal
Iron	Fe	26	8	Transition metal
Cobalt	Co	27	9	Transition metal
Nickel	Ni	28	10	Transition metal
Copper	Cu	29	11	Transition metal
Zinc	Zn	30	12	Transition metal

(Source: Author's compilation)

Table 3.1 clearly shows that the atomic number of the elements does not always correspond with the group number. For instance, helium is an element with atomic number 2 but belongs to group 18, a noble gas and potassium has an atomic number of 19 which belongs to group 1, the alkali metals. The symbolic representation of the same elements is often derived from the first letter or two letters of the elements' name in English. For instance, carbon and argon are respectively represented as C and Ar, but potassium and sodium are K and Na, respectively.

Not all elements occur naturally. For instance, elements 104 through to 109 on the PT were formed using nuclear accelerators from accelerator laboratories in the United States, Germany

and Russia. Additionally, they radioactively decayed a few seconds after their birth. These artificial elements influence the classification of the elements on the PT.

3.2.2 A brief history of the Periodic Table classification

The system of classifying the Periodic Table elements started over 200 years ago (Scerri, 2011). Over this time the PT has been subjected to robust changes in line with improved science and technological scientific research and findings. This has caused rejections, additions, alterations, confirmations, and improvement of the PT as new elements were discovered. The system for classifying the elements over these years was due to the concerted effort by many dedicated scientists.

Before Mendeleev's work in 1869, other renowned scientists had carried out extensive research regarding the classification, description, and arrangement of some elements. For instance, in 1787, a French chemist, Antoine Lavoisier, in collaboration with Louis-Bernard Guyton de Morveau, Claude-Louis Berthollet and Antoine Fourcroy,, developed a listing for the 33 known elements using one-dimensional representations. However, the modern PT can be presented in two- or three-dimensional representations.

The contribution made by De Chancourtois in 1862 is recorded as a milestone in the development of the PT. De Chancourtois became the first to identify the characteristics of the elements as a role played by their atomic weight and represented the PT as a helical graphic system. In 1865, Newlands released his law of octaves which explains the repetition of chemical properties after a sequence of seven elements (Scerri, 2011; Brito *et al.*, 2005; Van Spronsen, 1969). From the 1870s, Mendeleev's PT became easy to use for chemical lecturers and learners as it condensed a considerable amount of knowledge into meaningful connected facts, deleting isolated facts (Knight, 1998, xii).

3.2.3 History of naming selected elements

The International Union of Pure and Applied Chemistry (IUPAC) is a scientific body responsible for keeping a list of elements and unveiling the proposed names for comments, objections, and acceptance. IUPAC grew from other bodies such as the International Association of Chemical Societies (IACS). It was created in 1911 for international standardisation in chemistry. The same year (1911), IACS met in Paris and produced a set of proposals for the work of IUPAC. In 1892 the first international attempt to organise organic chemical nomenclature took place (Hepler-Smith, 2015).

The acceptance of new elements and names started with the submission of relevant literature on the discovered elements and fulfilling all the claims for discovery of the element(s) (Hofmann & Münzenberg, 2000; Hofmann *et al.*, 2018). This must be in line with the criteria for discovering the elements according to the IUPAC (International Union of Pure and Applied Physics), IUPAC and Transfermium Working Group (TWG) criteria. IUPAC and IUPAP, the Joint Working Party (JWP) are responsible for reviewing the literature and claiming of newly discovered elements. Temporary names are given, and then the discoverer(s) are invited to submit permanent names. The names are presented to scientists and the public for comments within five months and then finalised by IUPAC/IUPAP (Hofmann *et al.*, 2018; Koppenol, 2002). Finally, the newly discovered elements with their atomic numbers, names, and symbols are included in the Periodic Table of Chemical Elements (PT).

In 1997, the names of six new chemical elements with their symbols were proposed to be confirmed by the members of the IUPAC union in Geneva. The names were, element 109, Meitnerium (Mt); element 104, Rutherfordium (Rf); element 105, Dubnium (Db); element 106, Seaborgium (Sg); element 107, Bohrium (Bh); element 108, Hassium (Hs), (Browne, 1997). They were approved and included to the Periodic Table of chemical elements.

The chemical elements were named after their places of discovery or scientists who played significant roles and contributions in their discovery. Thus, the element Bohrium is named after Niels Bohr for his influence on quantum physics. Hassium, after Hesse, the seat of the laboratory where elements 109 and 110 were created. Meitnerium is named after the Austrian physicist, Lise Meitner (Browne, 1997).

However, some elements were given provisional names but were rejected. For instance, Joliotium was assigned to element 105 after the French physicist Frederick Jolie-Curie. Hahnium (element 108) was named in honour of the German physicist Otto Hahn (Browne, 1997). Unfortunately, these names were not accepted and therefore not found on the current PT.

In 2011, about five more elements (elements 110, 111, 112, 114 and 116) were added to the PT. Element 110 Darmstadtium (Ds) was named after the town in which it was discovered. Element 111 was named after the discoverer of X-rays, Wilhelm Conrad Roentgen. And Element 112 Copernicium (Cn) after the Polish astronomer Copernicus (Overbye, 2011). These names were given by the General Assembly of the International Union of Pure and Applied Physics (IUPAP) when they met in London, 2011. Interestingly, these elements do not last long once created and do not exist in nature (Overbye, 2011).

In addition, elements 114 and 116 were created in collaborative work of two organisations, namely: Lawrence Livermore National Laboratory in Livermore (Chang, 2011) and Institute for Nuclear Research in Dubna, Russia. Hence, names for elements 114 and 116 are flerovium (Fl) and livermorium (Lv) respectively. The names were subjected to scrutiny and analysis for acceptance within five months, after which they were finally recognised by an international committee of chemists and physicists in 2011. The chemistry union (IUPAC) then announced the accepted elements placed on the PT (IUPAC, 2018).

Four new elements were discovered and given temporary names, ununtrium (Uut), ununpentium (Uup), ununseptium (Uus) and ununoctium (Uuo) for elements 113, 115, 117, and 118 respectively (St. Fleur, 2016; Karol *et al.*, 2003;). These elements were discovered by different groups from Japan, Russia, and USA. The teams that discovered the elements were given the chance to suggest names for elements 115 and 117. They named element 115 Moscovium, symbol Mc, after Moscow, and element 117, Tennessine (Ts) after Tennessee (St. Fleur, 2016; Karol *et al.*, 2003).

3.2.4 Properties of the Periodic Table

The developmental stages associated with the history of the Periodic Table, according to Ben-Zvi and Genut, acknowledged a 'constructivist' way of scientific progress. However, as directly stated, "PT is used in an 'empiricist' manner, especially in textbooks " (Ben-Zvi & Genut ,1998). This implies that PT used in textbooks depicts knowledge that is gained by observing, seeing, hearing, touching, or sensing things directly. Direct experience of the PT makes it easier to gain knowledge and understand the PT.

Knowledge of the Periodic Table reveals specific patterns of the element's chemical properties and this is referred to as periodic trends. (Scerri, 2011). Examples of chemical properties are electronegativity, electron affinity, ionization energy and chemical reactivity. The physical properties on the other hand reveal the principles of periodicity and family or the group of which an element belong (Trudel & Métioui, 2015). Some examples of the physical properties are atomic number, density, state of matter, boiling and melting points.

Scerri (2019) maintains that quantum mechanics can explain the properties for classifying elements but not for hydrogen and helium and therefore proposed the continuous use of atomic number triads.

The structure and shape of the PT turn our focus on the columns, rows and blocks, which are a means of organising elements along two or three dimensions. The notion of valence contributed

significantly to determining the atomic masses and the grouping of elements in the columns. Hence, rows and columns of the PT are important (Scerri, 2010).

3.2.5 Importance of the Periodic Table

The Periodic Table is one of the most valuable models in science (Scerri, 2019). It is of theoretical, practical, and educational importance to working scientists (Scerri, 2010; Brito *et al.*, 2005), including teachers and educationists. The PT has a significant influence in the development of chemistry and physics (Scerri, 1997:229;) and is a holistic part of chemistry (Scerri, 2010). The Periodic Table according, to Scerri, is “the central concept in the study of chemistry” and a tool of utmost importance to modern chemists (Scerri, 1998:78). From this viewpoint, the PT is an important instrument in modern chemistry and for modern chemists.

Scerri (2010) stated that the PT embodies all the elements and highlights all the layers of relationship among the elements. Harvey (2014) affirms that the PT is chemistry’s most emblematic image.

The learning of key concepts in chemistry is linked to understanding the structure and role of the PT (Trudel & Métioui, 2015). If an individual understands the structure and properties of the elements of the PT, the learning of key concepts such as the reactivity of chemical elements and reactions becomes easier. Therefore, the PT is crucial for understanding chemistry (Franco-Mariscal *et al.*, 2017).

Though the Periodic Table is of fundamental importance to chemistry, learners in high school struggle to learn and understand the PT (Franco-Mariscal, Oliva-Martínez & Gil, 2015). This might be due to the fact that, learning the periodic table is not fun. This is affirmed by Franco-Mariscal *et al.*, (2017) stating that gaining knowledge about the names and symbols of the chemical elements is an activity that learners frequently find boring (Franco-Mariscal *et al.*, 2017). Therefore, it is essential to identify strategies and resources that can provide opportunities to overcome difficulties and shortcomings in learning the PT (Franco-Mariscal *et al.*, 2015).

3.3 PEDAGOGICAL STRATEGIES

Several researchers have proposed using different strategies to learn the Periodic Table. These learning strategies include contest and exhibition, card games, board and computer games, music, context-based approach, and simulation. This session focuses on the use of different learning strategies and resources proposed by researchers to encourage easy and exciting ways of learning the PT.

Strategies that enhance learning, motivation, and active engagement improve academic performance (Renzulli, 2015). Given the wide variety of learning strategies available in the literature, the sections that follow (sections 3.3.1 to 3.3.4) highlights the use of music, computer simulation and context-based inquiry strategies that are of paramount interest to this study.

3.3.1 Music

Music components of the PT have been composed as far back as in the 1950's. In 1959, mathematicians and musicians came together to compose a musical component of the PT. The song "Elements," can be downloaded at <https://youtu.be/DYW50F42ss8>. <https://www.youtube.com/watch?v=DYW50F42ss8>. There is a need for more and new verses of this song (Overbye, 2011).

3.3.1.1 Music as a pedagogical tool

Music is a pedagogical approach to science education that is appropriate and provides an alternative science teaching and engagement strategy (Crowther, McFadden, Fleming & Davis. 2016).

Though the use of songs and music as pedagogical tools in chemistry classrooms is infrequent in research papers, much has been done with music in learning. There are various literature on the usage of music in teaching and learning poetry, science, languages, and mathematics. Music as a learning strategy results in achieving an increasing engagement, improving test scores, making new information meaningful, developing interest, rote learning and memorisation (Crowther *et al.*, 2016; Kuśnierek, 2016; An, Capraro, & Tillman, 2013; Hijazi & Al-natour, 2012; Register *et al.*, 2007).

There are four styles of integrating music in the learning process. These are subservient, affective, social integration, and coequal-cognitive styles (Bresler, 1995). The first style is where music is used as a supporting role to help learners learn different subjects. The second style is integrating music in teaching and learning referred to as the Co-equal, Cognitive Integration Style. The third style, the Affective Style evoke mood and induce attitude towards learner-centeredness, initiative, and creativity. Also referred to as affective integration style. The fourth style of Bresler (1995) is the social integration style of using music as a social function of a school or class. These four styles are discussed and related to the four components of engagement.

3.3.1.2 Music and learning

Crowther *et al.* (2016) investigated the use of music in a primary and secondary school science class by concentrating on the impact of science-based lyrics, music, videos on content knowledge

and attitudes. Their findings revealed that learners improved their scores of simple knowledge questions to more complex conceptualised questions. In other words, the use of music video with scientific content-based lyrics improves performance and achievement.

Participants with multiple sclerosis exposed to the musical model, total and paired word memory improved considerably better than those in the spoken model (Thaut *et al.*, 2014). Research results on the effect of music on the functioning of the brain suggest that the chronological composition in music and rhythm improve cognitive performance (Thaut *et al.*, 2014).

Crowther *et al.* (2016) found that music can enhance both understanding and interest in science concepts. Salmon (2010) agreed that there is evidence to recommend that the use of music engage learners in thinking processes. Furthermore, music improves creativity in academic performance (Miché's, 2002).

Music triggers the ability to produce detailed responses. Children exposed to the story with soundtracks presented their understanding using drawings or writings that had more detailed information than drawings or writings of stories of those without soundtracks (Salmon, 2010).

Crowther *et al.*, (2016) found that enjoyment showed substantially higher among the experimental group who watched the musical videos than those who did not. These results were noticed across all age and gender groups that participated in the research. Music is an enjoyable way to activate prior knowledge and promote critical thinking which is a crucial aspect of learning (Crowther *et al.*, 2016; Salmon, 2010; Miché's, 2002).

Music as a strategy for learning promotes engagement, excitement, and creativity, yet the excitement may sway learners from complying with class discipline (Murphey, 2013; Kuśnierek, 2016). Music, songs or singing, if louder, may also disturb for learners in other classes.

Although there is a wide range of music, songs, music videos, rap songs and many more available about chemistry and the PT (Allgaier, 2013) not much research was found relating to the use of music and context-based inquiry in learning the PT.

3.3.2 Context-based inquiry

Context-based inquiry is the interrelationship between scientific concepts and the real world. For the benefit of the study, context-based inquiry is used to incorporate context, context-based approach, inquiry-based, as each integrates inquiry, investigation, context, and real-life scenario. The next sections describe and clearly link between context, context-based approach and inquiry-based.

3.3.2.1 Context-based inquiry as a pedagogical tool

Gilbert (2007:966) refers to context as the implementation of ideas to illustrate the use and significance of concepts. To give meaning to learning chemistry, context should be used in the process (Gilbert, 2007:960) because it exposes learners to a learning experience that is relevant to aspects of their lives. According to Bennett and Lubben (2006:999) to achieve a long-term impact, context should be the starting point for developing a scientific understanding of concepts. Walan noted that teachers found context effective in engaging their learners. However, (Walan, 2016:79) stated that it was challenging to find appropriate and suitable contexts connecting the curriculum and learners' daily life (Walan, 2016:79).

Researchers such as (Skinner *et al.*, 2009; Tsai, 2000) argue that the traditional teaching and learning of science in schools fail to sustain and develop interest, critical thinking, and curiosity of learners about the real-world. Therefore, this has led to an increase in context-based as an alternative approach to learning science. Thus, context-based activities and practices, including finding solutions to related problems, helping learners to give meaning to scientific concepts (Gilbert, 2006; De Jong, 2008).

Another alternative approach is inquiry-based learning. Inquiry-based learning aims to engage learners in authentic engagement through scientific discovery (Margus *et.al.*, 2015). This implies that inquiry-based learning involves seeking information through questioning, hypothesising, testing, problem-solving and observation. It improves skills, such as identifying variables and stating hypothesis (Ogan-Bekiroğlu & Arslan, 2014:1191; Simsek, & Kabapınar, 2010). However, inquiry-based learning does not always increase conceptual knowledge (Ogan-Bekiroğlu & Arslan, 2014:1190-1191).

Extensive research has been undertaken on context-based inquiry to find how it promotes learning, stimulates intrinsic motivation and interest in chemistry and its effect and impact (King *et al.*, 2011; Herranen *et al.*, 2019).

3.3.2.2 Context-based inquiry and learning

An in-depth review conducted by Bennett, Hogarth and Lubben (2003) demonstrated solid evidence in supporting the claim that a context-based inquiry enhances motivation in science classes and promotes positive attitude towards science. On the contrary, the effect of context-based inquiry on comprehension of scientific theories and improvement in understanding scientific concepts is insignificant (Taasobshirazi & Carr, 2008; Barber, 2001).

Duran and Dökme (2016:2888-2891) portray that context-based inquiry positively affect learners' critical thinking and enhances problem-solving. Additionally, views that support context-based inquiry as a learning strategy indicates that it bridges the gap between learning in class and everyday life, including solving problems relevant to learners (Herranen *et al.*, 2019; Duran, 2016; Walan, 2016; Walan & Rundgren, 2015; Gilbert, 2006) Thus, making learning science interesting. Context-based inquiry promotes curiosity in the learners, which is essential for learning (Pluck & Johnson, 2011) provided it is problem and inquiry related.

Context-based inquiry provides opportunities for learners to develop skills (Bennett, 2003). In general, context-based inquiry promotes the following aspects in learning: interest in learning science, understanding scientific processes, transferring knowledge, inspiring positive affect (Walan & Rundgren, 2015; Ogan-Bekiroğlu & Arslan, 2014; Dumbrajs *et al.*, 2013; Gilbert *et al.*, 2011; Gilbert, 2006).

Context-based inquiry has been viewed as having several beneficial aspects, including learner engagement to the content and learner responsibility to learn (Trudel & Métioui, 2015; Minner *et al.*, 2010) .

Holbrook (2014) argued that if learning science content is in isolation from the context and does not take the needs of the society into account, does not consider uncertainties in the real world, and does not relate to technology, it will not contribute to developing learners' scientific skills, attitude, values, and ability to link concepts to real-life. Instead, science should be context-based and inquiry driven to develop creative thinking and meaningful problem solving (Broman *et al.*, 2018; Fransco-Mariscal, 2015; Holbrook, 2014).

Demircioğlu *et al.*, (2009) investigated the impact of context-based inquiry on understanding the PT. They reported that context-based inquiry enhanced learners' knowledge of the PT, attitude, and performance in chemistry (Demircioğlu, *et al.*, 2009:245-246). The learners developed an improved positive attitude towards chemistry due to the use of context-based inquiry that enhances interactions among learners and learners and teacher.

Trudel and Métioui (2015) conducted a study on the inductive learning sequence about the PT. They led learners to gain knowledge of the properties of the chemical elements, scientific process skills and creativity. They engaged learners in activities where they had to propose their hypotheses and verify them against data. This was very challenging but produced motivated, highly engaged enthusiastic learners' (Trudel & Métioui, 2015:538-542). Their inductive learning sequence followed the process of context-based inquiry.

Even though inquiry, inquiry-based, context-based approach and context-based with inquiry has been studied separately and reviewed, there is still more research needed (Herranen *et al.*, 2019; Glynn & Winter, 2004). Studies done so far are mostly on generating familiar and interesting contexts, that provide real-world setups as the foundation for meaningful learning (Ültay & Ültay, 2014).

Context-based inquiry improves interest (emotional engagement), content knowledge (cognitive engagement), curiosity (authentic engagement) and change in attitude (behavioural engagement). In other words, context-based inquiry promotes engagement (Walan, 2016). Therefore, it is important to research and recognize specific ways learners use computer simulation to support inquiry (Glezou & Grigoriadou, 2010:39) and engagement.

3.3.3 Computer simulation

Computers have become part of our daily life at schools and homes due to technological advancement. Hence, we have different applications for computers. One of the applications is computer simulation and which can be defined as visualising and studying the resultant of what has been programmed on a computer for educational purpose.

3.3.3.1 Computer simulation as a pedagogical tool

Computer simulation was introduced as a scientific tool in meteorology and nuclear physics immediately after World War II and has now expanded into several research disciplines (Winsberg, 2013). It is the reproduction of the behaviour of a system using a computer to produce expected outcomes by running computer programs. This involves the application of mathematical models into the study of physical-chemical processes to predict the behaviour and properties of systems (Winsberg, 2013; Ören, 2011; Glotzer *et al.*, 2011; Glotzer, 2009). In other words, computer simulation is a method for studying an entire system process that runs on a computer (Winsberg, 2013). The system applies model-using and or model-building processes. When the simulation is model-using, the production of available simulation is used by a person other than the user, while model-building refers to the user building the simulation right from the start (Glezou & Grigoriadou, 2010). A typical example of model-using and model-building building is the PhET simulation (<https://phet.colorado.edu/en/simulations/?subjectschemistry>).

PhET is a project founded in 2002 by Nobel Laureate Carl Wieman based on the desire to improve the way science is taught and learnt in schools. The design and development of PhET simulations cover a variety of subjects and topics, including the PT.

PhET research on design and use of interactive simulations to understand better the characteristics effectiveness of the tools, engagement, and interaction with these tools towards promoting learning.

The developmental document of PhET is available at PhET libraries to assist individuals or organisations that want to build and develop their own simulations. Thus, displaying the model-building characteristics of PhET. The design identifies simulations key characteristics making it a good productive tool for learning engagement.

3.3.3.2 Computer simulation and learning

Computer simulation is used in a variety of teaching and learning situations as a substitute in the chemistry laboratory, scaffold science learning, a model for visualising scientific concepts and assessment tools (Rachula *et al.*, 2016; Akaygun & Jones, 2013; Griffin & Butler, 1979).

Computer simulation has become so versatile that its application is becoming interdisciplinary. Reliability of computer simulation for producing knowledge has increased due to the rise of application in different disciplines (Winsberg, 2013). With this in mind epistemology of computer simulation must reflect the acceptance of scientific theories. If the simulations involve exploring very complex sites or learning environment it may cause severe working memory load which, is dangerous to learning (Gafoor & Vevaremmal, 2012). Therefore, for a simulation-based teaching to be beneficial to learners, simulation developers should use effective instructional resources and direct activities to develop tasks that engage learners, provide healthy learning opportunities at the preparation, interaction, and debriefing stage (Wu & Anderson, 2015; Asal & Blake, 2006).

Sweller and Chandler (1991) argue that effective instructions reduce cognitive load and increase performance. In other words, instructional materials with integrated instruction contribute towards reduced cognitive load (Sweller & Chandler, 1991). In this case, text and diagrams should not be used separately in computer simulation instruction for learners. However, Avramiotis and Tsaparlis (2013:299) maintain that learners may miss information from different presentation components while focusing on other components of simulations. Nevertheless, Anderson and Wall (2016) argue that simulations allow learners to focus on important concepts if unnecessary details are removed.

The performance of learners who used computer science simulations improved substantially than those using the traditional method (Udo & Etiubon, 2011; Guy & Lownes-Jackson, 2015; Kunnath, 2017). Computer simulations can give a good image of a problem and improve problem solving scores by improving problem solving skills (Avramiotis & Tsaparlis, 2013).

Kunnath (2017) postulated that computer simulations can be used to teach complex physics concepts. Even though it can slow down learners' interpersonal skills (Guy & Lownes-Jackson, 2015), it can be used in learning other complex and abstract science concepts.

Regardless of the present advantages of computer simulation strategy there are some disadvantages attached to it. Some critics have pointed out that it causes split attention effect, cognitive over-load, impede development of interpersonal skills, promotes guessing and can produce poor outcome and performance (Asal & Blake, 2006; Wolfe & Luethge, 2003). On the other hand, those in favour content that computer simulation enhances the learning environment. It gives learners opportunities to manipulate variables in science which allow them to apply and test what they learn. This increases their understanding of theories and concepts and improve performance in exam scores. It further enhances substantive knowledge, critical and analytical thinking skills and provides fun and memorable educational experiences (Kunnath, 2017; Avramiotis & Tsapalis, 2013; Glezou & Grigoriadou, 2010; Shellman & Turan, 2006; Frederking, 2005).

Although, there are a variety of computer simulations on the PT available there were no investigations on the use of computer simulation to enhance the study of the PT. However, studies on applications of some aspects of the PT on a very low scale was found. Therefore, it will be significant to find how computer simulation enhances engagement while learning the PT.

Glezou and Grigoriadou (2010) reaffirm that the use of open software like MicroWorlds Pro, computer simulations and pedagogical liberty proved to support learners' active engagement and learning. Additionally, it strengthens learner's effective learning engagement and knowledge (Glezou & Grigoriadou, 2010).

3.4 ENGAGEMENT

Engagement as briefly described in section 1.2.3 can be summed up as the extent to which learners display attention, active participation, inquisitiveness, interest, enthusiasm, and excitement. Likewise, engagement has been defined as an interaction between moments, time, hard work, efforts, and appropriate resources spent by both learners and teachers. This is an attempt to optimise learners' experiences, enhance learning outcomes, develop learners' scientific process skills, and improve their academic performance (Jang *et al.*, 2012; Fredricks, 2011; Reeve & Tseng, 2011; Trowler, 2010; Fredricks *et al.*, 2004).

The notion of engagement has grown since the 20th century and as such, has been widely defined and discussed. As the popularity increases, some researchers describe engagement utilizing

terminology such as disengagement, dissatisfaction, estrangement, or burnout (Salmela-Aro *et al.*, 2009; Miceli & Castelfranchi, 2000; Vallerand *et al.*, 1993).

There are yet another school of thoughts that conceptualise engagement by including academic outcomes using results and achievement. In contrast, others use emotions, academic distinctiveness, good relationships with teachers and other learners (Skinner *et al.*, 2009). As the concept gains more recognition, it is becoming more important for researchers to clarify their understanding of engagement and explain how it operates (Skinner *et al.*, 2009).

3.4.1 Understanding the concept of engagement

Engagement in science, especially chemistry, is viewed as a multidimensional set of affective variables, including interest, enjoyment, value, self-concept, and motivation (Milne & Otieno, 2007). This view encompasses only one aspect of engagement which is 'affect'.

Researchers measure engagement according to the quality and quantity of participation in educational activities and the degree of active involvement in the classroom. This reflects the extend of interest, attitude, emotions, investment of effort, initiative, persistence, the responsibility of behaviour and contextual relations (Montenegro, 2017; Skinner *et al.*, 2009; Furrer & Skinner, 2003; Connell & Wellborn, 1991). This view of engagement embraces all four components of engagement which are: affect (emotional), agentic (authentic), behavioural and cognitive (Montenegro, 2017; Skinner *et al.*, 2009; Furrer & Skinner, 2003). According to Reeve and Tseng (2011), the four components of engagement are interrelated.

In this research, engagement will be viewed as active involvement, curiosity, and the drive to learn and achieve. Learners that are actively involved and curious are described as engaged learners. Engaged learners express their task-oriented activities by being goal- oriented, intentional, persistent, interested, and focused on learning processes (Skinner *et al.*, 2009; Furrer & Skinner, 2003; Connell & Wellborn, 1991). On the other hand, disengaged learners show less commitment and no interest. They are easily distracted, passive, helpless, in other words, they hate and dislike school (Maralani *et al.*, 2018; deCharms, 1976; Fiedler, 1975).

Additionally, engaged learners are characterised by the influence of affect, agentic, behaviour and cognitive features of engagement, yielding academic achievement (Abla & Fraumeni, 2019; Reschly & Christenson 2012; Barkley, 2010; Reeve & Tseng, 2011). The four interrelated components of engagement; affect, agentic, behaviour and cognitive, that form part of this study are described in sections 3.4.2 to 3.4.5.

3.4.2 Agentic/Authentic engagement

The three components of engagement, namely, affect, behavioural and cognitive emanate from the teacher's directives and, the fourth component agentic is an attribute of the learner and focuses on the learner's contribution to the learning process in engaging (Reeve, 2013; Reeve & Tseng, 2011). Montenegro (2017) indicated that agentic engagement is more of the latest concept than the other three components of engagement.

The terms, authentic and agentic will be used interchangeable as they will refer to the same type of engagement and abbreviated AGAU in this study. This is because agentic refers to interaction, explaining learners' emotions and behaviour in a class setting and activities as well as constructive contribution in class, high self-confidence, and interest in the learning process (Veiga 2016; Reeve & Tseng, 2011; Fredericks *et al.*, 2004). Similarly, authentic refers to highly attentive and committed learners who aim to reach out to succeed, achieve their learning outcomes, and take responsibility for their own learning and cognitive development (Pinel, 2017; Schlechty, 2011). Both authentic and agentic engagement relates to the input and process of learning.

Agentic engagement is how learners consciously and energetically personalise and improve their learning. It also describes the situations and conditions in which they learn (Mehran, 2014). Thus, taking responsibility of their own learning. Agentic engagement is defined by Reeve and Tseng (2011:258) as the constructive input by learners in class for the duration of the learning processes. This means that agentic engagement detects how the learning process is deliberately personalised including what is to be learnt and the conditions under which learning takes place and unfolds in the classroom. For example, they may ask questions, personalise the lesson, add their personal interest preference, and communicate their thoughts and needs (Maralani *et al.*, 2018; Mehran, 2014; Reeve & Tseng, 2011).

Agentic/authentic (AGAU) engagement describes learners' exposure to meaningful, valuable, significant tasks relevant to them. This gives them a feeling of purpose, possession, and the responsibility towards the individual personal learning (Newmann *et al.*, 1996; Skinner & Pitzer, 2012; Maralani *et al.*, 2018). If learners could select their own learning activities it paves the way for increased AGAU engagement (Maralani *et al.*, 2018).

3.4.3 Music, context-based inquiry, computer simulation and agentic/authentic (AGAU) engagement

The subservient approach (refer to section 3.3.1.1) points out the supporting role of music in learning. Learners may be required to compose their songs using content that could help them

learn the subject and increase AGAU engagement. In a nutshell, the subservient style attends to the basic concepts, contents and pedagogies (Bresler, 1995:7).

Chen and Cowie (2013:1345) argue that context-based inquiry can increase learner engagement in science, make science appropriate and understandable so that learners have actual motivations for learning science. This assumption was based on the work of Chen and Cowie (2013); Wieringa *et al.* (2011) and Jenkins (2011). Learners that are engaged in active discussions and reading tasks acquired new terminology and concepts. Consequently, this boosted their effective engagement with scientific concepts (Chen & Cowie, 2013:1359-1362) promoting AGAU engagement.

Frederking (2005) did six years' experiment on computer simulation on learning, exposing learners to simulation and tasks relevant to life application that provided a feeling of purpose and responsibility for their own learning and academic progress. The tasks reinforced the concepts taught earlier. The learners evaluated the simulation, gave their views on what they learnt, mentioned what they would modify, with an overall positive evaluation of the simulation (Frederking, 2005:388). In so doing, enhanced active learning increase engagement and learning (Frederking, 2005:392). The results indicate that computer simulation positively impacts learner AGAU engagement and achievement.

3.4.3.1 Agentic/authentic (AGAU) engagement and learning

Maralani *et al.*, (2018) argue that AGAU as a component of engagement is one of the most significant characteristics of learning engagements. The fact that learners enthusiastically attempt to discover; customise content, context, and learning, improve the circumstances and conditions where educational processes occur. As such, agentic engaged learners select, contribute, and promote independence (Maralani, *et al.*, 2018:4-6).

In addition, AGAU engagement gives learners opportunity to find ways to enhance their influence, recommend goals and determine how problems will be and are solved (Maralani, *et al.*, 2018; Mehran, 2014; Reeve & Tseng, 2011).

When learners are authentically engaged, they easily retain and remember both the content and context long after the assessment is complete. They also easily apply the knowledge learnt in different contexts (Pinel, 2017; Schlechty, 2011).

AGAU engagement concentrates on the contextual relationship, whereas behavioural engagement focuses on the level of passion and curiosity demonstrated in the classroom and during learning activities. This implies that AGAU engagement is about the relationship between

what is learnt, how the context is presented and the influence on the learners' active involvement and learning. While behavioural engagement is the response to good conduct and participation in class.

3.4.4 Behavioural engagement

Behavioural engagement is the level of active participation and good behaviour on the part of the learner (Fredricks *et al.*, 2004). Researchers view behavioural engagement as a construct with several meanings from different perspectives and with extended meanings in various domains and educational settings (Hospel *et al.*, 2016). For instance, some view it as participation or effort, while others as observable characteristics.

Behavioural engagement refers to learners' participation and commitment in schools, and other extracurricular events. (Fredricks *et al.*, 2004). Wang *et al.*, (2016) define behavioural engagement within the context of a domain-specific engagement in terms of learners' active participation, asking and answering questions, paying attention, persistence or giving up easily.

Behavioural engagement is behaviours linked to learner effort to achieve the learning process in an activity, task, assignment and or in the whole learning process (Fredricks *et al.*, 2004;). In other words, behavioural engagement is the measure of the learners' observable behaviour, which include learners' persistence, effort, attention, participation, and involvement in an activity, during class and in the school environment contributing towards their own learning and learning activities (Fredricks *et al.*, 2016; Fredricks *et al.*, 2004).

Behavioural engagement is measured based on how the learner is involved in school, class and or in a task, including consistency of the effort, extent of participation and attendance (Green *et al.*, 2008; Marks, 2000; Finn & Voelkl, 1993).

3.4.4.1 Music, context-based inquiry, and computer simulation on behavioural engagement

Behaviour includes social tasks (Finn & Zimmer, 2012:100) and music as a social norm that impact a community that is why it relates to (Bresler,1995). Bresler, emphasised the social function of a class and its role in a community using music. For example, when learners sing and perform at parents meeting or in the classroom, they get engaged in the activities that influence behaviour engagement.

Evidence suggests that context-based inquiry encourages a positive attitude towards science. (Bennett, 2016), thus promoting positive behavioural engagement.

Supporters of computer simulation acknowledge that computer simulations promote learner involvement and offer opportunities for behavioural engagement (Alexe, 2013; Sauter, Uttal, Rapp, Downing, & Jona, 2013). In addition, computer simulation produces greater learner involvement, and increased behavioural engagement towards achievement in chemistry (Udo, 2010; Udo & Etiubone, 2011:212-215).

3.4.4.2 Behavioural engagement on learning

Enthusiasm and cooperation are characteristics of behaviour engagement. Learners who were academically at risk demonstrated an increase in mathematics achievement from up to fourth grade, excluding the first year due to an increasing rate of enthusiasm and cooperation (Luo *et al.*, 2009; Hughes *et al.*, 2008). In support, Ladd and Dinella, (2009:13) stated that cooperation and participation are associated with gains in achievement. Unfortunately, class size has a negative effect on behavioural engagement. According to Pilotti *et al.*, (2017:148-152), behavioural engagement decreased as class size increased. Class size negatively affected involvement and active participation in class discussion. As the class size increases, the depth of discussions decreases (Pilotti *et al.*, 2017).

Recent research on examining the part played by classroom peer framework in the behavioural engagement of learners from low-income homes in the urban elementary schools reported greater levels of motivation to learn and fewer behavioural difficulties. (Cappella *et al.*, 2014). As learners spent more time engaged, behavioural engagement increased hence the impact of behavioural difficulties became insignificant.

Behavioural engagement encourages learners to believe that they can achieve their goals and create positive self-worth that empower them to boost up their self-esteem and self-efficacy. This eventually strengthens their sense of competence (Bowden *et al.*, 2019:12-14).

The application of frequent valuable teacher feedback, self-efficacy and creating an effective learning environment enhances behavioural engagement, thus improving engagement in science (Sökmen, 2019). Great behavioural and affective engagement showed more significant growth in academic achievement (Ladd & Dinella, 2009).

Moreover, behavioural engagement had registered the highest effect on actual performance, but emotion energizes the appropriate behavioural and cognitive engagement leading to mastery learning (Skinner, *et al.*, 2008).

3.4.5 Affective/emotional engagement

Affective engagement is emotions that are observable and measurable. Affective engagement refers to learner emotional feelings in the classroom including happiness, amusement, and pride (Pagán, 2018:20), as well as enthusiasm, enjoyment, fun, and satisfaction (Arslan *et al.*, 2014).

Emotions can be categorised as positive or negative. Examples of positive emotions consist of love, joy, like or reaction towards objects, events, or people (Arslan *et al.*, 2014; Artino *et al.*, 2012; Leventhal, 1982). In addition, affect with positive meaning are categorised as positive affect. Examples of positive affect include enjoyment, relaxation, fun, like, happiness, amusement, joy and love (Arslan *et al.*, 2014; Artino *et al.*, 2012; Leventhal, 1982). Hence the word affect will be used to categorise emotion and affect. Therefore, affective engagement will refer to emotional engagement.

Strategies used to promote affective engagement include the management of emotions, attitudes and techniques with which learners gain better control over their emotions and attitudes as related to learning (Sadighi & Zarafshans, 2006).

3.4.5.1 Importance of affective engagement on learning

According to Leventhal (1982:122,149) affect is a form of cognition which is attached to and interact with perception and abstract. Alsop and Watts (2003:1046-1048) affirm that affect surrounds cognition. Implying, if learners are not happy, joyful, and comfortable they will not learn regardless of the extent to which the teaching strategies, pedagogic practices are best designed. On the contrary critics often argue that affective engagement focuses on making learners feel good, happy, and excited at the expense of being educated.

Although critics may have a good point, Skinner *et al.*, (2008) attest that affective engagement sustains behavioural participation, effort, and interest in academic activities over time. In other words, if learners discover that the learning activities are exciting, pleasant, fun, entertaining and enjoyable, they tend to put in an extra effort and pay more attention (Skinner *et al.*, 2008; Skinner & Belmont, 1993) to their studies. This implies that learners happy and excited learners can learn better than those who are unhappy and stressed, despite all the good available strategies put in place.

Pekrun *et al.*, (2006:583) also contend that “emotions significantly add to the prediction of learning and achievement”. In addition, other researchers mention that positive emotions promote learner involvement in learning activities (DeCuir & Schutz, 2002; Goetz *et al.*, 2002).

3.4.5.2 Impact of music, context-based inquiry, and computer simulation on affective engagement

Learners who enrolled for the music extracurricular activities increased their affective engagement (Pagán, 2018). Affective engagement influences music performance outcomes, since music contributes to the individual's development of motor skills, thinking abilities and affect responses (Pagán, 2018). It can also have a positive influence on skill and intellectual development. However, Demorest and Morrison (2000) warn against the danger of linking music to academic achievement despite the numerous positive results relating music to academic achievement in literature.

The affective style emphasis emotions induced by music in learning, taking initiatives, beliefs, creativity, and self-expression. Teachers consent that these characteristics that are not used to the academic curriculum (Bresler, 1995).

Context-based inquiry with a rich, flexible, and computer-embedded learning environment allows learners to build projects that enable them to attain more significant academic successes than traditional teaching, including overcoming cognitive and affective challenges (Doppelt & Barak, 2002: 22-26).

Learners working in groups and engaged in construction of engineering models to find solutions to real-life problems brought about improvement in engagement and achievement (Doppelt *et al.*, 2008:33-34).

Affective engagement focuses on making learners feel good and excite and therefore, the management of emotions improve affective engagement. This is why application the of computer simulation discussions during debriefing may excite learners to talk about their feelings and emotions during the activity (Bouvier *et al.*, 2014:11-13). Computer simulation promotes learner interest and provides opportunities for affective and behavioural engagement (Sauter *et al.*, 2013; Alexe, 2013).

Engagement can be enhanced by combining various kinds of visualisations, but the specific order may not be essential (Jones *et al.*, 2005:147). Therefore, using different visualisation in a computer simulated lesson to determine learners' understanding of chemistry concepts showed improvement.

Emotional disaffection results in boredom put pressure on learners' effort and determination, leading to withdrawal from academic tasks (Skinner *et al.*, 2008). Consequently, affective engagement motivates learners to stick to their academic tasks.

Sustaining interest over time and maintaining affect, influences conceptual understanding in chemistry topics (Nieswandt, 2007: 927-929). In addition, Bowden *et al.*, (2019) argued that comparing affective with cognitive engagement; affective engagement is the principal determining variable of transformative learning, and learner success.

3.4.6 Cognitive/intellectual engagement

The terms cognitive and intellectual are used alternatively in literature and this study, the applicable term is cognitive. The term cognitive is the mental involvement in learning (Blumenfeld & Paris 2004). Cognitive engagement has been described by including cognitive investment in learning, metacognition, and self-regulated learning (Gober *et al.*, 2015; Blumenfeld *et al.*, 2004). In other words, cognitive engagement is the ability to invest mentally in learning using self-structured and planned strategies.

Moreover, cognitive engagement uses a combination of thoughtfulness and readiness to apply a degree of determination needed to understand complex concepts and master difficult skills. This includes memorising and adopting learning strategies to develop insight acquisition of skill and knowledge (Fredricks *et al.*, 2004:61-63).

Researchers relate cognitive engagement to “active learning”. Hence “active learning’ is often referred to as engaging cognitively and meaningfully (King, 1993; Bonwell & Eison, 1991; Corno & Madinach, 1983). Learners generate cognitive interpretive processes such as perceptions, appraisals, and self-evaluations into their academic work (Corno & Madinach, 2004:299) to develop cognitive engagement.

3.4.6.1 Importance of cognitive engagement on learning

Cognitive engagement is connected to motivation, motivational goals and self-structured learning (Barkley 2010; Boekarts *et al.*, 2000). This suggests that cognitive engagement has the potential to motivate learners to learn and motivated learners can make an effort towards learning.

Hughes *et al.*, (2009:4) argue that the of effort learners put into engaging in a task determines the extent of achievement. Therefore, effort contributes more towards mastery of subject matter than the conduct of learners. Furthermore, Chi and Wylie (2014) suggested that the benefits of learning increase as learners become more engaged with learning materials. However, not all increased engagement led to increased learning benefits (Chi & Wylie, 2014).

Cognitively engaged learners go beyond the compulsory schoolwork and what is expected of them. This is important because it can lead to learning benefits, high expectations and

achievement. For instance, when learners do more and go beyond what is mandatory, achievement benefits of cognitive engagement are exhibited (Fincham *et al.*, 1989).

Cognitive engagement combines freedom and creativity in solving challenging problems, determination and optimistic coping mechanisms when a failure occurs (Connell & Wellborn, 1991). This encourages the learner to forge on to overcome learning obstacles and failure, thus promoting mastery learning and achievement.

Meaningful cognitive engagement is influenced by perceived ability, learning goals, and positive affect achievement (Greene and Miller, 1996). Moreover, Greene *et al.*, (2004:182, 185-187) indicated that effective cognitive engagement is linked to mastery of goals. Coupled with empirical evidence, the results paint a compelling view of the significance of class activities as an instrumental role for achievements in the future. In addition, classroom activities influence learner achievement positively as they employ cognitive strategies to guide their learning (Greene *et al.*, 2004).

3.4.6.2 Importance of Impact of music, context-based inquiry, and computer simulation on cognitive engagement

According to literature, cognitive engagement can be obtained through different strategies, for example, music, context-based inquiry, and computer simulations.

The application of music using cognitive integration style focuses on specific subjects, for example, chemistry, requires the use of a subject-specific knowledge or skills (Bresler, 1995). This style integrates the curriculum with a particular certain content, skills, articulations, lyrics, and means of using music. Salmon (2010) proposed that music has the ability to activate a unique learning environment and cognitive development.

Another critical point to remember is that context-based inquiry strategy starts with exposing the learner to relevant, everyday life experiences, followed by cognitive science (Vaino *et al.*, 2012). Moreover, there is evidence to suggest that self-regulated context-based inquiry sustained learners' competency while they demonstrated the value and uses of chemistry to their personal lives and future careers. It also stimulated their intrinsic motivation to learn chemistry and raised their motivation level (Vaino *et al.*, 2012). This implies that context-based inquiry positively impact motivation, skills, value, and belief.

Computer simulations encourage active learner participation, stimulate memorisation and retention of information (Alexe, 2013). Researchers that favour computer simulation maintain that it offers repetitions, opportunities to practice a concept repeatedly, provide feedback instantly,

enhances the application of information, knowledge, and capabilities from the class to the real-life environment (Alexe, 2013; Bell & Trundle, 2010). However, the results of Guy and Lownes-Jackson (2015) revealed that computer simulations alone did not improve learners' performance. Therefore, it is more beneficial when computer simulation is used as reinforcement of concepts by providing opportunity to repeat the simulations repetitively till they obtain better knowledge and improve learning (Guy & Lownes-Jackson, 2015:103-105). In other words, repetition by the learner personally can increase their cognitive engagement.

The components of engagement agentic, affective, behavioural, and cognitive have shown to be essential contributors to academic success (Fredricks, 2011; Reeve & Tseng, 2011; Fredricks *et al.*, 2004) and learning engagement in school.

3.5 FACTORS THAT INFLUENCE ENGAGEMENT

Although the attention on engagement has escalated in the past years, the differentiation between engagement and motivation continues to be the subject of debate (Appleton *et al.*, 2006). Motivation is a theoretical framework that explains the cause(s) of engagement, degree of investing in a specific behaviour, attention and effort in learning (Barkley, 2020:9; Brophy, 2004:4) 2009:225). The indicator of engagement is the direct observation of learners in the classroom because engagement refers to the visible manifestation of motivation (Skinner *et al.*, 2009:499).

As learners are motivated, they manifest positive engagement traits. Intrinsically, learner engagement indicates various components of engagements within the school or classroom reflecting in learner schoolwork, enthusiasm, positive emotions, and cognitively focused and participation in learning activities (Skinner *et al.*, 2009; Skinner *et al.*, 2009; Connell & Wellborn, 1991).

There are several points to endorse the view that learner engagement is important in the classroom. Firstly, learner engagement increases experiences of deep engagement. Secondly, it reduces the incidence of indifference due to lack of engagement. And thirdly, provide a variety of ways that can be adopted in teaching and learning to enhance engaged learning (Barkley, 2010).

Even though academic achievement has been reported in literature as having a positive association with learner engagement however this is not the case of Pagan's current study (Pagan, 2018). There are factors that influence learners' potential to engage in a subject material, activities in school, class activities and learning that correlate between academic achievement and engagement.

There is a variety of factors that affect engagement. For instance, a learner who is emotionally engaged may fail to engage in a specific new activity because it is perceived as not interesting. Some of the factors include beliefs and values, classroom environment, climate or atmosphere, resources, active participation, repetition, mastery, assessment achievement scores.

3.5.1 Beliefs and values

Beliefs are habits, states of mind in which trust or confidence is placed in a person or something as an acceptance that it exists, it is true, or it is held as an opinion. learners have certain opinions, mindsets, and acceptance of aspects of science, chemistry, mathematics. These emerge in their abilities, own expectations, teachers' expectations, peers, relations with peers as their learning beliefs.

The beliefs that learners have about their teachers' impact at the extent of their engagement in class. For instance, from the study results, learners' belief about their teacher's perception, interpersonal relationship and self-efficacy affects their engagement (van Uden, *et al.*, 2014). Again, learners who belief their teachers like them are more engaged and achieve better than their counterparts (van Uden *et al.*, 2014; Goldin *et al.*, 2011). In support of this motion, Brophy (2004:27-28) argues that learners will put up any reasonable effort in their studies if they like and admire their teacher.

Self-efficacy is the individual belief in their own abilities, capacity, capabilities to meet challenges, reach a specific goal and complete a task successfully (Akhtar, 2008; Bandura, 1986, 1997). Therefore, a learner who thinks that she/he has the capability to influence specific goal or outcome will devote time and effort to achieve it. Furthermore, Green and Miller (1996:187) argue that there is a connection between perceived competence and significant cognitive engagement.

Essentially if a teacher recognises a learner's ability, his/her self-efficacy beliefs may be improved (Goldin *et al.*, 2011). Self-efficacy beliefs have an impact on learner engagement, therefore, a teacher who feels more effective and confident have a higher chance of getting learners more engaged (van Uden *et al.*, 2014).

It is significant to concentrate on beliefs, values, and goals to discover why learners engage or disengage and how that affects their achievement instead of their performance (Eccles & Wigfield, 2002).

3.5.2 Classroom environment

Despite the beliefs, values and goals learners may have, Barkley (2010:82) indicated that it is impossible to expect all the learners to be engaged simultaneously and all the time in the

classroom. However, the classroom environment is contagious. For instance, if some of the learners are enthusiastic it positively affects the class. In the same way, a display of disengagement will have a harmful effect on classroom environment (Barkley, 2010).

Creating a classroom condition that promotes engagement lies heavily on the teacher rather than the learners (Barkley, 2010). Therefore, to maintain an engaged classroom the teacher must be helpful, approachable, respectful, respect learners, avoid intellectual ignorance (McGlynn, 2001) and avoid authoritarian behaviour (Mainhard, 2009). In addition, a helping, friendly behaviour, and good leadership promote cognitive and emotional engagement in the classroom (Uden *et al.*, 2014).

Additionally, Finn *et al.*, (2003) argued that class size has a more significant effect on class engagement than the performance of the teacher. Numerous studies have indicated that an increase in class size is associated with a decrease of engagement in class. (Blatchford *et al.*, 2011; Bassett *et al.*, 2003; Finn *et al.*, 2003). In larger classes with large class sizes more learners in the low attainment group experience a decline in task behaviour and engagement. Low attainers spend more time off class activities, tasks and exercises in larger classes than in a smaller class size (Blatchford *et al.*, 2011:721-726). On the contrary, according to Bourke (1986) class size did not have any effect on engagement in primary schools.

The impact of class size has gained more incredible support among researchers. However, class size had a negative impact on learner cognitive and behavioural engagement (Kim, 2013; Taft *et al.*, 2011). This implies that learners in larger classes show a decline in behavioural and cognitive engagement (Pilotti *et al.*, 2017:150-151). Additionally, learners' emotional engagement increases grades while instructors' cognitive engagement decreases grades (Pilotti *et al.*, 2017: 148-150) in smaller class sizes.

3.5.3 Resources

When class size and classroom atmosphere are favourable learners' engagement increases. However, not all increased engagement leads to increased learning.

Other factors such as engagement with learning material (resources) that are essential. Chi and Wylie (2014:224) argued that as learners become more engaged with learning materials (resources), the greater their learning gain. Furthermore, the engaged learner is committed and voluntarily deploys scarce resources (time, attention, and effort, under their control) to support the activity, and the task at hand (Schlechty, 2011).

Clark (2011) suggested that the quality of the learning material system is one of the essential tools for producing content that can be accessed anytime, anywhere and offers access to learning material on cell phones, online, cellular devices, offline and via internet. The emphasis on giving learners what, when they need it most, can be a significant learner engagement approach to enhance engagement.

3.5.4 Active participation

According to Skinner, Furrer *et al.*, (2008) active participation in the early years may function as a protective buffer during challenging times in transitions to middle and high school. However, educators' efforts to improve behavioural engagement using approaches that engage positive emotions may have long-term effect on learner's active participation in class activities. This is because learners' interests and emotions sustain them in participating in a class activity. Likewise, boredom, frustration, or anxiety about schoolwork undermines behavioural participation in academic activities (Skinner *et al.*, 2008:776-779). On the other hand, some learners can pretend to be active and engaged while avoiding genuine participation just to appear active to the teacher and or peers (Goldin *et al.*, 2011:554).

3.5.5 Repetition

Weibell (2011) analysed the work of researchers and summed up the importance of repetition in learning. This includes enhancing learning any skill, the ability to reproduce content from retention, and avoiding what is learnt. Repetition also provides means to knowledge gain. Lastly, it facilitates the transfer of knowledge.

In contrast, Bruner (2004) indicated that too much repetition creates boredom, learner passivity, and rote learning. Therefore, teachers need to find a way to achieve a sensible balance, neither too much nor too little repetition. To achieve such a balance, the focus in the classroom should be on learning, the learner, ideas rather than teaching, the teacher, or the material (Bruner, 2004).

Repetition is a crucial tactic for enhancing learning (Weibell, 2011; Bruner, 2004). Vocabularies, addresses, and poems of any extent cannot be learnt by a single attempt even with exceptional ability. Therefore, it is necessary that a sufficient number of repetitions must be done to ensure final mastery (Weibell, 2011) which supports self-paced discovery, reflection, consistency, and clarity of thoughts. Thus, deep learning is promoted (Bruner, 2004).

3.5.6 Mastery of content

Mastery orientation has the aim of learning and mastering the content according to self-determination and individual standard values (Hsieh *et al.*, 2011). When a learner is focused on

acquiring new skills and additional knowledge, Havik and Westergård (2019:12) indicates that teacher and learners are mastery-oriented. They then create a mastery-oriented classroom. Learners in these mastery-oriented classrooms have higher energy levels, lower degree of anxiety, increased interest in class, increased motivation due to achievement and high achievement goals (Harackiewicz *et al.*, 2002). Therefore, become proficient to master of content.

There is a strong correlation between mastery orientation and teachers' emotional support. The higher the level of teacher emotional support, the higher the levels of mastery orientation (Havik & Westergård, 2019).

3.5.7 Assessment achievement scores

Assessment scores are useful ways to measure whether or not learners are learning. High performance on activities, tasks, tests, exams are usually evidence that new knowledge and skills have been gained. Nevertheless, research has found that learner engagement is a strong indicator to predict a person's learning performance (Taylor *et al.*, 2016).

The results of a study by Nystrand and Gamoran (1991) on measuring learners' in-depth understanding revealed that substantive engagement (cognitive engagement) was related positively to achievement test scores.

It is important to note that the interest learners show, and their mastery demonstrated in their field of study depend mainly on how they were taught (Ojogan & Oganwu, 2006, Schunk, 2005). Today, keeping learners engaged and motivated is a necessity for learning (Saeed & Zyngier, 2012: 261-262).

3.6 ENGAGEMENT LEARNING STRATEGY

Mastery goals and self-efficacy have a significant relationship to using a meaningful learning strategy (Green *et al.*, 2004:476). Numerous studies have supported a positive relationship between meaningful strategy use, mastery goals and self-efficacy (Greene & Miller, 1996; Miller *et al.*, 1993, 1996; Pintrich & Garcia, 1991; Nolen, 1988; Meece *et al.*, 1988; Ames & Archer, 1988)

There are many benefits of engagement discussed in sections 3.4 and 3.6. However, there are some barriers to engagement. These barriers have to be minimised or eliminated. They can be eliminated using innovative workable, simple, effective learning engagement strategies (Abla & Fraumeni, 2019; Marzano & Pickering, 2010). All these factors need to be planned and incorporated in the presentation of a lesson. The identified tactics that may be applied in class by

the teacher to enhance engagement and learning based on research are discussed in sections 3.6.1 to 3.6.5.

3.6.1 Effective pacing

Effective pacing strategy is a combination of steps to ensure the learning process is not too slow or too fast. Due to exposure to innovative ideas and computer games, the brains of the current generation of learners have been trained to pick up and process new information at a much faster speed. Therefore, they get bored when they come to the traditional classroom set up (Nunley, 2006:37-38). Hence, teachers who want to hold their learners' attention should consider utilising effective pacing strategies that increase engagement.

One way to focus on "on-task" behaviour is to maximise engagement in the classroom and present content in smaller units. Actions are taken to ensure learners are helped to master each learning unit before introducing more advanced learning. The list of actions as indicated by the respective researchers enhance effective pacing and assist learners in mastering learning units.

(i) The setting of clear learning goals

Since learners are said to learn better when they know what is expected, clear goals must be set and communicated. This must relate to one of the learning engagements to capture their attention right from the beginning (Gregory & Kaufeldt, 2015:14-16).

(ii) Adopting a clear, appropriate routine

Routine helps the learners to come to class with an expectation. Learning may be ineffective if teachers do not have clear and well-practised routines (Abla & Fraumeni, 2019; Marzano & Pickering, 2010). Getting learners into groups, handing in assignments, distributing materials (Marzano & Pickering, 2010) and checking homework should be planned and included in the class routine.

(iii) Designing content in smaller units

Construct content in small, manageable units that are easy to digest (Marzano & Pickering, 2010). This includes introducing a small unit of information at a time then learners are given time, as individuals or in small groups, to process this added information, ask, answer questions or review what they have learnt (Abla & Fraumeni, 2019).

(iv) Creating a conducive environment in the classroom

Conducive learner-teacher relationship, activities and classroom environment will support learners' daily autonomy (Reeve, 2016:133). This can be accomplished by drawing up structural instruction, procedure, and notes with clear information that gives learners a great deal of freedom to interact and enhance engagement (Skinner & Belmont, 1993:571-578).

Learner engagement may be improved through a framework that supports autonomy (Connell & Wellborn, 1991), which is the extent to which the learner can choose or self-initiate an action (Deci & Ryan, 1987). Autonomy support influences learner behavioural engagement (Skinner & Belmont 1993). When learners know their role in the learning process, they are focused, and work diligently on different tasks where nobody is distracted. Hence, the appropriate balance is achieved (Abla & Fraumeni, 2019).

(v) Planning for top and fast achievers

Have a set of activities prepared for learners who work fast and finish quickly. Work together with your learners toward a higher-quality level of motivation (Marzano & Pickering, 2010). Moreover, learning materials should be accessible anytime, anywhere, be it online, offline, or on mobile devices so that they can engage with it anytime (Abla & Fraumeni, 2019; Marzano & Pickering, 2010).

3.6.2 Arranging resources

Gather quick, accessible learning resources related to the content/lesson that learners will want to engage with frequently. Present information in formats that keep learners coming back for more, such as summarised powerpoint notes, templates, short videos, checklists, activities that stimulate real-life and infographics that summarize the lesson (Abla & Fraumeni, 2019).

(vi) Effective questioning

Effective questioning is associated with many positive engaging behaviours, that trigger interest, attention, motivation, curiosity, and problem solving in the context of cognitive engagement (Marzano & Pickering, 2010; Abla & Fraumeni, 2019). Effective questioning evolves from a variety of questions which include the use of inference questions, probing questions, transfer questions (application of knowledge), pre-planned questions, emerging questions, complex questions and use of sufficient wait time between questioning technique (Abla & Fraumeni, 2019; Walsh & Sattes, 2016:11-12; Marzano & Pickering, 2010).

The use of questions can generate mild pressure that stimulates attention. However, the use of questioning as an engagement strategy has its own disadvantage. For instance, if one person answers a question, the others may be disengaged (Marzano & Pickering, 2010:151). Nevertheless, there are practical and effective questioning techniques. In other words, there are possible ways to strengthen questioning techniques and to facilitate higher levels of cognitive engagement in learners (Smart & Marshall, 2013:266). The listed practical suggestions may be applied in the classrooms to strengthen questioning techniques.

(i) Questions that focus on the content

Put together questions that draw learners to focus on the content aligned with the learning goals and facilitate thinking at an appropriate cognitive level that engages all learners (Walsh & Sattes, 2016:27,32-35; Marzano & Pickering, 2010:151-152).

(ii) Analytic (reasoning) questions

Formulate questions that encourage learners to elaborate on ideas, a typical characteristic of cognitive engagement. In science classes, questioning is a potential integral component for an effective classroom atmosphere (Smart & Marshall, 2013:250-251).

(iii) Creative questioning technique

Arouse learners' inductive reasoning by asking creative questions and give each learner the opportunity to creatively write down their questions or answer the question(s) and not just listen to others. To achieve this, each learner should write answers or questions on sheets of paper, and this increases the number of engaged learners by developing their answers (Cangelosi, 1984:471- 472) to questions.

3.6.3 Physical movement incorporation

Previous studies have demonstrated that implementing physical activity in the school increases learners' physical activity levels and stimulates on-task behaviour (Bartholomew & Jowers, 2011; Mahar *et al.*, 2006; Riley *et al.*, 2015). It also lifts their energy level, deepens understanding of content and stimulates the entire class (Donnelly & Lambourne, 2011; Marzano & Pickering, 2010) and improves learning outcomes (Donnelly & Lambourne, 2011; Riley *et al.*, 2017).

Physical movement positively affect learners' ability to engage emotionally, cognitively, behaviourally, and agentic, thus addresses all the aspects of engagement (Marzano & Pickering, 2010). The integration of physical activity in daily mathematics class enhanced enjoyment and

engagement (Riley *et al.*, 2017). Practical application of physical movement incorporation strategy includes:

- Design tasks that use movement for understanding

Design tasks that use movement to deepen learner understanding of content by incorporating 'corner' activities. Learners physically move and assemble at different corners to discuss different parts of the content as designed by the teacher (Marzano & Pickering, 2010).

3.6.4 Authenticity realistic

Authenticity affects learning engagement and performance (Taylor *et al.*, 2016). Authenticity refers to the extent to which tasks or activities require learners to solve real-world problems which have value beyond the class and school (Lombardi, 2007; Newmann, Bryk & Nagaoka, 2001). These authentic activities require using what is learnt in class to accomplish life application problems (Brophy, 2004).

Through authentic tasks and activities, learning science by memorizing facts or following scientific procedures engages learners in scientific discourse that uses science in the way scientists would (Taylor *et al.*, 2016:4-5).

When learners engage in authentic work, the quality of their academic performance increases in middle and elementary schools (Newmann *et al.*, 2001; Newmann & Associates, 1996). As a result of these findings, learners should learn through engaging in authentic activities (Brophy, 2004).

Authentic activities include among others:

- (i) Exposing learners to realistic simulations

Exposing engaged learners to realistic simulations of real-life applications if it is impossible to engage them in the actual life applications that the learning experiences are designed to prepare them for (Brophy, 2004:39; Taylor *et al.*, 2016).

- (ii) Connecting tasks and scenarios to learners' own lives (real-life application)

Connect tasks and scenarios to learners' lives and interest. When problems and scenarios are related to learners' own lives, performance and engagement increase (Walkington, 2013; Meier, 2008).

(iii) Incorporating a variety of information sources

Incorporate a variety of information sources and stimuli such as original text, realistic data figures, tables and charts that represents a scientific concept, investigation, procedure, experiment that does not occur naturally (Taylor *et al.*, 2016).

(iv) Designing context-based inquiry

Design context-based inquiry including problem-solving, formulating hypotheses, investigating the problem using content learnt in class (Marzano & Pickering, 2010).

(v) Administering authentic intellectual tasks

Support your learners to get engage with authentic intellectual tasks that involve the construction of knowledge, disciplined inquiry, and emphasis on real-world connections (Taylor *et al.*, 2016).

3.6.5 Thoughtful technology usage

The rapid development of technology in the 21st century is changing how people learn (Koller *et al.*, 2006:30-36). There is solid evidence that technology can help boost learner engagement (Abla & Fraumeni, 2019).

Learners who could become irritated by technology become less engaged. The absence of interaction between instructor and learner and other learners using technology is a challenge on its own (Koller *et al.*, 2006:30-36). Such challenges could be overcome by adopting the following measures:

- (i) Plan the use of technology to provide opportunities for active engagement of learners. For effective use of technology, learners should be provided with opportunities to discover learning, group activities and discussions. Research suggests that simulations can be particularly effective in using technology in transferring knowledge (Koller *et al.*, 2006:30-36).
- (ii) Find and use technology that provides relevant content and links with what learners already know, produce feedback and support the aims of learning objectives and outcomes (Abla & Fraumeni, 2019:7; Koller *et al.*, 2006).
- (iii) Use technological innovation efficiently from a learning objective to a learning outcome. For example, a teacher who uses technology as a tool, a means to an end, can get better results (Abla & Fraumeni, 2019:7-8).

- (iv) Apply technological tools that aid visualisation of concepts with a guided sequence of steps to promote clarity and engagement. Technology becomes helpful when the lesson allows learners to visualise concepts (Abla & Fraumeni, 2019).
- (v) Use a multimedia approach, e.g., music samples, short film clips from video games, movies or real-life situations. Keep electronic slides to the minimum with fewer slides full of texts and use more graphics (El-Shamy, 2004:21-29). Multimedia and discussion could increase the emotional engagement of learners even though they may not automatically increase their behavioural engagement and cognitive engagement (Nueva & Calica, 2018:115-118).
- (vi) Multimedia activities will lead to improved understanding, increased retention, efficient skills and knowledge transfer by purposefully engaging learners through technological media (Abla & Fraumeni, 2019; Taylor *et al.*, 2016; Wu & Puntambekar, 2012; Marzano & Pickering, 2010).

3.7 AFFORDANCE

Affordance is a theoretical concept which was developed by Gibson. The concept was introduced to play a key role he was convinced that no other existing concept in psychology could play at the time (Gibson, 1979). The term affordance alludes to the functional “properties of an object”, activity or environment that describes what it offers or how it could be used (Pea, 1993).

3.7.1 Affordance(s) from Gibson’s point of view

Affordance is not in the dictionary (Jones, 2003; Pea 1993; Norman 1998; Gibson, 1966). However, the verb afford can be found in the dictionary. For example, according to the Cambridge dictionary, afford allows someone to have something pleasant or necessary. Collins English dictionary defines afford as to give, yield, or supply and as a verb to be able to do or spare something.

Gibson’s affordance was concerned with how animals appear to partake in an awareness opportunities afforded by environmental (Jones, 2003:110-111). Gibson suggested that “affordances of the environment are what it offers the animal, what it provides or furnishes either for good or ill” (Gibson, 1979:127). The values and promises are the positive affordances, and the set of threats are the negative affordances (Scarantino, 2003:950).

Gibson defined affordance of anything as “a specific combination of the properties of its substance and its surfaces taken with reference to an animal” (Gibson, 1977: 67). The concept of affordances has received extensive research by others besides Gibson. One such researcher is Norman.

3.7.2 Norman's Affordances

Norman acknowledged that the perceptual psychologist Gibson coined the word affordance, including the idea, perception and understanding provided by affordance. But he disagreed with him on fundamental ideas which they often discussed at a personal level or formally at conferences and seminars (Norman, 1988:12). Among others, Norman viewed the processing mechanism as important, but to Gibson, it was irrelevant (Norman, 1999:38-39). Norman (1988), on the other hand, related affordance to the relationship between a physical object and a person.

Norman combines affordances with past knowledge and experience. Norman concluded that affordances reflect the possible relationships among actors, objects, and the physical manipulation of the objects (Norman, 1988;1999).

3.7.3 Comparing Gibson's and Norman's ideas about affordances

This section highlights the different meanings assigned to the concept of affordance by Gibson and Norman (McGrenere & Ho, 2000).

Gibson's Affordances

- Introduced the word affordance to explain how people handled the world.
- An affordance subsists, or it does not subsist.
- Does not distinguish between different affordances (perceived and real).

Norman's Affordances

- Introduced the word affordance into the world of interaction design.
- Perceived characters may exist or may not.
- Distinguish between perceived and real affordances.

3.7.4 Conceptualizing affordance

Development of the notion of affordance moved from design and psychology into many areas of study. However, there are claims that Affordance is poorly defined, therefore, more work is to be done on the definition (Stoffregen 2000; Jones, 2003).

Corno and Mandinach analysed how Snow used Gibson's (1977) notion of affordances to explain how situations activate and develop human potential. The finding was that the more affordances learners perceive to be present in a given task, the more meaning they can take from the

experience (Corno & Mandinach, 2004:307-312). According to Corno and Mandinach (2004:309-311,) there is an ecological “fit” between learner and situation, a person and environment. When learners adjust to what a situation offers and the opportunities it affords, they get locked into place and absorb what they can.

3.7.5 Usefulness and usability of affordances

In recent studies, different researchers have identified various objects, artifacts, environments and animals related to affordances. This include learning, instructions, and scientific representations that could be used to ensure diverse affordances support learners’ engagement in scientific activities (Milne & Otieno, 2007).

The use of everyday items and resources for demonstration affords learner agency (agentic engagement), but unfamiliar resources and scientific equipment hinder their agency because learners are overwhelmed by the equipment or learning how to use the equipment before attending to the science contents (Milne & Otieno, 2007:527-539). A structured classroom allowing interactions affords learners’ observation and manipulation of resources (Milne & Otieno, 2007).

Affordances of flipped learning environment

Bormann’s (2014) study produced the following affordances in a flipped learning environment.

- Has the ability to access various types of learners with varying cognitive levels.
- Affordance of increase in perceived engagement affords more learners to perceived to be engaged.

Affordances of using fiction for teaching chemistry

- Yerrick and Simons (2017:232 -233) identified the following affordances for using fiction for teaching chemistry:
- Increase and expand the interest of non-science learners and cross-disciplinary learning.
- Creating serious-minded regular users of media
- Explore the real-life environment we live in.

Affordances of music

McGrenere and Ho (2007:7) on the usefulness of affordance, contended that affordance of music playability for piano is the playability, within which the piano keys have affordance of depress

ability. Gall and Breeze mentioned that technological affordance allowed individual learners or groups to control their time composing music (Gall & Breeze, 2005:429-430).

Musical affordances provide different forms of musical engagement (Krueger, 2014). Krueger proposed that musical affordances increase the operational intricacy of emotion (Krueger, 2014). Furthermore, musical affordances are the specific things we can do with music (Krueger, 2014:7-9):

- Music affords movement to the listener.
- Music affords responsive engagement.
- Musical affordances provide resources and feedback that enhance factors responsible for creating and maintaining emotional experience.
- Musical affordances enhance the listener access to emotional improvement, attention, and distinct facial expressions.

Affordances of context-based inquiry

Context-based learning provides opportunities to identify and solve significant problems, which aim to make learning more meaningful (Broman, Bernholt, & Parchmann, 2018:1176). Context-based learning comprises of different learning tasks and approaches resulting in different affordances. Broman *et al.*, categorised the tasks and affordances according to levels of complexity by the following keywords:

- Affordance level 1 Everyday experiences
- Affordance level 2 Name
- Affordance level 3 Describe
- Affordance Level 4 & 5 Explain

Broman *et al.*, (2018) argued that the specific affordances of context-based problems and context questions, (which are not easy chemistry-related application questions) was reflected in the learners' answers. This implies that affordances can be detected from learners' responses.

Wu and Puntambekar (2012) identified the following affordances of demonstration, physical models' representations, planning and conducting investigations which are characteristics of context-based inquiry:

- Relate to a real-life context.
- Physical interaction.
- Measuring and collecting data.

According to Webb (2005:723-724), affordances of projects (CBI project) include:

- Recognising factors from the real-life scenario.
- Reviewing progress feedback and solving problems.

The use of the symbolic environment and laboratory activities will be able to provide cognitive and social affordances that encourage the building of shared knowledge of scientific experience (Kozima, 2003:200-224).

Affordances of computer simulation

Wu and Puntambekar (2012) specified that affordances of simulation allow learners to do the following:

- Conduct investigation that are not easy to manipulate variables in the physical world.
- Visualise relationships between variables in science context (Wu & Puntambekar, 2012:756).

Webb (2005) argued that computer simulations provide new affordances for learning when they are based on experiences and context that cannot easily be observed and explored in the real world. Webb (2005: 727-728) formulated the following conclusions:

- Simulations on laboratory experimentations provide affordances that make it easier to interaction, think and understand the context.
- The use of computer simulations afford conceptual change.
- Affordance of computer simulations activities enables learners to work at higher cognitive levels.
- The designs address Piagetian formal operations that are abstract and difficult.
- Computer simulations that have internet support learner research project.

It is argued that technology affords learning and education when technology facilitates merging of social and educational contexts (Kirschner, 2002:18).

3.8 SUMMARY

Several authors have used ‘affordance’ to explain the links between an educational intervention and the types of learners with the aim of stimulating learning (Kirschner, 2002). These include the characteristics of whether and how a specific learning behaviour can be achieved (Kirschner, 2002:17-19).

Engagement components is characterized by compliance with attendance and involvement (behavioural engagement), investment in acquiring knowledge and appreciation of challenges (cognitive engagement), positive affective reactions, including enjoyment and sense of belonging (affective engagement), and explanation of learners, feelings and behaviour when facing the school environment and class activities (AGAU engagement), (Fredericks *et al.*, 2004; Reeve & Tseng, 2011).

However, learners in high school struggle to learn and understand the PT (Franco-Mariscal, Oliva-Martínez & Gil, 2015). Learners often find learning the names and symbols of the PT boring, even though it is vital for understanding chemistry (Franco-Mariscal, España-Ramos & Blanco-López, 2017). Therefore, it is of great significance to identify learning approaches and resources that could reduce or overcome these difficulties in teaching and learning the PT (Franco-Mariscal, Oliva-Martínez & Gil, 2015).

Measuring the attributes of the components of engagement compared with task characteristics can determine the affordances of an engagement strategy is important to assist learners to overcome the difficulties associated with learning the PT.

Learner engagement plays an essential part in the value of their everyday experience in class. Productive engagement, coupled with realistic learning activities, facilitates proficiency in learning which leads to improved performance. Learners who are emotionally engaged show positive affective reactions, and their beliefs show close relation to their emotions, experiences and opinions displayed in the classroom. Behavioural characteristics such as commitment, attention and persistence promote behavioural engagement and learning.

For learners to profit from schooling, they have to “engage” in a manner that will increase their learning (Ladd & Dinella, 2009). Engaging in class promote engagement. The three engagement strategies investigated in this research study are music, context-based inquiry and computer simulation. The use of music and musical instruments in general, has been reported in literature to improve maths, science, and English performance in learners that engage in music compared to those who do not (Gouzouasis & Guhn, 2019). Consequently, it was expected in the study reported in the thesis that using music as an engagement strategy may enhance the learning of

the PT and thus improve chemistry performance. The use of music helps improve the processes of scientific inquiry and inquiry -based education (Gershon and Ben-Horin, 2014).

Context-based inquiry engage learners to design and conduct investigations, achieve outcomes and understand the natural world of scientific inquiry (Crawford, 2014). Importantly, inquiry should be thought of as an approach to learning content (Crawford, 2014:522). Context-based inquiry as a strategy was used in this study to engage learners to acquire learning skills, content and achieve learning outcomes.

Computer simulation allows learners to clearly observe the connections between sub-microscopic, macroscopic, and symbolic levels of chemistry clearly (Stieff & Wilensky, 2003). PhET simulation, a free online flexible tool, supports a wide range of learning styles allowing for a safe, engaging, and fun learning experience for learners.

The effective benefit of computer simulation, context-based inquiry in learning lies in how the models of simulation and inquiry activities are constructed. Too much information, variety of text, pictures, animation, tasks, activities, cause cognitive overload (Avramiotis & Tsaparlis, 2013; Gafoor & Vevaremmal 2012; Sweller, 1988; Johnstone & El-Banna, 1986).

Researchers have found that science activities that are hands-on in nature and allow for engagement elicit high interest in performance among learners. Therefore, investigating how music, computer simulation and context-based inquiry as learning strategies to detect the affordances of engagement in chemistry for learning the Periodic Table of chemical elements is viable. For that matter, chapter four zooms into an empirical study using these engagement strategies to afford learning the PT.

CHAPTER 4 RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter provides an extensive explanation of the research methodology implemented to address the research problem. Explanation of the theory of the why and how of each method used in the study is elaborated (Midgley, 2000:1). In this chapter, the theoretical views behind the methodology, data collection and data analysis to achieve the study's primary aim. The purpose of the empirical study is to investigate the impact of music, context-based inquiry, and computer simulation engagement strategies on the four components of engagement (behavioural, emotional, cognitive, and authentic engagement) in learning the first twenty elements of the Periodic Table and identifying the affordances of these engagement strategies.

While chapters two and three reviewed the relevant literature related to learning, CLT, MIT, PT, music, computer simulation, context-based inquiry, engagement, and affordances. Chapter four focused on how these relevant works of literature are applied to generate answers to the research problem and questions.

The sections of the chapter are in the following order: Section (4.1) the introduction; Section (4.2) provides the research paradigm and process; section (4.3) addresses the research design; section (4.4) describes the empirical study, and details of the intervention; section (4.5) deals with data collection; sections (4.6) explains how data was analysed; while section (4.7) provides a summary and remarks related to the study.

4.2 METHODOLOGY

The methodology is described as collection of methods undertaken in this research and the theories that underpin the research process (Leedy & Ormrod, 2001:346). This is influenced by the paradigm in which the theoretical viewpoint is set (Becker, 2007:35). The paradigm is an important component of the methodology. Pragmatism is the paradigm (see 1.6) associated with the study in the view that it draws on what works, promotes use of diverse approaches, focuses on consequences of actions (the interventions), research questions, multiple methods of data collection to inform the problems under study connected to real-world application. For these reasons, mixed methods research is applied to encourage the use of multiple methods in the study. Therefore, these methods should be systematically structured.

This systematic structure which includes generating understanding of the study, the collection of data to resolve the identified problem, creating knowledge, and answering the research questions are described in the following sections.

4.2.1 The research processes

This study is in accordance with the seven characteristics of research (Leedy & Ormrod 2010:3-6; Boudah, 2011:14-15) which are:

Identifying the research problem and research question. The researcher formulated research questions with a clear goal that were written clearly and unambiguously (section 1.3) in addition to finding answers and solutions, as discussed in chapters 5 and 6.

The problem was stated and addressed as objectives and research questions (section 1.3). The formulated hypothesis is indicated (section 1.4).

Relevant facts and information through literature review (Chapters 2 and 3) served as the theoretical foundation and background in conducting the study (Taylor and Watson, 2010:46). The collection and interpretation of data to resolve the research problem was based on facts evident in (Chapters 4, 5 and 6).

Mestre (2000:151) likened research with 'blocks' of empirical data used for 'building' knowledge. These blocks are the research processes which are methods, strategies, intervention, empirical study and theory of the research design. These are summarised in the flow diagram below, Figure 4-1.

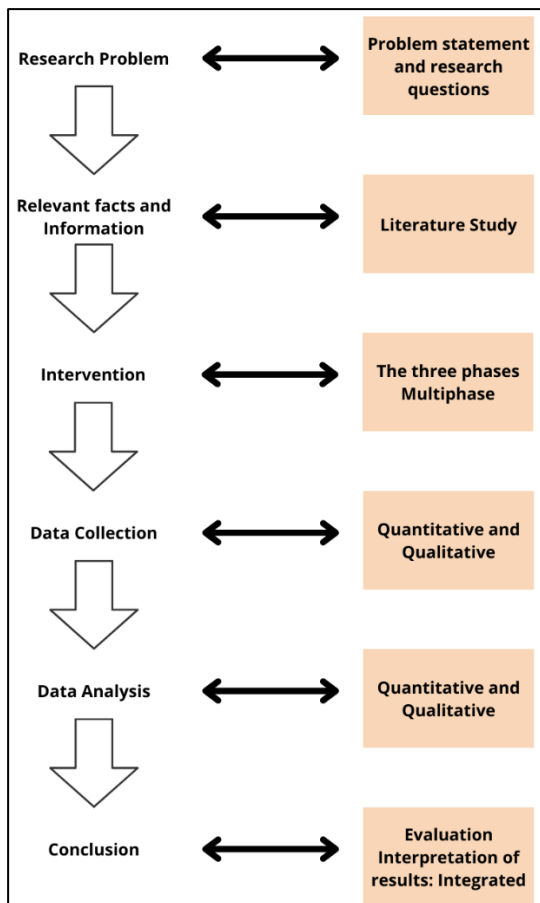


Figure 4-1: The research process model

The research process model in this study, started with identifying the problem, then formulating research questions and determining facts and information to develop the intervention from literature and suggestions from experts in the field. Quantitative and qualitative methods were used to collect and analyse the data. The results from the analysed data was interpreted, and conclusions are drawn. This followed a systematic plan. The systematic plan developed to address the research questions integrated and combined several research methods as described in section 4.3.

4.3 RESEARCH DESIGN

The study followed a mixed method research. The type of mixed method applied in this present study is sequential explanatory. The sequential explanatory started with quantitative and sequentially followed by qualitative. Therefore, the appropriate research design is a sequential explanatory mixed method. This is summarised in Figure 4-2.

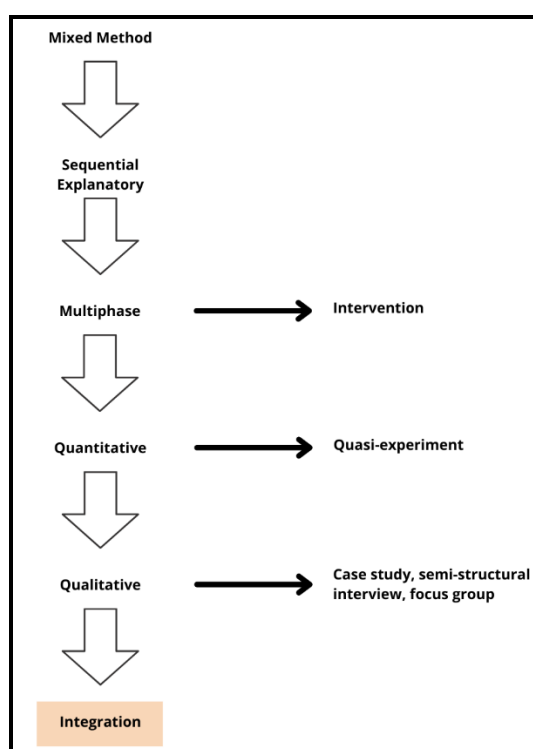


Figure 4-2: Schematic representation of the research design

(Source: Author's compilation)

Mixed method paradigm which is pragmatism, guided the methodological choices by providing flexibility to use diverse methods that works for this study. Pragmatism provided the foundation for the multiphase method (Creswell & Clark, 2011:101). Accordingly, multiphase was used to study the problem through different phases linked to quantitative and qualitative methods (Creswell & Clark, 2011). The data was collected and analysed sequentially with quantitative method followed by qualitative method.

A detailed description of each component of the research design summarised in Figure 4.2 is explained starting with mixed method (see section 4.3.1- 4.3.5).

4.3.1 Mixed method

Mixed method research is used research to answer research questions using qualitative and quantitative data collection and analysis (Teddle & Tashakkori, 2009:23-27). The advantage of mixed method is verifying and generating theory in the same study using confirmatory and investigative questions which can provided by the researcher (Teddle & Tashakkori, 2009:33). For instance, the quantitative method produces precise and measurable data which are easily drawn into tables and graphs. Whereas the qualitative method enhances the understanding of the data produced (Teddle & Tashakkori, 2010; Dahlberg & McCaig, 2010).

Mixed method offers better inferences and wider divergent opinions (Teddlie & Tashakkori, 2009:33). However, mixed method is much more time consuming and takes much more resources and planning. It is more costly printing the quantitative instruments, the pre and post-test questionnaires, recording and transcription of qualitative interviews, focus groups, statistician fees and cost of software programs for this study. Nevertheless, the advantages outweigh the challenges, as it is more valuable by providing more evidence drawn from different data sources such as qualitative and quantitative data. Therefore, in order to utilize the strengths of both qualitative and quantitative components of the mixed method, the researcher used a sequential explanatory mixed method to integrate the qualitative and quantitative methods (Creswell & Clark, 2011).

4.3.2 Sequential explanatory mixed method

Sequential explanatory mixed method is preferred because it is the simplest of all the mixed method designs as it begins strongly with quantitative direction. (Creswell & Clark, 2011:83). The ability to conduct quantitative (QUAN) and qualitative (QUAL) methods separately and collect only one type of data at a time is a great advantage, even though it is time consuming. Furthermore, the data was analysed separately. The final report began with quantitative section followed by the qualitative part making it a useful way of writing and easier for readers (Creswell & Clark, 2011:83-85). The sequential explanatory mixed method is illustrated in a flow diagram in Figure 4-3.

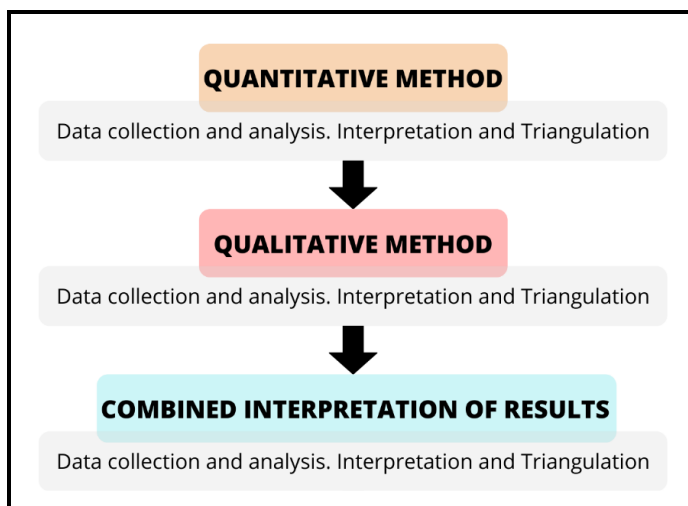


Figure 4-3: Schematic representation of sequential explanatory mixed method
(Source: Author's compilation)

It further supports mixing the QUAN and QUAL strands at the final stage of the research process after collecting and analysing both data sets (Creswell & Clark, 2011:66-67) for understanding

and verification (Johnson *et al.*, 2007; Teddlie & Tashakkori, 2010). And the multiphase connects the three phases within the sequential explanatory mixed method design.

4.3.3 Multiphase in mixed method

Multiphase is a type of mixed method research that combines both sequential and concurrent components over time with distinct phases implemented within the study (Creswell & Clark, 2011). Concurrent component occurred when both the quantitative and qualitative methods were implemented during each phase (see section 4.5) of the empirical study. And sequential when quantitative method is implemented before the qualitative. The research question for each phase is stated as required by the multiphase mixed method (section 1.3). Each new phase is built on knowledge learnt or acquired from previous activities.

The strengths of multiphase applied in the study are:

- The researcher incorporated the flexibility needed to apply mixed methods features to address the five related research questions (section 1.3).
- The researcher used the multiphase mixed method to provide a complete frame for conducting the three phases of the study.
- The researcher published the results from individual phases and, as combined complete study (chapter 6 and 7).

The purpose of multiphase was to address the five sets of phased (step by step) research questions that advanced from one programmatic (scheduled, methodical) research aim as stated in section 1.4 (Creswell and Clark, 2011). Again, the study is considered multiphase because the researcher cannot fulfil the main aim of the study with a single mixed method study, hence the study is subdivided into three phases (three empirical studies).

Quantitative and qualitative methods were applied in the three empirical studies listed below:

- (i) Using music to determine the impact of music activities on the four components of engagement (behavioural, affective, cognitive, and authentic/agentive (AGAU) engagement) in learning the first twenty elements of the PT (Atomic numbers, atomic mass, names and symbols).
- (ii) Using context-based inquiry to determine the impact of context-based inquiry activities on the components of engagement in learning about the combustion of some Periodic Table

elements; magnesium, lithium, phosphorous, sulphur, carbon and hydrogen in oxygen and linking their use to everyday experiences.

- (iii) Using computer simulation to determine the effects of computer simulation on the engagement components in learning about atoms and molecules of PT elements.

The three different phases contribute towards understanding the effect of using music, context-based inquiry, and computer simulation for learning the PT and generalise the findings to the population. These three phases were executed as an intervention at each of the two scheduled workshops.

4.3.4 Intervention: The three phases

Intervention is a creative means of developing situation-specific solutions combined with a logical procedure of evaluating these solutions (Van Aken & Romme, 2012:3; Oliva, 2019). Knowledge of the intervention outcomes deduced from participant-observer perspectives was essential for examining the findings on the intervention outcomes in specific phases of the workshops (Van Aken & Romme, 2012:4).

These designed interventions were experimented with teachers during two workshops and a case study, a lesson was presented by one of the workshop participants afterwards to see if the results answered the research questions. The features of the designed interventions suggested by CLT and MIT guided creating specific learning materials and strategies (music, context-based inquiry, and computer simulation engagement strategies) designed to realize learning gains (Walker, 2006:9). The theories were applied to discover, build and test the intervention's effectiveness using the three engagement strategies. Hence, creating a connection between the research and learning theories. As discussed in the literature (chapters 2 and 3) the theories applied to each engagement strategy per phase are summarised in sections 4.3.4.1 to 4.3.4.3 and Figure 4-1.

4.3.4.1 Phase one: Music as an engagement strategy

One of the problems identified is memorising and recalling of the names and symbols of the first twenty elements of the PT (refer to chapter 3). The development of the intervention included searching, selecting appropriate songs, composing songs, singing, thus using repetition through music as an intervention strategy. As mentioned in section 3.5.5, repetition enhances understanding learning. It also prevents forgetting what has been learnt (Weibell, 2011). The theoretical aspects governing this intervention is repetition (section 3.5.5) and engagement (section 3.4-3.5).

Technology usage (3.6.5) such as songs from YouTube videos, video recording, use of computers and cell phones form part of the implementation of the intervention. Thus, connectivism learning theory (section 2.3.4), and technology-based learning (section 2.6.4) under CLT (section 2.4- 2.6) are among the theories guiding this intervention.

4.3.4.2 Phase two: Context-based inquiry as an engagement strategy

Context-based inquiry included combustion reaction of selected elements with emphasising transfer of knowledge within the class and the real-life (Herranen *et al.*, 2019; Gilbert *et al.*, 2011). It engaged learners regarding first-hand activities and discussions. Therefore, engaged participants efficiently in the classroom (section 3.3.4).

Context-based inquiry is guided by constructivist theory (section 2.6.2). It initiated learning by creating real-world problems and working in groups (Duch, *et al.*, 2001) which provided opportunity for the participants to find solutions to the problems critically and proficiently (Lederman, 2009).

4.3.4.3 Phase three: Computer simulation as an engagement strategy

Computer simulation applies technological tools (internet, PhET) that aid visualisation of abstract PT concepts with a guided sequence of steps to promote clarity and engagement (Abla & Fraumeni, 2019). The connectivism (use of the internet and technology) provided guided learning skills and tasks needed in the modern digital era (Simens, 2013). Therefore, connectivism and CLT provided guidance regarding the intervention using computer simulation (Section 2.3.4; 2.4; 2.6.4). The study implemented the three phases mentioned using quantitative and qualitative methods in the empirical study (section 4.3.5, 4.3.6, 4.4, and 4.5).

4.3.5 Quantitative method

The quantitative method is deductive and theory-driven (Okeke & van Wyke, 2015). The study is driven by learning theories, CLT, and MIT. It emphasises objectivity, outcomes, experimental verification, and generalisation of findings.

To collect detailed, precise, quantifiable, and unbiased data were reasons for using the quantitative method to collect data for the study (Creswell, 2008:54-55). This is followed by analysis with statistical process (Leedy & Ormrod, 2010:182) to determine the affordances of music, context-based inquiry, and computer simulation as engagement strategies in learning the PT. Focusing on quasi-experiment, which trend with the quantitative method.

(i) Principles of quasi-experiment

Pre-test and post-test forms part of the study, therefore, experimental design should be an appropriate quantitative method. But the study does not involve random sampling of participants (Schreiber & Asner-self, 2011: 14). Since randomisation was not applied in this study, it is described as a quasi-experiment.

Applying quasi-experiment, the study included an empirical investigation to determine the impact of the intervention on teachers as the target group without any randomisation. Since quasi-experiment occurs in a natural setting, the findings may be applied to other settings as such generalization can be made about the population. Again, in this present study, there is manipulation of independent variables, no random selections, no active manipulation, and no control group was applied. Figure 4-4 is a summary of the quantitative method where quasi-experiment was used to investigate the conditions within which one of the entities is being surveyed (Yin, 2014:66).

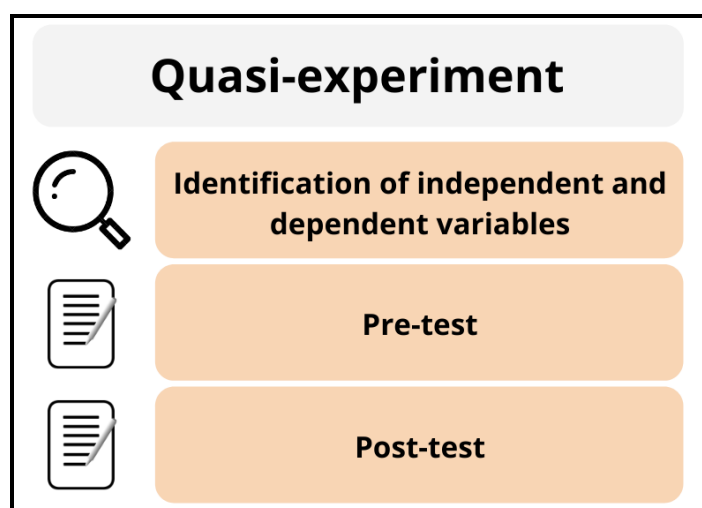


Figure 4-4: An overview of quantitative method of study

(Source: Author's compilation)

Quasi-experimental quantitative method was useful in generating results of general trends from the pre-test and post-tests. The quantitative method was followed with a qualitative method to discover and understand individual experiences, opinions, and trends to poke deeper into the problem at hand.

4.3.6 Qualitative method

The trends were discovered through interactive and non-interactive inquiry that took place in a natural setting to investigate and interpret the impact of the engagement strategies in terms of the

meaning and experiences of the participants (Schreiber & Asner-self, 2011:10-11). Producing data that comes from the natural setting of the investigation (Okeke & van Wyke, 2015:209). The purpose of the qualitative approach was to conduct a systematic study of a case to produce detailed description of the object of the investigation (Boudah, 2011:127), which are the affordances of the engagement strategies.

The qualitative method is concerned with the understanding of how individuals or groups of individuals think. This was achieved through interviews and focus groups. Structural interviews seemed unrealistic in this study since varying opinions and answers were provided to questions from the questionnaire. Therefore, a set of ordered predetermined questions could not be administered. Semi-structured open-ended individual interviews were considered appropriate. The interviewees (participants) were asked open-ended questions. The questions were modified to explore what was heard and their experiences of the three different phases during the interventions. This encouraged the researcher to adopt ways to represent the voices or actual words of the participants in the research report (Okeke & van Wyke, 2015:209).

The focus group was a small gathering of participants related to the phenomenon of interest and could answer questions (Schreiber & Asner-Self, 2011) on the periodic table, engagement strategies and affordances. The focus group interview was used to get what the participants think about the engagement strategies; music, context-based inquiry, computer simulation to enhance engagement in learning the PT and identify the affordances of the engagement strategies.

The participants could hear the views, responses of others and were able to consider their own views (Johnson & Christensen, 2019; Fraenkel & Wallen, 2008:452). The participants talked and interacted well in the groups. The focus groups provided a great deal of useful data from the participants answers and comments (Johnson & Christensen, 2012; Fraenkel & Wallen, 2008).

The use of participants actual words made qualitative method to claim in-depth meaning and understanding of the context (Creswell, 2012:238; Okeke & van Wyke, 2015:209). Moreover, Djan (2014:104) indicated that the use of qualitative research as part of a mixed method study helped to identify existing learning resources and problems of grade ten learners, thus the data collected gave detailed information about the phenomenon under investigation. This confirms an advantage of using qualitative research to acquire an in-depth data in this study.

For these reasons, qualitative approach was used in this study to help identify and describe the guidelines relevant for the application of engagement strategies in the South African school chemistry curriculum (Leedy & Ormrod, 2010:136). To compile the guidelines, the point of views,

perceptions, experiences of individual participants and groups involved in the study is valuable. Therefore, the principles of phenomenology were applied to the study.

(i) Principles of Phenomenology

Phenomenology is the study of evolvement of meaning developed and experienced by individuals or people based on their own point of view and experiences over time (Okeke & van Wyke, 2015; Schreiber & Asner-self, 2011:13). Researcher identified concepts as perceived by the participants and described the understanding of a meaningful experience from the participant's point of view (Leedy & Ormrod, 2010:141).

Phenomenology allows qualitative data gathering using recording, interviews and observation. In phenomenological research the researcher did not include her own personal experiences, but the participants were asked to describe their experiences during the intervention (Trumbull & Watson, 2010:67).

Phenomenology provides the ability to engage few teachers in a detailed description of their experiences and deeper understanding of their perceived affordances of context-based inquiry, music and simulation engagement strategies in learning about the PT; as well as support needed as guidelines to apply the three engagement strategies in the South African school chemistry curriculum to enhance engagement in the classroom resulting in the improvement of performance and achievement in chemistry.

To iterate the definition of phenomenology as stated in the first paragraph of section 4.3.6.1 by (Okeke & van Wyke, 2015; Schreiber & Asner-self, 2011:13), which signifies that the experiences acquired throughout the inventions of the three phases by the individual or participants will contribute meaningful information to the study. Individuals and participants developed experience and meaning of the three engagement strategies based on their own point of view could be identified and overlapping data and repetitions eliminated. However, in the case of observation in the natural classroom setting, a case study was preferred to gain insight into the functioning of the engagement strategies.

(ii) Principles of Case study

A case study is a systematic collection of information about a person, group, community and or event in order to gain insight within a specific time and place (Schreiber & Asner-self, 2011:12). The researcher focused on obtaining a holistic view and real-world perspective (Yin, 2014:4) of how music, context-based and computer simulation as engagement strategies contribute to learning the PT of elements and achievement

Investigating the “case” and collecting information about the engagement strategies in the classroom is the main purpose of using a case study. Case of decisions and individuals “intervention” in the study is the central focus of the case study and not the method (Stake, 2005). The teacher in the classroom is the case that was observed.

The study is interested in a more general understanding of engagement in the classroom using music, context-based and computer simulation as engagement strategies and to evaluate how effectively it is operating.

Designated time, geographical limits of the case were defined as well as the activities. Exhaustive effort to collect all relevant evidence was made. Preferably to complete within constraints of time indicated in the proposal but was limited by time due to the COVID-19 pandemic. The teacher applied the three phases of the engagement strategy in a lesson, and the case formed part of the qualitative data collection.

4.4 THE EMPIRICAL STUDY

The empirical study was based on investigated and analysed the affordances of music(MU), context-based inquiry(CB), computer simulation(CS) as engagement strategies and their impact on the four components of engagement (behavioural, emotional, cognitive, and authentic engagement) in learning the first twenty elements of the periodic table was delineated as solution to the research problem identified and elaborated in chapter one.

The development of the interventions (see section 4.2.4, 4.2.4.1 to 4.2.4.3) took six months. This included: the selection of music videos, identification of context, equipment and experimental set, selection of appropriate computer simulations, preparation of instructional sheets and worksheets. These were all put together to form a unit and was thereafter subjected to criticism, suggestions by colleagues (teachers) and experts before finalizing and implementing.

The implementation of the intervention was initially evaluated by experts who indicated that the duration per phase was too long. Consequently, the intervention was reduced from six hours per session per phase to three hours. Long sessions made the participants exhausted. According to the curriculum work schedule (DBE, 2011a:63) the PT’s content is three hours per week.

The Likert scale was used to compile the pre-test and post-test questionnaires. Completion of the questionnaire was surveyed to produce information. Survey data was collected by asking the participants to answer predetermined set of questions using the questionnaire compiled by the researcher (Duarte & Miller, 2015 243-245; Schreiber & Asner-Self, 2011:97).

Survey popularity stems from its cost-effectiveness, efficiency, and ability to yield much information within a reasonable time (Vogt, 2007: 90). For these reasons, survey was preferred using interviews and completion of questionnaires to collect data that was analysed (Duarte & Miller, 2015:247; Boudah, 2011:158), to describe experiences, draw inferences, and select preferences (Boudah, 2011:158; Schreiber & Asner-self, 2011:15). A survey was used to avoid producing unrepresentative results that do not easily influence the nature of the data collected (Tolmie *et al.*, 2011:33) from the participants within the population.

4.4.1 Population

The participants come from a population of South African natural sciences and physical science teachers. This is the larger group from which the study stems, wishing to generalize and apply the research results (Boudah, 2011:186). The theoretical population, of whom to generalize the research results is South Africa natural and physical science teachers. There are 9 provinces in South Africa, a 10% of the 9 is 0.9, which is equal to one (10% of 9 provinces = $0.9 = 1$). Therefore, the study population is one (1) province out of the 9. The target population was purposively identified as the Northwest province of South Africa. The sampling frame is the list of all schools and teachers in the Northwest Province from which the sample was drawn (Lumandi, 2015: 224-229). The selected samples played a vital role to measure and describe the individual opinion of the population as well as the constructs of the survey (Boudah, 2011).

4.4.2 Sample

The sampled unit for the research was selected from a population of teachers from schools in the Northwest province of South Africa. The sample group included natural sciences and physical sciences teachers.

Non-probability sampling methods, purposive and convenience sampling, were applied in the study. According to Leedy, and Ormrod (2015), non-probability sampling does not guarantee the presentation of each element of the population in the study. However, it is cost-effective, and the researcher can quickly contact the sample (Schreiber & Asner-Self, 2011:85). As an additional strength backing its use, purposeful sampling assures the provision of the required information needed (Schreiber & Asner-Self, 2011:86). The researcher has prior knowledge and access to the science teachers in the province hence convenience sampling is preferred for the qualitative study.

Mixed method sample size was determined by combining two different types of sample sizes, which was achieved by using purposeful and convenience sampling techniques.

4.4.3 Research participants

The researcher used science teachers as participants. Teachers participated in assessing the use of music, context-based inquiry and simulations in teaching and learning chemistry content, specifically the PT. The teachers that participated came from schools in the North-West Province of South Africa. The number of teachers that participated in each workshop varied, ranging between 20 and 30 participants.

Thirty is a manageable number to handle and ensure maximum participation. Thirty teachers are adequate for statistical analysis. The intervention, research instruments and interaction are much easier with a manageable number than with a larger group.

Clean toilets and bathrooms were clearly marked and running water, soap and tissue paper were provided for their use. Participants were provided with breakfast and lunch. Clean and safe drinking water, tea and coffee, biscuits, and juice were available in the data collection area where participants accessed it freely at any given time.

4.4.4 Intervention

The intervention took place in the Northwest University Faculty of Education Science laboratory. The first workshop took place in November 2019 with 33 participants and 20 in March 2020 at the second one. The numbers decrease due to the awareness of coronavirus. The intervention was completed before South Africa declared a state of emergency and started closing down institutions. The intervention was presented in three phases.

The pre-test for all the three phases was written before the intervention and the post-test after each intervention. During each workshop, the same group of teachers went through all the three phases in one day.



Figure 4-5: Completing the pre-test before the intervention commenced

4.4.4.1 Phase 1: Music as engagement strategy

The researcher explained the procedure to the participants. They were placed in 5 groups of 4 to 7 participants. A periodic table, worksheet, summary of basic names, symbols, and properties of the first 20 elements of the PT and the questionnaire were given to each participant.



Figure 4-6: Periodic Table song on the screen

(Source: <https://youtu.be/uJGrwWOWteQ>)

- Music was introduced as an engagement strategy. A pre-downloaded song with lyrics on basic concepts of the PT including names, symbols, atomic number, atomic mass, metals, and non-metals from YouTube was played. They listened and watched the video, then they sang along and then they tried to sing without looking at the lyrics.
- The following three steps were followed: A second song different from the first was played firstly, the participants listened, sang along, then tried to sing without looking at the lyrics.
- For summative evaluation, individuals and groups were asked, and they voluntarily accepted the researcher's request to sing. By learning the songs, they learnt some concepts of the PT, and these included the names, symbols, atomic numbers, mass numbers of the first twenty elements of the PT. Information sheet was given to participants to select their own lyrics compose their own song using the PT content from the information sheet.

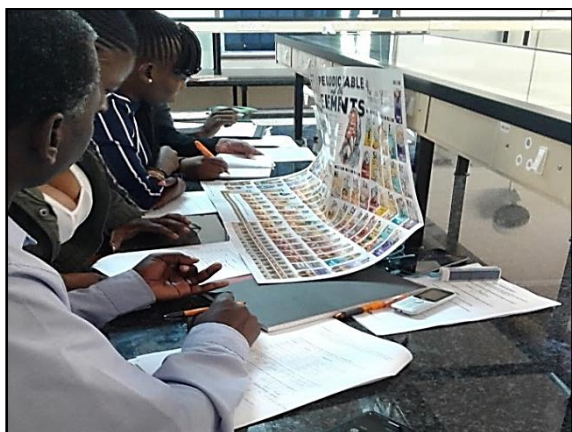


Figure 4-7: Participants in a group discussing the lyrics for composing their own song



Figure 4-8: Groups presenting their songs with action and excitement

Each group presented their song from the content provided on the information sheet. The music (songs) was used to learn the names and symbols of the first twenty elements of the PT in the correct order. The importance of repetition and engagement was deliberated. At the end of phase 1, the participants completed the post-test related to phase 1.

4.4.4.2 Phase 2: Engagement strategy two, context-based inquiry

- The participant worked in the same groups as in phase 1. The research team prepared the laboratory equipment and chemicals needed, arranged and neatly set in the laboratory ready to be used. An instruction sheet was given to each participant by the researcher.
- The researcher introduced the context-based inquiry project: "From the context of what you have studied, identify one metal or non-metal and explain how the combustion reaction of that metal or non-metal can be used to generate energy for communities in South Africa".
- The participants formulated hypotheses and questions which focused on what they would like to know about the combustion of magnesium, lithium, phosphorous, sulphur, carbon in their

groups. Then they used the instruction worksheet provided to investigate the combustion of the different elements. The participants in their groups discussed and completed the investigations, which included “Investigate what happens when the elements magnesium, lithium, phosphorous, sulphur, carbon identified on the PT undergo combustion reaction”.



Figure 4-9: Participants actively engaged in investigating combustion reaction

Based on the context, each group solved the context-based problem using inquiry.” From the context of what you have studied, identify one metal or non-metal and explain how the combustion reaction of that metal or non-metal can be used to generate energy for communities in South Africa”.

Each group presented their solution. The worksheet was completed in groups and one per group was submitted as part of the data collected.

4.4.4.3 Phase 3: Engagement strategy three computer simulation

- Background data was collected to inform the study on the prior experience participants have with computer, simulations, immersive environments and comfort and skill with technology.
- The participants watched a brief introductory video showing how to use PhET simulation. Due to the lack of computers, the simulation was projected on a screen for the participants to watch. A brief introduction to PhET (Source: <https://phet.colorado.edu/en/simulation>).
- The availability of Wi-Fi made it possible for each participant to download PhET on their phones and devices. (<https://phet.colorado.edu/en/simulations/category/physics>, University of Colorado Boulder, n.d.). Each group manipulated the computer simulation.

- Participants were given 10 minutes to explore and acquaint themselves with the two given simulation activities. This was to assist the participants that were unfamiliar with computer simulation to familiarise themselves first.
- The researcher revised concepts of the PT learned earlier using music and context-based inquiry with the participants.
- Open-ended questions (challenge) were given to participants. (1) "How does the use of computer simulations impact on learning the basic concepts of the PT and their use in our everyday experiences?" (2) "How does the use of computer simulations impact learner engagement and participation in the classroom to understand the basic concepts of the PT and their use in our daily experiences?"
- Participants built stable atoms for Na, Cl, O, S, H and C using PhET computer simulation (Activity one).

ACTIVITY ONE- BUILDING THE ATOMS

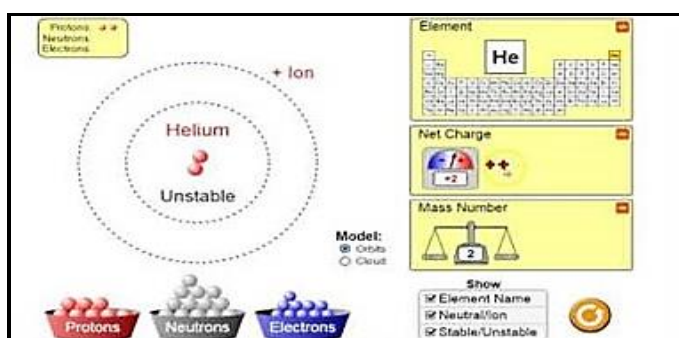


Figure 4-10: Atom building simulation

(Source: <https://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass>)

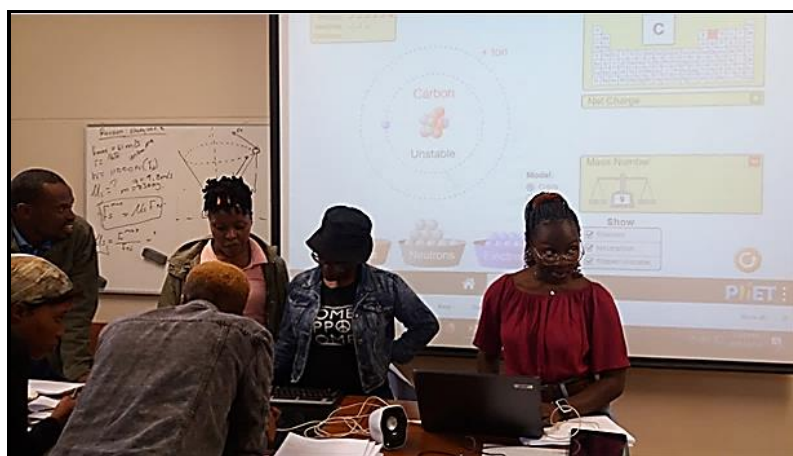


Figure 4-11: Exploring atom building simulation

ACTIVITY TWO- BUILDING MOLECULES

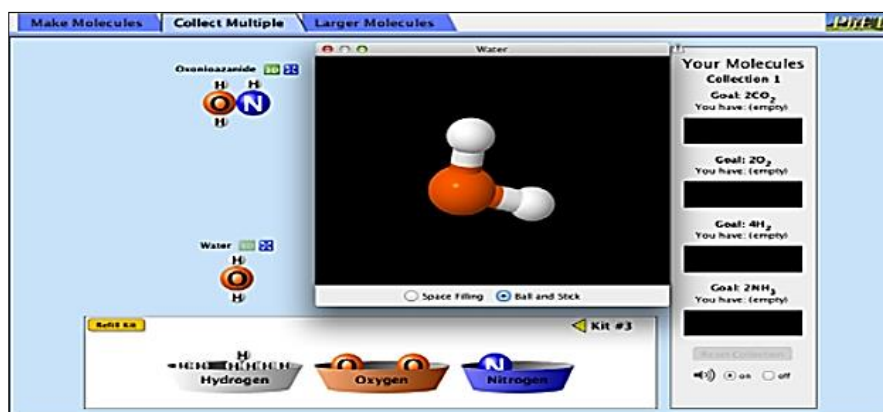


Figure 4-12: Molecule building simulation

(Source: <https://phet.colorado.edu/en/simulation/build-a-molecule>)

- Participants built more complex molecules composed of different elements NaCl, H₂O, SO₂, CO₂ and HCl. After a molecule was built, it was viewed in 3D models, followed by scaffolding with tables.
- Reflection took the form of feedback on the given open-ended challenge: The team members reflected upon their experiences. Each group provided feedback on the given open-ended questions (challenge) stated earlier.
- During the debriefing discussion about what was done successfully and what was not as well as what went well, was noted by researcher and participants.



Figure 4-13: Group discussions

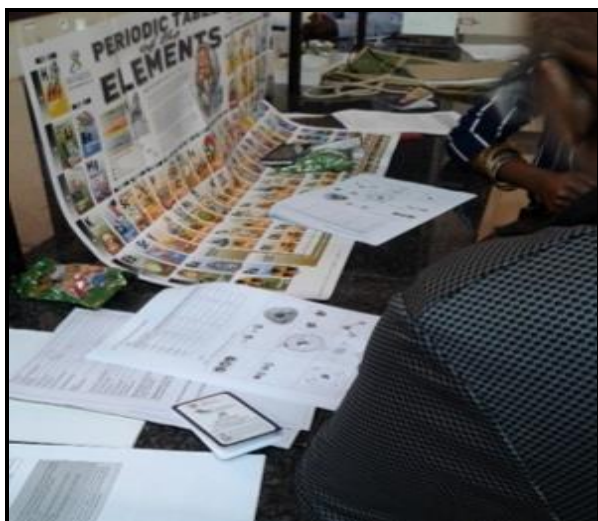


Figure 4-14: Completing the worksheet

By running the simulation on a computer and individual devices. The simulation provided the participants with a text and pictorial representation of atoms and molecules.



Figure 4-15: Completing post-test and worksheet

4.4.5 Quantitative data collection

There are different modes of collecting quantitative data: Electronic questionnaires and paper-based questionnaires. Paper-based questionnaires were used in the present study and the questionnaires (Appendix D) served as the research instrument.

4.4.5.1 Research instrument: Questionnaire

Questionnaires that contained an orderly organised series of questions were given to the research participants. These were used to obtain data for the study. The researcher compiled the

questionnaires from literature, exam papers and textbooks with the addition of self-compiled items. Likert scale, a type of rating scale with a numerical set that presents a statement asking respondents to rate the extent to which they agree with the statement was used to measure the participants' opinion (Johnson & Christensen, 2019:173-174). A 4-point Likert scale was implemented in Section B of the questionnaire to investigate the impact of engagement strategies on the participants' perception towards chemistry, cognitive, affective, behavioural, and authentic engagement, connected to learning the PT. The questionnaire (Appendix D) is comprised of three sections.

Section A: Demographic information; Section B: Engagement components (emotional, cognitive, behavioural, and authentic engagement) and engagement strategy (music, context-based inquiry, computer simulation) questions. These are quantitative questions, mostly close-ended questions (Johnson & Christensen, 2019). Section C: Multiple-choice items and short questions on the basic content and symbols of some elements of the PT were to determine how the engagement strategies affected the participants' content knowledge about the symbols, names, atomic structure, chemical physical properties of the first twenty elements of the PT. Section C was omitted from the pre-test because the participants were teachers and expected to have prior knowledge of the PT. The items in the questionnaire were structured in such a way that they started with lower-order thinking questions and progressively moved to more complex ones (Johnson & Christensen, 2019). These questions are reflected in the pre and post-test.

4.4.5.2 Pre-test

Part A of the pre-test questionnaire (Appendix D) was used to collect nominal data on participants' background and relevant personal details. Part B tested participants' conceptual understanding of the PT (cognitive engagement), their affect (emotional engagement), perceptions of the connection between the real-world and chemistry (authentic engagement), and their attendance and participation in class (behaviour). In addition, the questionnaire tested their perceptions of the effectiveness and affordances of the engagement strategies and the level of engagement experienced by the participants. Only one pre-test was administered before and three post-tests after the intervention.

4.4.5.3 Post-test

The pre-test questionnaire was given to the participants before the intervention in each workshop and this was followed by post-tests (Appendix D). Each phase followed the quasi-experiment methodology. Each post-test contains Section B questions relevant to the engagement strategy implemented in the phase under investigation. In other words, three post-tests, one per phase,

was administered to determine the effect and impact of the different strategies used in the phases as engagement strategies. Section C questions were repeated in all post-tests for consistency of content related to the PT.

4.4.6 Qualitative data collection

The emotional, cognitive, behavioural, and authentic engagement was assessed in the survey in relation to how each of the learning activities associated with using music, context-based inquiry, and computer simulation influenced the answers provided for the relevant questions. The means of collecting qualitative data are semi-structural individual interviews, focus group interviews and worksheets with audio and video recording, a part of the questionnaire reported qualitatively, and lesson observation (Appendix D). The validity and reliability of the interview were ensured (see 4.3.6, 4.4.6, 4.5). Additionally, video recording was authenticated by focusing on participants' engagement and carefully avoiding the inhibiting effect of perceived intrusive use of equipment and personnel, which may lead to bias or participants becoming reserved (Penn-Edwards, 2004).

Two crews as part of the research team were assigned to record (audio and video) the sessions during the intervention, semi-structural individual interviews, focus group interviews. The researcher however recorded the lesson observation. The number of outsiders in a class was regulated due to the COVID-19 pandemic, hence the researcher had to record the lesson(case study). The recordings gave first-hand information of what really happened; how the participants interacted; and how they engaged in the entire intervention and interview process. Video recording allowed the researcher to record and replay the pictures and sound repeatedly. The video recording equipment was in full view, and roles of the two crews were introduced so curiosity, among the participants was diminished, allowing a lapse in time for a return to normal behaviour before commencing recording to overcome any disadvantage, performance and behaviour interruption (Penn-Edwards, 2004). Furthermore, video recordings were considered because, according to Shi *et al.* (2001), it is a reliable communication data that cannot be questioned.

4.4.6.1 Semi-structured interview

A semi-structured individual interview was conducted with six teachers conveniently selected from the participants during the intervention. The interviews took place after the completion of all three phases of the intervention and face-to-face interviewing was preferred. Open-ended questions (such as which aspects and grades will this strategy apply in South African (SA) school curriculum, MU, CB and or CS?).

Furthermore, conversational and dialogic style of interviewing was used to encourage the respondents to participate more actively. Open-ended questions and probes were then used to yield in-depth responses about the participants' experience, perception, opinion and knowledge.

4.4.6.2 Focus group interview

The four focus group interviews took place at the end of each phase. The focus group was a small gathering of 4-6 participants related to the phenomenon of interest and could answer questions (Schreiber & Asner-Self, 2011) on the periodic table, engagement strategies and affordance. The focus group was used to get to what the participants really think about the engagement strategies, enhance engagement in learning the PT and determine the affordances. The focus group experiences of the effectiveness of MU, CB, CS to learn the first twenty elements of the PT, combustion reactions, atoms and molecules. This includes their success, difficulties as well as support and guidance needed.

The focus group generated information on collective views, the meanings behind those views and a rich understanding of participants' experiences and beliefs.

4.4.6.3 Before-after worksheet

The participants completed the before-after worksheets at the end of the intervention. The before-after worksheets were completed before and after the intervention. The same questions were used in both before and after worksheets. The questions were in a table of three parts. Part one was about the effectiveness of using MU, CB, and CS to engage in learning the first twenty elements, part two combustion reaction and part three atoms and molecules.

4.4.6.4 Part of the questionnaire that was reported qualitatively

Questions 5, 6 and 7 from the questionnaire were reported qualitatively. Question 5 responses refer firstly to resources and the purpose of using MU, CB and CS in learning science. Secondly, MU, CB, CS was used to acquire information on cognitive, affective, behaviour, agentic/ authentic (AGAU) engagement, and passion. And lastly, the impact of MU, CB, and CS on studying PT, chemistry, developing a positive attitude towards chemistry, inducing cognitive development and understanding of science knowledge, providing science process skills, bringing interest in a classroom, creating realistic classroom environment and make new information meaningful. Question 6 (short questions) and 7 (multiple choice questions) are content questions on PT related to noble gases, names, symbols, group, period, and atomic numbers of selected elements of PT where participants had to provide the answers.

4.4.6.5 Lesson observation

Lesson observation took place in the case study. The lesson was presented by a teacher who had participated in the workshops. The teacher presented the lesson using music, context-based inquiry, and computer simulations engagement strategies to Grade ten physical science learners at his school. An observation schedule consisted of five themes (A–E), and each theme was measured against certain criteria (see Table 5.19). The data obtained were analysed with thematic methods.

4.4.6.6 Observation

In the observational recording, the camera was focused on specific actions and recorded material was used as database for coding and interpretation. The content of the observation schedule during the intervention focused on the participants reflecting and discussing their opinions, beliefs and values related to using music, context-based inquiry, and computer simulation as learning engagement strategies to learn the PT. During the lesson observation(case study), the teacher's application of MU, CB and CS by and the impact on engagement was observed using the observational schedule and video recording.

4.4.6.7 Summary of the data collection

The logical sequence of both quantitative and qualitative data collection that connects the empirical study to the research questions and to the conclusion is summarized in Figure 4-16 below. The mode of data collection and the methods used to collect the data are also included in Figure 4-16.

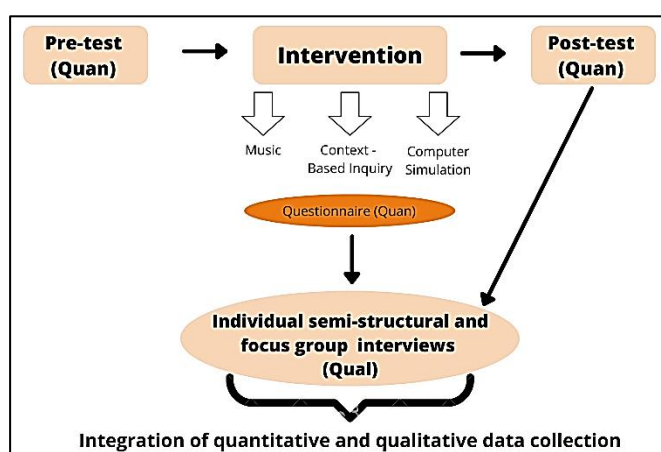


Figure 4-16: Process and mode of data collection (Source: Author's compilation)

In summary, as in Figure 4-16, data was collected with a pre-test given at the workshop, followed by the intervention then the post-test. A focus group interview was administered after the post-test. The individual interviews took place during each phase of the intervention. The questionnaire used to collect quantitative data includes cognitive, behavioural, emotional, and AGAU engagement questions. This consists of 20 questions with 4-point Likert-type scales (strongly disagree, disagree, agree, and strongly agree) per phase.

4.5 DATA ANALYSIS

The responses to the questionnaires, individual interviews, and other information from the focus group interview were the raw data. The data collected were changed into understandable and usable information. This was achieved by analysing the data quantitatively using descriptive and inferential statistics and qualitatively focusing on themes. All of our participants authentic and natural responses and observational data from the focus groups were analysed and interpreted. The ethical process of analysing the data include the following:

- (i) **Data editing and quality control checks:** The data were edited and checked to eliminate numbers that are out of range and data entry errors. Missing data and patterns of response were identified and rectified where necessary. A data set from response to the questionnaire was extracted and an identification (ID) number was assigned to each of the respondents. The ID number was written on the paper questionnaire to link the paper questionnaire to the data. According to Thomas (2004:134), assigning ID numbers to respondents ensure quality control and easy verification to determine whether there has been an error. The ID number also served the purpose to compare pre-test and post-test results.
- (ii) **Dependability and reliability:** The research process was consistent with enough information provided in a logical, traceable, and documentable to the reader (Schreiber & Asner-Self, 2011). The arguments were based on the reported results which were grounded on the statistical analysis.
- (iii) **Neutrality:** The criteria and methodological procedure described in previous sections resulted in a neutral investigation because of the high degree of detail and procedural clarity provided.

Each phase consisted of quantitative and qualitative data, which were collected separately. The validity applied in the study involved addressing potential issues such as bias in data collection, data analysis and merging qualitative and quantitative strands (Creswell, 2011:417) through data and method triangulation and content evaluation.

4.5.1 Quantitative Data analysis

The Statistical Consultation Services at the North-West University analysed the results using descriptive statistics to summarise and analyse the questionnaire responses. The purpose for the quantitative data being descriptive is to determine the impact of MU, CB and CS on the four components of engagement (behavioural, emotional, cognitive, and authentic engagement) in learning the names, symbols, and basic concepts of the first twenty elements of the PT and possible correlations (Leedy & Ormrod, 2010:182).

A measure of the number of occurrences of the pre-test and post-test score in a given set of data was determined and displayed on frequency tables (see section 5.3.1).

4.5.1.1 Reliability and Validity

The reliability of the pre and post-tests refer to the consistency of scores obtained by the same participants when the same test was taken at different workshops and the ability of the instrument to yield the same results over various tests, test-retest consistency (Anastasi & Urbina, 1997:84) and internal consistency across items. The instrument reliability was statistically evaluated with the aid of Cronbach Alpha coefficients, while factor analysis statistically determined the validity (section 5.4).

4.5.1.2 Factor analysis

Construct validity is relevant for the intervention, where group construct was measured using the pre-test, then the construct was taught and measured again, using the post-test. The same constructs in the pre-test were used to test for reliability, using factor analysis Kaiser's measure of sample adequacy (MSA) to determine the appropriateness of the data in terms of factor analysis, including determining factors retained by the Mineigen criterion.

4.5.1.3 Cohen effect size d

Cohen's effect size d for dependent groups was calculated to determine if practical significant differences between the pre- and post-tests results existed (see section 5.5.2). Dependant groups were used to compare the means of the constructs (Cohen, 1988) before and after the interventions. The pre-test and post-test results for each engagement component assessed for the different intervention strategies (MU,CB and CS) were the two matched groups. Since random sampling was not done, Cohen effect sizes (d) was used to indicate whether practical significance was achieved (Steyn & Ellis, 2003; Cohen, 1988). P-values yielding by t-tests for dependent groups were determined for completeness.

4.5.1.4 Comparing differences between pre-test and post-test

The effect of differences between the means scores obtained from matched groups were confirmed with a Paired T-test. This test was conducted between paired values (pre- and post-test results for each intervention strategy as well as pre- and post-test results for each engagement component).

The paired T-test was used to test differences between the means of the two matched groups. If the p-value is smaller than 0.0001, the pre and post scores differ statistically significantly at a 99% confidence level (section 5.5.1).

4.5.2 Qualitative data analysis

Thematic analysis was the systematic method used to identify, organise, and record patterns in the given data set, for easy grouping of themes and sub themes. The inductive approach applied allowed the determination of the themes from the data (Creswell & Creswell, 2017:193–198; Nowell *et al.*, 2017:4). The data was analysed and reported (sections 5.6.3 and 5.6.4).

The themes identified and reported had enough data accrued from the qualitative section of the questionnaire, worksheets, observation sheets, video recordings, focus groups and individual interviews (see 5.6.2, 5.6.4 5.6.5 5.6.4.1 for the themes and subthemes).

Step1: Familiarized responses

The researcher familiarized herself with the responses written or spoken by the participants. The researcher read, listened and reflected on the responses written and spoken by the participants several times and reflected on the overall meaning.

Step 2: Created initial codes

Certain phrases and sentences from the responses were highlighted, and codes were generated to describe the content.

Step 3: Organise codes with supporting data

The codes identified were checked and grouped.

Step 4: Group codes into themes

Themes were named and clearly defined in order to understand the data collected. This was done by formulating exactly what each theme meant and the themes were broader than the codes.

Step 5: Review and revise themes

Identified patterns among the created codes and themes were reviewed to ensure that they represented the original data collected.

The final step was writing up the thematic analysis narrative that had been compiled. This was done by representing the description and themes using tables and figures (section 5.5).

In summary, the content of the data collected derived codes which closely match the content. Description and themes were generated from the codes and these themes appear as major findings in qualitative analysis. An inductive approach to data coding and analysis was predominantly used (Braun & Clarke, 2012:57).

4.5.2.1 Qualitative data analysis of before-after worksheets

Before-after worksheets with open ended questions were analysed by determining the rate at which participants indicated the effectiveness of MU, CB and CS in aiding their learning of the content of PT (Appendix D). These open-ended questions were used as a follow-up for a deeper understanding of the participants' perception of affordances of the engagement strategies and a greater understanding of their reasoning (Fontana & Frey, 2008:129).

4.5.2.2 Qualitative data analysis of interviews

After reviewing the worksheets and questions 5,6 and 7 responses it was realised that some of the questions had not been clearly answered by the participants. Therefore, a few of the questions in the worksheet and questionnaire that were important for the analysis, were added to the interview. The thematic analysis procedure outlined in section 4.5.2 was applied.

The themes (section 5.6.2) were reported and submitted at the 2021 SAIP conference (SAIP-South Africa Institute of Physics). Identification of other themes are elaborated in section 5.6.3 and 5.6.4.

4.5.2.3 Analysis of qualitative data obtained from the questionnaire

The post-test questionnaire (Appendix D), consisting of qualitative questions 5, 6 and 7 responses were analysed qualitatively (see section 5.6.3) by counting the frequency of codes, the coded responses which were the answers to questions 6 and 7 and responses to question 5.

4.5.2.4 Analysis of observation, interview, focus group

A combined thematic analysis was conducted for the worksheet, interview, focus group, open ended questionnaire questions and observation data. The transcribed responses were read several times. For each response, codes were identified and, from the codes, themes and sub themes were generated. Hence, an inductive approach was taken for the analysis of the responses. The procedures and steps taken for the thematic analysis were the same as outlined in the qualitative analysis (see section 4.5.2) hence, it is not described here.

4.5.2.5 Analysis of lesson observation

An observation schedule was used to observe the lesson. The same thematic analysis procedure explained in section 4.5.2 was applied.

The quantitative data collection and analysis were expressed in numbers and more objective, while the qualitative data collection and analysis was expressed in words, more subjective (Dahlberg & McCaig, 2010:22-23; Taylor, Trumbull & Watson, 2010:164). Notably stated, quantitative research reaffirms the objectivity and reliability of the study (Teddle & Tashakkori, 2009:209). On the other hand, the use of participants' actual words makes a qualitative approach to claim in-depth meaning and understanding of the context (Creswell, 2012:238; Okeke & van Wyke, 2015:209).

4.6 ETHICAL CONSIDERATIONS

Consent: During each data collection section, consent was reconfirmed to the participants and the fact that participation was entirely voluntary and withdrawal from the study at any time, without being penalised in any way, was emphasised. Informed consent form was completed by the teachers who volunteered, parents and learners of the schools for class visit and observation.

Permission was obtained from the Department of Education, the school principals of participating teachers. Samples of the letters without school details are attached (Appendix B). Goodwill permission letters for principals of schools and chairs of school governing bodies on an official NWU letterhead as attached (Appendix B) was sent, and approval (Appendix C) was received before commencing with the research.

Attendance: The teachers attended the workshop voluntarily and freely applied the strategies in their class. There was no monetary implication.

The safety of the teachers was assured by adhering to the safety precaution, rules and guidelines of the North West University at the workshops and throughout the intervention and entire research process where the workshops took place.

Privacy and confidentiality: No names of individuals, schools, districts, provinces, and participants will be mentioned in the disseminating the results.

There is no conflict of interest, and we do not anticipate any conflict of interest. The researcher's school, learners, personal relations are NOT involved in the study.

4.7 SUMMARY

The pragmatic research design emphasises the importance of how, when, and why the empirical study was done. The study described the problem, analysed the causes and developed an alternative solution for the problem. The pragmatic paradigm thus utilized suggestions that informed the researcher concerning how to create preferred realities.

The study utilised the teachers' evolvement of meaning developed and experienced based on their points of view and experiences before, during and after the intervention. This included suggestions received on construction, developing, implementing and evaluating the intervention using the learning engagement strategies. In the implementation stage, reasons for the intervention and why it works was taken into consideration when the designed intervention was modified for each phase to the specific context of application. This was to ensure the impact of the intervention using music, context-based inquiry, and computer simulations, as learning engagement strategy was amplified.

The current study focused on the impact of MU, CB, CS on the four components of engagement (affective, cognitive, behavioural, and authentic engagements) in learning the PT was determined quantitatively.

Mixed Method was used to collect data to evaluate the implementation of the interventions. Data collection entailed gathering quantitative (QUAN) data with the aid of a questionnaire supported by qualitative (QUAL) data collection using video recordings, semi-structured interviews, focus groups and lesson observation.

The quantitative and qualitative methods for collecting, analysing, and linking data in the present study are important because they provide insight that a single method cannot provide, thus strengthening the study (Teddle & Tashakkori, 2010). A detailed discussion of the results and analysis is delineated in chapters five and six.

CHAPTER 5 RESULTS

5.1 INTRODUCTION

The previous chapters entail discussions on literature study, theoretical background, methodology and design of the research study. Chapter 5 of the thesis focuses on presenting and discussing the data and results of the empirical study. The data was collected through questionnaires, worksheets, individual interviews, observation, and focus group interviews completed during the interventions. The case study, a class observation took place after interventions and interviews.

The quantitative data addressed research questions 1, 2,3, while research questions 4 and 5 required triangulating the qualitative and quantitative data to determine the guidelines and affordances of the engagement strategies.

The sections of the chapter are in the following order: Section (5.1) the introduction; Section (5.2) provide demographic information; section (5.3) outline the descriptive statistics; section (5.4) describe the reliability and validity of the constructs; section (5.5) deals with the inferential statistics; sections (5.6) explain the qualitative data; while section (5.7) provides a summary of the chapter and remarks related to the study.

5.2 DEMOGRAPHIC INFORMATION

The demographic information represents all the teacher participants. The participants were science teachers from grades 4-9 (GET) and 10-12 (FET). The information was obtained from Section A of the pre-test questionnaire (Appendix D) which was completed before the intervention workshops.

5.2.1 Gender

Figure 5-1 indicates the gender distribution. It clearly shows the percentage of female and male participants.

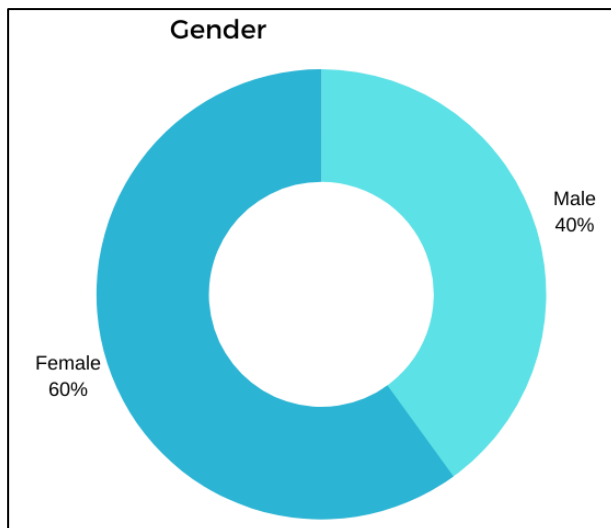


Figure 5-1: Gender of participants

The pie chart shows that 60.0% of the respondents were female and 40.0% were male. Both genders were well represented in this study. There were 0.0% other, this means none of the participants indicated a preference for any other sexual orientation except female and male.

5.2.2 Age

Figure 5-2 is a graph showing the age of the participants involved in the study.

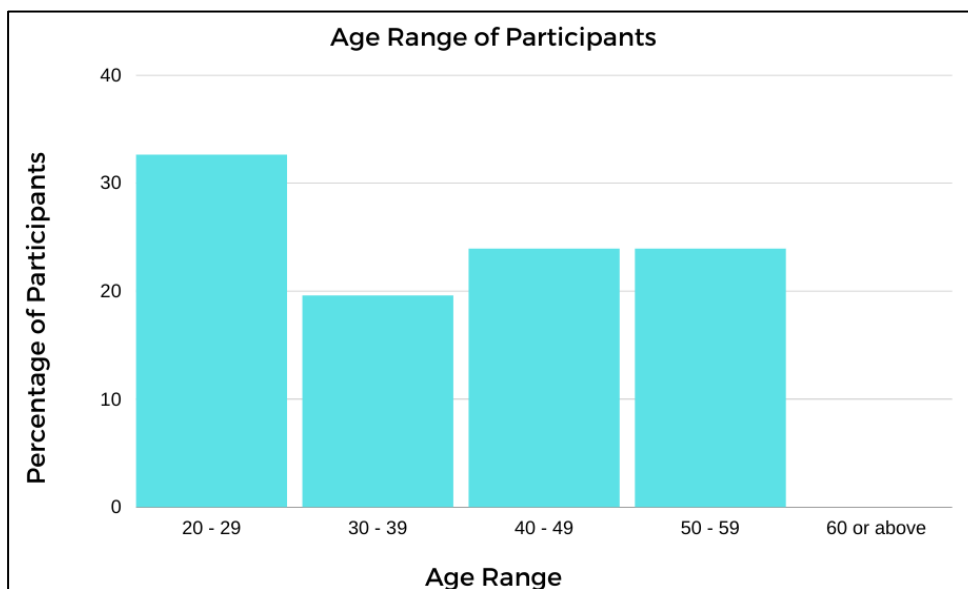


Figure 5-2: Age range of participants

The most significant percentage (32.6 %) of participants at the workshops were aged between 20 and 29 years. The graph shows that 23.9% of the participants were between 40 and 49 years. Participants aged 50 to 59 years also represent 23.9 % of the population. It is clear that the intervention workshop attracted both young and relatively older participants.

5.2.3 Educational qualification

Figure 5.3 shows the participants academic qualification

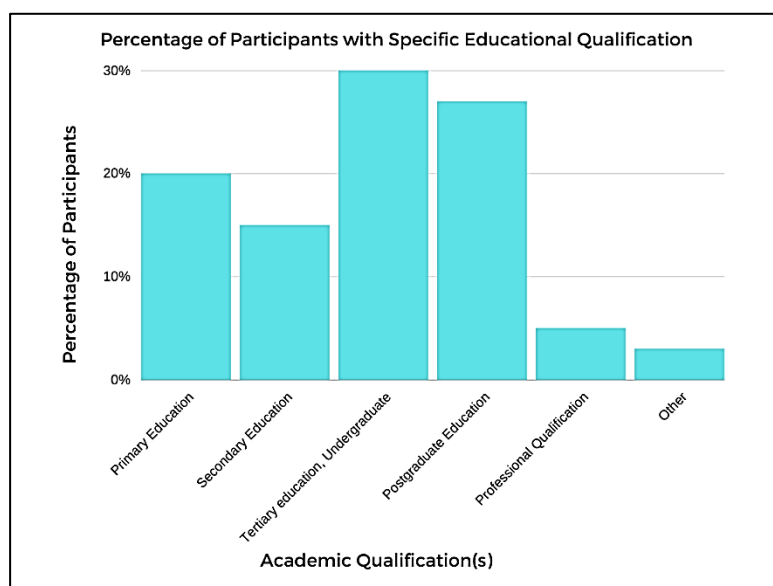


Figure 5-3: Academic qualification of participants

The graph indicates that 30.0% of the participants have obtained undergraduate tertiary education while 27.0% had postgraduate qualification. The graph indicates that 20.0% specialised in primary education with only 15.0% specialising in secondary education. However, a total of 8.0% was made up of respondents with other non-teaching and professional qualifications before joining education.

Participants that studied for a degree before pursuing a professional educational qualification accounted for 5.0%. A total of 65% plus 5%(70%) had obtained a professional educational qualification from a college of education or university with specialisation in a science subject as indicated in 5.2.4.

5.2.4 Major subjects of participants

Figure 5.4 gives a picture of the major subjects offered by the participants

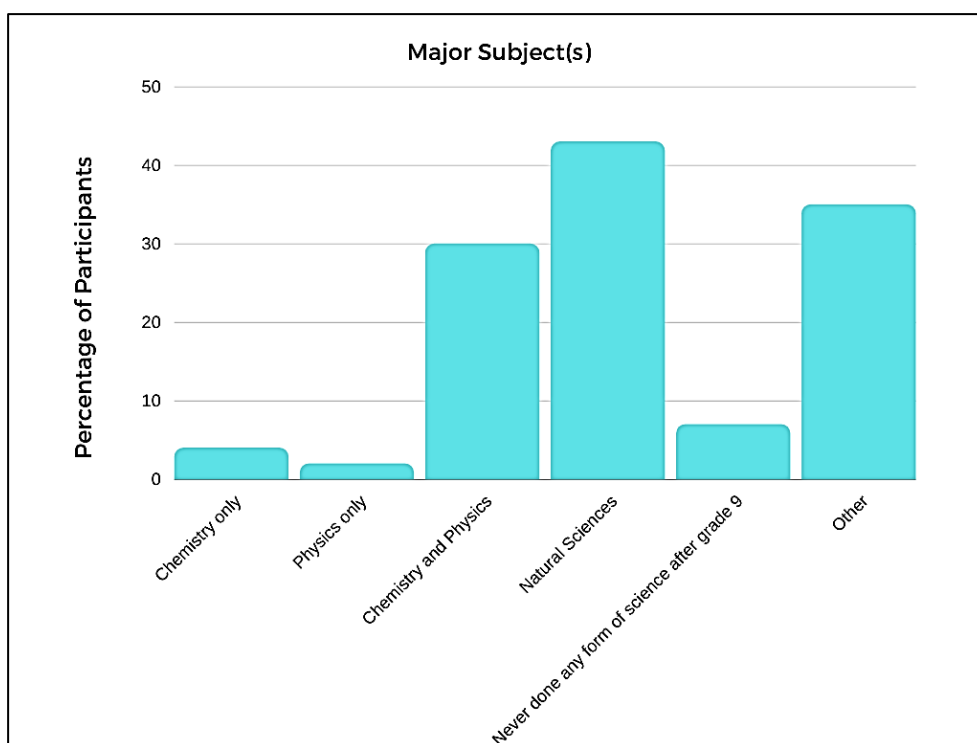


Figure 5-4: Major subject(s)

According to Figure 5-4, 7.0% of participants did not study (after grade 9) any of the subjects listed on the graph as a major. Chemistry and physics were offered by 30.0% of the participants, while 43.0% had natural sciences as their major subjects. The remaining 35.0% of the participants had other related science subjects as major.

5.2.5 Subjects offering (teaching) at current school

Figure 5.5 represent the percentage of the participants that are currently teaching natural sciences and physical sciences.

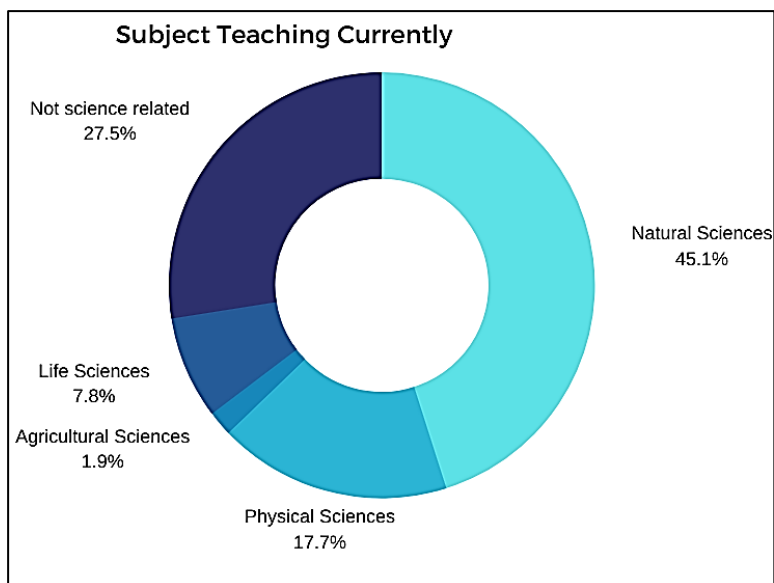


Figure 5-5: Subject participants are currently teaching

According to Figure 5-5, there were 45.1% of the participants teaching natural sciences and 17.7% physical sciences at the time of the study. This amounts to a total of 63.8%. However, 27.5% do not teach any of the sciences indicated in Figure 5-5 at the time of the study even though they were science teachers.

5.2.6 Aspects of natural sciences I like best.

Regarding Figure 5-6, out of the 63.8% of participants teaching physical sciences and natural sciences, only 17.0% liked chemistry (called matter and material in natural sciences). A percentage of 23.4% liked physics (called energy and change in natural sciences). The largest percentage, 40.0%, liked Life Sciences (also called life and living) best.

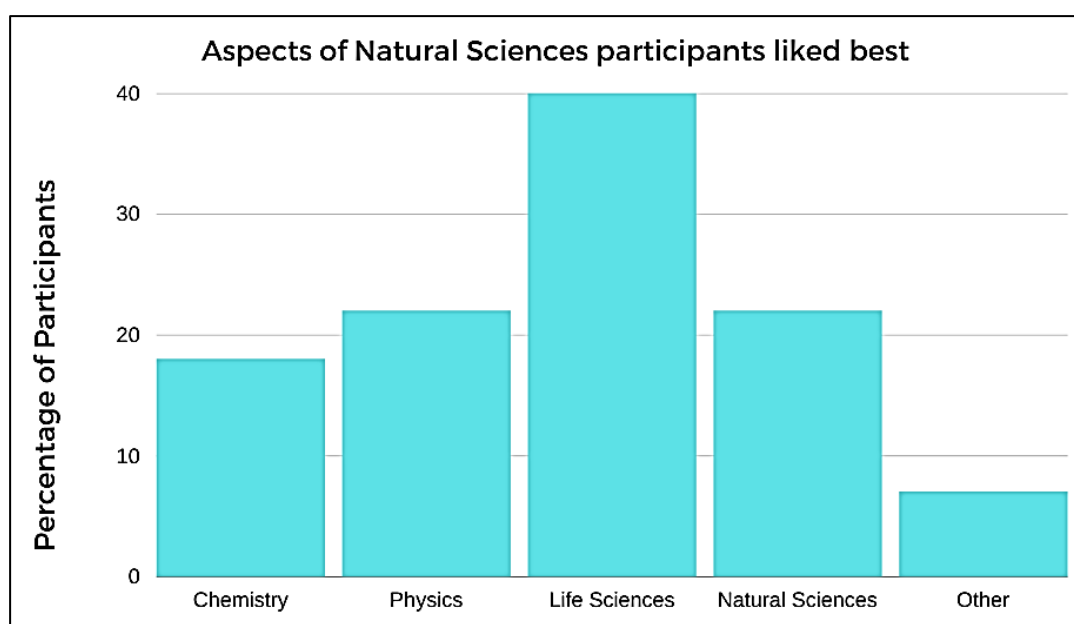


Figure 5-6: Natural Sciences enjoyed most by participants

In summary, the biographical data indicated that the larger percentages of the participants were females, were young (in the age group between 20 and 30), had tertiary education in natural or physical sciences and are currently teaching natural sciences and physical sciences.

5.3 DESCRIPTIVE STATISTICS OF QUANTITATIVE RESULTS

Descriptive statistics was used to describe the basic features of the data to provide simple summaries about the constructs. Together with simple graphics analysis as in section 5.3.1, they form part of the quantitative analysis of the study. The two sets of questionnaires (pre-test and post-test) contained questions relevant to Phase 1 (MU), Phase 2 (CB), and Phase 3 (CS). The perceptions of the participants regarding the effect of each engagement strategy on the four components of engagement (cognitive, affective, behaviour and authentic) were determined. Authentic in the tables represent agentic/authentic (AGAU). Authentic is used because it looks neater in the tables.

Section 5.3.1 reports on the pre- and post-test questionnaire results of Section A, questions 1, 2, 3 and 4.

5.3.1 Comparison of the frequencies in the pre- and post-tests

Table 5-1 summarises the average responses of the teachers before and after the intervention and this is summarised as percentage frequencies for each engagement strategy. The results indicate the effect that music (MU), context-base inquiry (CB) and computer simulation (CS) had

on the perceptions of teachers on the four components of engagement (cognitive, affective, behaviour and authentic (AGAU).

Likert scales consisted of a statement and four options, namely option 1 totally disagree, 2 disagree, 3 agree, and 4 totally agree. In Table 5-1, the percentages obtained for the selected options are given for each phase and engagement component in both the pre- and post-tests. For clarity and to simplify further processing, options 1 and 2 (totally disagree and disagree) were combined and represented by DAG. In contrast, a combination of options 3 and 4 (agree and totally agree) is represented by AG, which signifies agreement.

Table 5-1 the overall average percentages are calculated in the last row to illustrate the average percentage obtained in the pre- and post-tests for all three strategies on engagement components.

Table 5-1: The overall average percentages

CONSTRUCTS	PRE-TEST						POST-TEST					
PHASE 1 Music (MU):	Totally disagree	Do not agree	Total	Agree	Totally agree	Total	Totally disagree	Do not agree	Total	Agree	Totally agree	Total
MU: Cognitive	2.00%	10.00%	12.00%	58.00%	30.00%	88.00%	0.00%	2.00%	2.00%	43.00%	55.00%	98.00%
MU: Affective	0.00%	10.00%	10.00%	48.00%	42.00%	90.00%	0.00%	8.00%	8.00%	41.00%	51.00%	92.00%
MU: Behaviour	3.00%	10.00%	13.00%	61.00%	26.00%	87.00%	0.50%	6.00%	6.50%	37.00%	56.50%	93.50%
MU: Authentic	0.40%	6.00%	6.40%	53.00%	40.60%	93.60%	0.00%	7.00%	7.00%	44.00%	49.00%	93.00%
PHASE 2 Context-based (CB):	Totally disagree	Do not agree	Total	Agree	Totally agree	Total	Totally disagree	Do not agree	Total	Agree	Totally agree	Total
CB: Cognitive	0.00%	5.00%	5.00%	42.00%	53.00%	95.00%	5.00%	0.00%	5.00%	45.00%	50.00%	95.00%
CB: Affective	0.00%	6.00%	6.00%	62.00%	32.00%	94.00%	3.00%	0.00%	3.00%	54.00%	43.00%	97.00%
CB: Behaviour	0.40%	4.00%	4.40%	50.00%	46.00%	96.00%	4.00%	2.00%	6.00%	41.00%	53.00%	94.00%
CB: Authentic	0.00%	4.00%	4.00%	58.00%	38.00%	96.00%	3.00%	1.00%	4.00%	53.00%	43.00%	96.00%
PHASE 3 Computer simulation (CS):	Totally disagree	Do not agree	Total	Agree	Totally agree	Total	Totally disagree	Do not agree	Total	Agree	Totally agree	Total
CS: Cognitive	0.40%	4.00%	4.40%	43.60%	52.00%	95.60%	0.00%	0.60%	0.60%	25.40%	74.00%	99.40%
CS: Affective	0.00%	6.00%	6.00%	53.00%	41.00%	94.00%	1.00%	3.00%	4.00%	38.00%	58.00%	96.00%
CS: Behaviour	0.00%	2.00%	2.00%	55.00%	43.00%	98.00%	2.00%	3.00%	5.00%	36.00%	59.00%	95.00%
CS: Authentic	0.40%	8.00%	8.40%	54.60%	37.00%	91.60%	1.00%	4.00%	5.00%	43.00%	52.00%	95%
Total	6.60	74.60	81.20	649.20	480.60	1118.80	19.50	36.60	56.10	500.40	643.50	1144.00
Average%	0.55	6.22	6.77	54.10	40.05	94.15	1.63	3.05	4.68	41.70	53.63	95.33

The high AG values already obtained in the pre-test suggested that participants had high expectations that the strategies would effectively engage them. It seems as if their expectations for music were lower than for the other two strategies. Context-based inquiry yielded about the same percentages for the four engagement components in the pre-test, while the percentages for computer simulations show more variation.

In general, it seems as if the post-test percentages were higher than the pre-test percentages, but not in all cases. These results are discussed in more detail below.

The graph in Figure 5-7 shows the overall percentage averages of AG and DAG before and after the intervention. The Total AG values (overall percentage of participants who agreed or totally agreed with the statements) are compared to the Total DAG (overall percentage of participants who disagreed or totally disagreed).

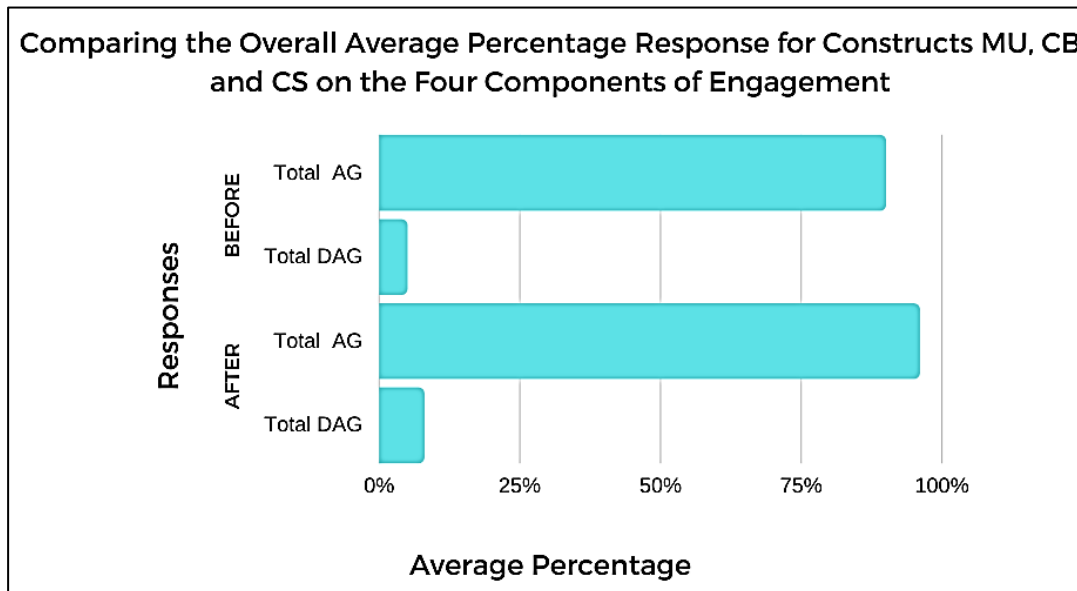


Figure 5-7: Overall percentage averages

The overall percentage averages indicate a shift from disagreeing(DAG) to agreeing(AG) after the intervention, with a percentage shift of about 1.2% towards AG due to the interventions. This can be interpreted as a general positive impact of MU, CB, CS (MUCBCS) on cognitive, affective, behaviour and authentic engagement.

The results in Table 5-1 and Figure 5-7 are now discussed under (1) phase 1:Music, (2) phase 2:context-based inquiry, and (3) phase 3:computer simulation.

(i) PHASE 1: MUSIC (MU)

Figure 5-8 compares the pre and post-test frequency results of music(MU) as summarised in Table 5-2, followed by the discussion of phase 1 results.

Twelve percent of the participants disagreed and strongly disagree (DAG) that music will have a positive impact on the four components of engagement while 88% agreed and strongly agreed (AG) before the intervention. After the intervention, DAG presented 2.0%, and AG increased to 98.0% (Table 5-1). This implies that MU positively impacted on cognitive engagement, as illustrated in Figure 5-8.

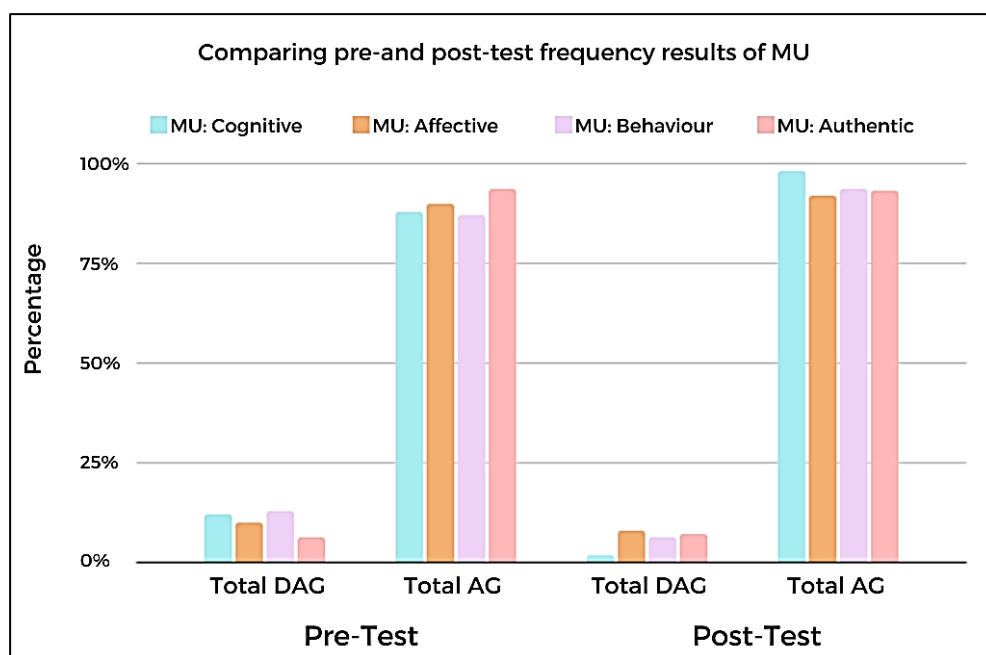


Figure 5-8: Comparing pre-and post-test frequency results of MU

The graph in Figure 5-8 shows that authentic engagement has the highest AG before intervention and cognitive engagement the highest after the intervention. However, both of these components, as well as behavioural engagement experienced increases in AG due to the intervention. The authentic results show AG's slight decline (0.6%) after the intervention. This implies that MU did not have a major positive impact on the authentic engagement after the intervention. This might be due to the perceptions of the participants that music cannot help learners very much to make connections between subjects and reflect on learning. Table 5-2 summarises the results of phase 1.

Table 5-2: Summarised results of Phase 1: MUSIC

Constructs	Impact	
	AG	DAG
Components of engagement		
MUSIC: Cognitive	Increased	Decreased
MUSIC: Affective	Increased	Decreased
MUSIC: Behaviour	Increased	Decreased
MUSIC: Authentic	Decreased	Increased

(ii) PHASE 2: CONTEXT-BASED INQUIRY (CB)

There was no percentage increase on participants' cognitive engagement perceptions after using context-based inquiry as strategy in the intervention. However, the high percentage in both the pre- and post-tests (as shown on Table 5-1 and Figure 5-9) indicates that the participants acknowledge that context-based inquiry would positively impact on cognitive engagement even though perception before and after did not change.

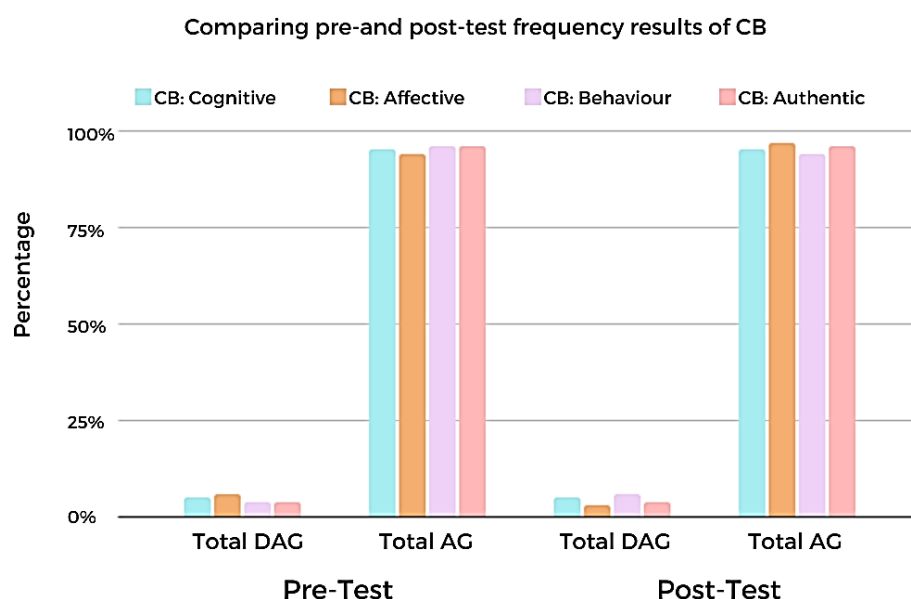


Figure 5-9: Comparing pre-and post-test frequency results of CB

The results reported in Table 5-1 and Figure 5-9, context-based inquiry had a positive impact on the affective engagement as it saw an increase in AG after the intervention. However, behavioural engagement results revealed a slight decline in AG after the intervention. But no major effect was perceived for authentic because 96% of participants indicated that context-based inquiry will have a positive impact on authentic engagement both before and after the intervention Table 5-3 is a summary of context-based inquiry (CB) results.

Table 5-3: Summarised results of Phase 2: CONTEXT-BASED INQUIRY

Constructs	Impact	
	AG	DAG
Components of engagement	AG	DAG
CONTEXT-BASED INQUIRY: Cognitive	Same - No Change	Same - No Change
CONTEXT-BASED INQUIRY: Affective	Increased	Decreased
CONTEXT-BASED INQUIRY: Behaviour	Decreased	Increased
CONTEXT-BASED INQUIRY: Authentic	No change	No change

(iii) PHASE 3: COMPUTER SIMULATION

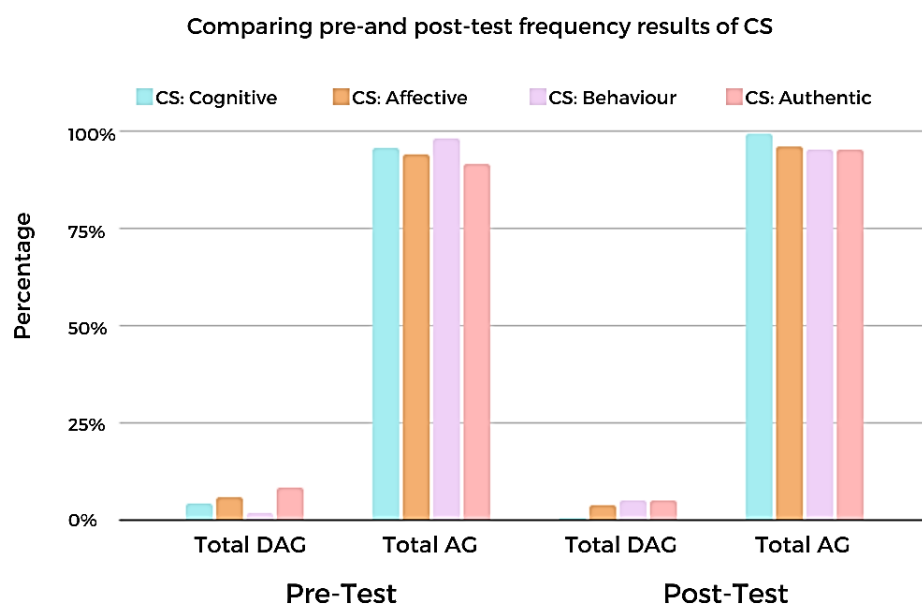


Figure 5-10: Comparing pre-and post-test frequency results of CS

The results captured in Table 5.1 and Figure 5.10 compare the pre and post-test frequency results of computer simulations. The overall percentage of AG on all four engagement components increased from 94.2% to 95.3%.

After the intervention cognitive percentage of AG increased from 95.6% to 99.4%. The increase of AG after the intervention implies that CS had a positive impact on cognitive engagement.

Results of affective engagement from participants' responses disclosed that CS had a positive impact, AG, increasing from 94% to 96% after the intervention. Contrary to these increases, AG results of behaviour engagement decreased from 98% to 95%. AG declined after the intervention implies that the intervention lowered teachers' perceptions of CS as contributing to behavioural engagement. Although there was a decline in behavioural engagement, 95% towards agreement is still relatively high. Participants that disclosed that CS will have a positive impact on authentic engagement increased from 91.6% to 95% after the intervention.

In summary, the effect (increase or decrease from pre- to post-test) that the intervention had on the percentage frequencies of participants who agreed (AG) or disagreed (DAG) with the statements are given in Table 5-4 for visualisation of the results at a glance.

Table 5-4: Summarised results of Phase 3: COMPUTER SIMULATION

Constructs	Impact	
	AG	DAG
Components of engagement		
COMPUTER SIMULATION: Cognitive	Increased	Decreased
COMPUTER SIMULATION: Affective	Increased	Decreased
COMPUTER SIMULATION: Behaviour	Decreased	Increased
COMPUTER SIMULATION: Authentic	Increased	Decreased

The perception that CS will enhance cognitive, affective, and authentic engagement reflected an increase in AG but slightly decreased for behaviour engagement. However, the percentage of AG after the intervention for each engagement is above 90%, therefore we can conclude that CS impacted positively on cognitive, affective, and authentic engagement.

The average summary of the impact of MUCBCS on the four components of engagement is displayed in Table 5-5.

Table 5-5: The total average impact of MUCBCS on the four components

Component of engagement	AG	DAG
Cognitive	Increase	Decrease
Affective	Increase	Decrease
Behaviour	Increase	Decrease
Authentic	No change	No change

There is an increase towards AG for cognitive, affective and behaviour engagement and a decrease in authentic. Although authentic shows a decrease after the intervention, nevertheless it is above 90%. Therefore, we can conclude that MUCBCS enhance cognitive, affective, behaviour and authentic engagement.

The frequency tables indicated trends in the data, for example, whether the participants' perceptions about the strategies increased or decreased after the intervention. The impact of the intervention was quantified with the aid of statistical processing, as mentioned in chapter 4.

While this section (5.3.1) has considered the pre- and post-test frequencies in terms of the engagement strategies, the following sections (5.3.2 to 5.3.5) discuss the results of the

intervention with reference to the components of engagement, starting with cognitive engagement in section 5.3.2.

5.3.2 The impact of intervention on Cognitive engagement

Section B of the pre-test and post-test questionnaires consists of four questions. Each question dealt with one of the engagement components. For example, participants' perceptions on cognitive engagement were probed in Question 1 on MU, CB and CS. All Question 2's focused on affective engagement, Question 3 on behavioural engagement and Question 4 on authentic engagement. Each question comprised of five statements that the participants had to evaluate. The five statements concerning an engagement component on one strategy differed from those of the other strategies due to the different subject content the strategy was applied to. Still, corresponding statements were given. In total, eight aspects were assessed related to each engagement component. The results are given in Tables 5-6 to 5-9 in which the symbols C, Af, B and Au represent cognitive, affective, behaviour and authentic engagement respectively.

Table 5-6 is a summary of aspects assessed on the cognitive component of engagement (i.e. in question 1 from phases 1, 2 and 3). Aspects C1 to C8 are the 15 corresponding aspects on cognitive engagement assessed in the three phases fused into the eight items C1 to C8. A dash represents where there was no common item for MU, CB or CS.

Table 5-6: Cognitive frequency results

CONSTRUCT ITEMS		PRE-TEST						POST-TEST					
		DAG %			AG %			DAG %			AG %		
Item		MU	CB	CS	MU	CB	CS	MU	CB	CS	MU	CB	CS
C1- Learning Scientific concepts	Cognitive Engagement	5.00%	0.00%	7.00%	95.00%	100.00%	93.00%	0.00%	2.00%	0.00%	100.00%	98.00%	100.00%
C2- Problem solving		-	-	9.00%	-	-	91.00%	-	-	0.00%	-	-	100.00%
C3 - Relationship and conceptual understanding		9.00%	0.00%	2.00%	91.00%	100.00%	98.00%	3.00%	3.00%	3.00%	97.00%	97.00%	97.00%
C4- Connecting and integrating knowledge		9.00%	5.00%	-	91.00%	95.00%	-	5.00%	6.00%	-	95.00%	94.00%	-
C5- Everyday life application (transfer of knowledge and Skills)		7.00%	5.00%	0.00%	93.00%	95.00%	100.00%	17.00%	6.00%	0.00%	83.00%	94.00%	100.00%
C6- Master and visualize concepts		0.00%	9.00%	2.00%	100.00%	91.00%	98.00%	0.00%	2.00%	0.00%	100.00%	98.00%	100.00%
C7- Master content knowledge and skills		-	7.00%	0.00%	-	93.00%	100.00%	-	3.00%	0.00%	-	97.00%	100.00%
C8- Active constructing of own knowledge		0.00%	9.00%	0.00%	0.00%	91.00%	0.00%	21%	6.00%	12.00%	79.00%	94.00%	88.00%

C1- Learning Scientific concepts

According to Table 5-6, after the intervention, AG increased to 100.0% for MU, 100.0% CS, with a 2.0% decline for CB at 98.0%. Even though there was a decrease after the intervention with a high percentage of 98.0%, one can conveniently infer that using CB also promotes learning of scientific concepts. This implies that the teacher participants perceived that using MU, CB, and CS as engagement strategies aid in learning scientific concepts, names and symbols of the PT elements, atomic and mass numbers.

C2- Problem solving

Before the intervention, 91.0% of participants considered CS as a useful learning strategy to meaningfully engaged learners to solve problems. The rise of AG after the intervention implies that CS is considered a useful strategy for learners to engage in science problem solving in a meaningful manner that is not possible with a traditional classroom setting. There were no questions on the questionnaire under MU and CB that pointed directly to the item problem solving hence the symbol – (dash) on the table.

C3- Relational and conceptual understanding

The percentage of AG before and after is above 90.0%. A high percentage of participants, 91.0% initially perceived that the use of music as a strategy could enhance learners conceptional and relational understanding. After implementing engagement strategies, the results indicated an increase in AG of 6.0% for MU, while both CB and CS resulted in a decrease of 3.0% and 1.0% respectively. However, with the high percentages above 90.0%, it can be concluded that MUCBCS is useful for learners to understand concepts of PT and relationship between the names, symbols, atomic number, atomic mass and application of Mg, Li, P,S,C,O, and H to everyday life experience.

C4- Connecting and integrating knowledge

MU showed a 4.0% increase, CB decreased by 1.0% after the engagement strategies were implemented. Another dash (-) where no question on the questionnaire was under CS that pointed directly to the item connecting and integrating knowledge. Thus, indicating that MU and CB provided the opportunity to integrate theory and practice and to connect knowledge between subjects.

C5- Everyday life application (Transfer of knowledge and skills)

With regard to everyday life applications, the expectations regarding MU decreased by 10.0% and CB by 1.0%. CS remained 100.0% before and after implementing the engagement strategies. Therefore, CB and CS strategies can be used to transfer scientific knowledge and skills effectively. These results align with the findings of (Alexe, 2013; Rackaway & Goertzen, 2008) as stated in section 3.4.4, that computer simulation(CS) enhances the transfer of knowledge, skills, and abilities from the classroom to real-world environment by relating to everyday life.

C6- Master and visualise concepts

The use of the engagement strategies CB, and CS enhance learners' ability to master scientific content and visualise abstract concepts and MU only enhanced mastering scientific concepts. This assumption is based on the result that there was an increase of AG from 93.0% to 97.0%

for CB. AG from 98.0% to 100.0% for CS, while MU remained 100.0% for mastering scientific concepts and not for visualising abstract concepts.

C7- Master content knowledge and skills

CB and CS engagement strategies could be used to improve skills to master content, knowledge and skills as AG for CB and CS were 97.0% and 100.0%, respectively, after implementing the engagement strategies. Another dash (-) where no question on the questionnaire was under MU that pointed directly to the item master content knowledge, and skills.

C8- Active constructing of own knowledge

The teacher's perception was that MU, CB, and CS can fairly be used to assist learners to actively construct their own knowledge considering the post-test results of MU 79.0%, CB 94.0%, and CS 88.0%.

5.3.3 The impact of intervention on Affective engagement

The symbol Af represents affective engagement, question two of phases 1, 2 and 3 of the questionnaires.

Table 5-7 is a summary of the combined question 2 items from phases 1, 2 and 3. Af1 to Af8 refer to corresponding aspects assessed in the three phases regarding affective engagement.

Table 5-7: Affective frequency results

CONSTRUCT ITEM		PRE-TEST						POST-TEST					
		DAG %			AG %			DAG %			AG %		
Item		MU	CB	CS	MU	CB	CS	MU	CB	CS	MU	CB	CS
Af1 -Interest	Affective engagement	7.00%	4.00%	5.00%	93.00%	96.00%	95.00%	9.00%	3.00%	3.00%	91.00%	97.00%	97.00%
Af2 -Class climate		4.00%	4.00%	2.00%	96.00%	96.00%	98.00%	3.00%	3.00%	0.00%	97.00%	97.00%	100.00%
Af3 - Passion		9.00%	0.00%	11.00%	91.00%	0.00%	89.00%	6.00%	3.00%	8.00%	94.00%	97.00%	92.00%
Af4- Enjoyment		7.00%	5.00%	4.00%	93.00%	95.00%	96.00%	11.00%	2.00%	3.00%	89.00%	98.00%	97.00%
Af5- Satisfaction, easier to learn and understand abstract concepts		0.00%	700.00%	4.00%	0.00%	93.00%	96.00%	14.00%	3.00%	0.00%	84.00%	97.00%	100.00%
Af6- Belief and values (self-perception)		0.00%	9.00%	7.00%	0.00%	91.00%	93.00%	14.00%	2.00%	14.00%	86.00%	98.00%	86.00%
Af7- Interesting and easier learning		7.00%	19.00%	11.00%	93.00%	81.00%	89.00%	18.00%	3.00%	3.00%	82.00%	97.00%	97.00%
AF8- Concentration		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.80%	5.40%	5.40%	95.20%	94.60%	94.60%

Af1- Interest

There was a decrease of 2.0% in MU, while CB and CS saw an increase of 1.0% and 2.0%, respectively, after applying the learning engagement strategies. The high percentages in the pre-

and post-tests (above 90 %) for all the three strategies indicate an interest in using MU, CB, and CS to arouse interest when learning about the PT.

Af2- Class climate

MU, CB, and CS created a pleasant class climate and a friendly working climate and thus, creating a conducive class environment as per the results moving towards higher percentages from the pre- to the post-test for MU(96-97%); CB (96-97%) and CS (98-100%). This implies that MUCBCS improved the class climate by creating a more pleasant and friendly working environment.

Af3- Passion

The participants indicated that they are satisfied enough to develop passion for science using MUCBCS. The results show that the use of MU, CB and CS can create and develop passion for science, chemistry, and pursue careers in the field of chemistry.

Af4- Enjoyment

The use of CB, and CS as learning engagement strategies proved to provide enjoyment while learning the PT as per the following results: CB increased by 3% and CS by 1%. On the other hand, MU showed a slight decline from 93% to 89%. This implies that the participants enjoyed watching simulation of building Na, Cl, O, S, H, C atoms and molecules, investigating how combustion of magnesium, lithium, phosphorous, sulphur, carbon and hydrogen is applied in the industry and domestic and composing a song using information about the Periodic Table in the lyrics.

Af5- Satisfaction, easier to learn and understand abstract concepts

Participants were not satisfied that MU could make learning and understanding abstract concepts regarding the PT easier as it showed a low AG of 84%. AG was 97% and 100% respectively for CB and CS after the intervention. CB and CS saw a shift to the right towards AG with an increase of 4% for both. This implies that the participants felt satisfied with the lesson using context-based inquiry because it makes it easier to learn the combustion reactions of magnesium, lithium, phosphorous, sulphur, carbon, hydrogen with oxygen. They also felt satisfied with the lesson using computer simulation because it makes the abstract concepts easier to learn and understand.

Af6- Belief and values(self-perception)

There was a decline in each of MU and CS, with an increase of 7% for CB implying the intervention enhanced the perceptions of CB only. In the post-test, 98 %, of participants perceived that CB can be used as an engagement strategy to provide the opportunity for learners to reflect and interact with their beliefs and values.

Af7- Interesting and easier learning

The results for CB and CS was favourable, indicating that learning the PT was easier and more interesting using context-based inquiry and computer simulation. CB and CS showed a large positive change from 81% to 97% and 89% to 97% respectively. On the other hand, MU experienced a decline after the intervention from 93% to 83%.

Af8- Concentration

After implementing MU, CB and CS as learning engagement strategies the results produced are MU 95.2%; CB 94.6% and CS 94.6%. This suggests that these strategies, can promote concentration on the content by consolidating the knowledge and the beat, as such, the participants indicated that they would be happy if more research could be done on the use of these strategies in learning.

Interestingly, no participating teachers strongly disagree for Af1 to Af7 to the two strategies; MU and CS. On the contrary, all the variables Af1 to Af7 for CB had 3% who strongly disagreed. The results of Table 5.8 on behavioural engagement are discussed in section 5.3.4.

5.3.4 The impact of intervention on Behaviour engagement

The symbol B in Table 5.8 represent behaviour engagement, the results obtained for questions 3 for phases 1, 2 and 3 on the questionnaire. The results are discussed in Table 5.8 is a summary of the combined question 3 items from phase 1, 2 and 3. B1 to B8 refer to combined related corresponding aspects of behaviour engagement assessed in the three phases regarding behaviour engagement.

Table 5-8: Behaviour frequency results

		PRE-TEST						POST-TEST					
CONSTRUCT ITEMS		DAG %			AG %			DAG %			AG %		
Item		MU	CB	CS	MU	CB	CS	MU	CB	CS	MU	CB	CS
B1 - Ability to apply acquired knowledge to answer questions.	Behavioural engagement	7.00%	0.00%	2.00%	93.00%	100.00%	98.00%	7.00%	3.00%	3.00%	93.00%	97.00%	97.00%
B2 – Participation helps with concentration		11.00%	2.00%	0.00%	89.00%	98.00%	100.00%	6.00%	3.00%	3.00%	94.00%	92.00%	97.00%
B3-Watching,investigating and stimulating the elements of PT: Enhance understanding of chemistry.		13.00%	0.00%	0.00%	87.00%	0.00%	0.00%	7.00%	3.00%	3.00%	93.00%	97.00%	97.00%
B4 – Active participation in class		9.00%	2.00%	2.00%	91.00%	98.00%	98.00%	7.00%	7.40%	8.00%	93.00%	92.60%	92.00%
B5- Be counted on to do own work		20.00%	7.00%	2.00%	80.00%	93.00%	98.00%	7.00%	6.00%	6.00%	93.00%	97.00%	94.00%
B6 - Work harmoniously in a team		-	4.00%	-	-	96.00%	-	-	3.00%	-	-	92.00%	-
B7- Contribution to teamwork		0.00%	83.40%	0.00%	0.00%	16.60%	-	2.40%	5.00%	7.80%	97.60%	95.00%	91.20%
B8- Draw conclusions		-	-	2.00%	-	-	98.00%	-	-	3.00%	-	-	97.00%

B1- Ability to apply acquired knowledge to answer questions

The results (MU 93%, CB 94% and CS 97%) displayed on Table 5.8 after the intervention can be inferred that the participants agree that what is learnt about the PT through MU, CB and CS can be applied in answering questions related to PT. This implies that MUCBCS foster a person's ability to apply what is learnt about PT to answer questions related to the PT.

B2- Participation helps with concentration

The increase in AG above 90% indicates that participation in composing song, investigating and simulation of the elements of PT helped participants to concentrate on the content. This was achieved through the use of MU,CB and CS.

B3- Understanding chemistry: Watching, investigating, and stimulating the elements of PT

The use of MU, CB, and CS as engagement strategies to learn the PT enhances understanding of chemistry by watching content rich music videos, investigating combustion of selected elements, and simulating atoms and molecules of the first twenty elements. This perception is based on the results after applying the strategies as reflected in Table 5.8 as follows MU 93.0%; CB 97.0%; and CS 97.0%.

B4- Active participation

The high AG after the intervention of 93.0%, 93.0%, 92.0% for MU, CB, CS respectively indicates that using music to learn PT, participating in the investigation and the use of computer simulation to learn the elements of PT improved participants active participation. This implies that simulation of the elements, completing the context-based inquiry project and using music to learn about the elements of the Periodic Table (PT) supported active participation in class.

B5- Be counted on to do own work and complete

The participants indicated that they could concentrate on their work and complete major tasks using MU and CS. This infers that using MU, CB, and CS to learn the PT enhanced the completion of work/task because the participants worked independently. They also indicated that learners could be accounted on to work independently to complete a task successfully. But the results of all three were above 90%. Therefore, MUCBCS can afford learners the ability to concentrate on one's own unique task to complete.

B6 - Worked harmoniously in a team to complete a task

The results of 97% AG for CB means the participants agreed they could work harmoniously in a team to complete the context-based inquiry project. This indicates that the application of CB

evoked the desire to work harmoniously in a team to complete task(s). The dash (-) as indicated on Table 5.10 means there were no questions on the questionnaire under MU and CS that pointed directly to the item worked harmoniously in a team to complete a task.

B7- Contribution to teamwork

The results for MU, CB and CS are 97.6%, 95.0% and 91.2% respectively after the intervention. This can be inferred that the participants agree that MU, CB and CS enhances a person's ability to work in a team. Furthermore, what is learnt about the PT through MU, CB, CS can be applied in answering questions related to PT in a team. There was an increase in CB from 83.6% to 95% after the applying the strategy indicating the positive impact on the identification of the task at hand and contribution in a team to complete the project.

B8- Draw conclusions

The dash (-) as indicated in Table 5.8 under MU and CB means there were no questions related to drawing conclusions. There was a decrease from 98% to 97% for CS. Therefore, the use of MU and CB did not enhance the scientific process skill of drawing conclusions.

5.3.5 The impact of intervention on Authentic engagement

Table 5-9 is a summary of question four items on authentic engagement, symbol Au from phase 1, 2 and 3. The symbol Au in Table 5-9 represent authentic engagement results obtained for questions 3 for phases 1, 2 and 3 on the questionnaire. Au1 to Au8 refer to combined related corresponding aspects of authentic engagement assessed in the three phases with reference to authentic engagement.

Table 5-9: Authentic frequency results

CONSTRUCT ITEMS		PRE-TEST						POST-TEST					
		DAG %			AG %			DAG %			AG %		
Item		MU	CB	CS	MU	CB	CS	MU	CB	CS	MU	CB	CS
Au1-Activities related and matched real world tasks	Authentic / agentic] AGAU] engagement	-	5.00%	9.00%	-	95.00%	91.00%	-	3.00%	6.00%	-	97.00%	96.00%
Au2- Promote collaboration		0.00%	2.00%	13.00%	0.00%	98.00%	87.00%	12.00%	6.00%	9.00%	88.00%	96.00%	91.00%
Au3-Understand most difficult concept		0.00%	-	6.00%	0.00%	-	94.00%	14.00%	0.00%	3.00%	86.00%	-	97.00%
Au4-Opportunity to create and use variety of resources		7.00%	4.00%	9.00%	93.00%	96.00%	91.00%	7.00%	3.00%	6.00%	93.00%	97.00%	94.00%
Au5-Opportunity to examine problems		7.00%	9.00%	5.00%	93.00%	91.00%	95.00%	7.00%	3.00%	3.00%	93.00%	97.00%	97.00%
Au6- Make connections between subjects		9.00%	3.00%	-	91.00%	97.00%	-	7.00%	6.00%	-	93.00%	94.00%	-
Au7- Allow reflection on learning and creativity		7.00%	0.00%	3.00%	93.00%	0.00%	97.00%	6.00%	3.00%	6.00%	94.00%	97.00%	95.00%
Au8- Promote engagement in learning		4.00%	-	23.00%	96.00%	-	77.00%	7.00%	-	3.00%	93.00%	-	97.00%

Au1- Activities related and matched real-world tasks

The dash (-) as indicated in Table 5.9 under MU means there were no questions on the questionnaire under MU that pointed directly to the item activities and assessment related to or match real-world tasks. However, after applying the learning engagement strategies, there was an increase of 2% AG and 5% for context-based (CB) and computer simulation (CS), respectively. These results indicate that classroom-based CB and CS activities may match real-world tasks of professionals in practice.

Au2- Promote collaboration (teamwork)

The use of MU, CB and CS promoted collaboration and teamwork as in everyday life situations. Nevertheless, there was a decrease of 2% AG for CB and an increase of 13% for CS after the intervention, showing different changes in perceptions, MU show no change from 88%.

Au3- Understand most difficult concepts

After effecting computer simulation as a learning engagement strategy, 97% and 86% of participants agreed that CS and MU can visualise abstract concepts to make learning PT easier to understand. AG increased by 3% for CS, thus MU and CS could assist learners to understand the most difficult concepts. However, the dash (-) as indicated under CB means there was no question on the questionnaire under CB that pointed directly to the item understanding the most difficult concepts.

Au4- Opportunity to create and use a variety of resources

The increase and high percentages for MU 93%, CB 97%, CS 94% in the post-test in Table 5.9 show that during the application of the strategies, participants had the opportunity to use a variety of resources rather than a limited number of preselected references that required them to separate relevant from irrelevant information. They agreed they had relevant information to work with.

Au5- Opportunity to examine problems

Even though AG for MU remained 93%, that of CB increased by 6% and CS 2%. This implied that MU, CB, and CS afforded the opportunity for participants to examine problems from a variety of options and resources to make appropriate choices.

Au6- Make connections between subjects

The dash (-) as indicated under CS means there was no question on the questionnaire under CS that pointed directly to the item making connections between subjects through the use of CS. The

results show that AG declined by 3%, MU increased by 2% for CB and CS, respectively, after the intervention.

Au7- Allow reflection on learning and creativity

The Au7 results show that AG for MU increased by 1%, CB remained 97% and CS declined by 2% due to the intervention. These results imply that participants agreed that MU, CB, and CS created an opportunity for participants to reflect on learning. Additionally, the assessment of the activities was integrated with the major task in a manner that reflected real-world assessments.

Au8- Promote engagement in learning

MU, CB increased by 1%, and CS by 2%, respectively. These results suggest that MU, CB and CS as learning engagement strategies can be used to promote learning engagement. Therefore, it helps to reach out to learners struggling, engage them in learning and induce a positive effect on science achievement.

In summary, MUCBCS afforded the opportunity to reflect on learning, examine problems using various resources, and promote collaboration and teamwork in everyday life situations. And reach out to struggling learners by engaging them to learn towards positive achievement in chemistry while mastering the PT.

In section 5.3, the effect of the intervention was described with the aid of frequency tables. Pre- and post-test percentages were compared and the possible contribution of the three phases of the interventions on the participants' perceptions regarding the affordances of the strategies to successfully engage learners in four different ways (cognitive, affective, behaviour and authentic) were deduced. These results were further processed using statistical methods to determine the practical significance and effect size of the intervention (Section 5.4).

5.4 RELIABILITY AND VALIDITY OF CONSTRUCTS

The questionnaires used in this study contain different groupings of questions that formed constructs. In the first place, all questions pertaining to each phase (music, context-based inquiry, and computer simulation) formed constructs P1, P2 and P3. Secondly, each phase consisted of four constructs of questions that related to cognitive, affective, behaviour and authentic (AGAU) engagement components. The notations for the four constructs of music (for example) are P1Q1, P1Q2, P1Q3, P1Q4, as they refer to the four questions on phase 1 music (P1) in the pre-test. Similar notations are used for the other two phases of context-based inquiry (P2) and computer simulation (P3). In the post-tests, the same questions were repeated, and therefore, the same notation was applied. Each of these constructs contains five sub-questions (e.g., 1.1 to 1.5) on a

component of engagement. The validity and reliability of the constructs as determined with the aid of statistics are reported in the following subsections.

5.4.1 Reliability of constructs

The reliability is illustrated in Tables 5-10 to 5-12 for the three phases respectively. Cronbach's Alpha coefficients statistically determined reliability due to the consistency of participants' responses to a group of questions. According to Field, Cronbach's Alpha Coefficient values above 0.6 is an indication of reliable constructs (Field, 2014).

Phase 1 (Music)

The reliability of the constructs of phase 1 (music) follows from the Cronbach's Alpha coefficients summarised in Table 5-10. The results are given for the four different constructs on engagement (e.g., P1Q1 on cognitive engagement).

Table 5-10: Cronbach Alpha Coefficients on pre-tests for the constructs of phase 1 (music)

Construct	N	Cronbach's alpha	Reliable?
Cognitive P1Q1	47	0.91	Yes
Affective P1Q2	47	0.88	Yes
Behaviour P1Q3	47	0.84	Yes
Authentic P1Q4	47	0.85	Yes

All Cronbach Alpha values pertaining to phase 1 (music) of the pre-test are above 0.84 (Table 5-10) thus show excellent consistency in the way the participants answered the questions. Therefore, the constructs under the engagement strategy, (music) are reliable.

Phase 2 (Context-based inquiry)

Although some of the questions on phase 2 that used context-based inquiry as engagement strategy were similar to those of phase 1 music strategy, there were some slight differences. Table 5-11 shows the Cronbach's Alpha Coefficients for phase 2 constructs.

Table 5-11: Cronbach Alpha Coefficients on pre-test for the constructs of phase 2 (context based inquiry)

Construct	N	Cronbach's alpha	Reliable?
Cognitive P2Q1	46	0.87	Yes
Affective P2Q2	46	0.83	Yes
Behaviour P2Q3	46	0.91	Yes
Authentic P2Q4	46	0.81	Yes

Since all the Cronbach Alpha values in Table 5-11 were above 0.80, the constructs of context-based inquiry were assured to be reliable.

Phase 3 (Computer simulation)

The reliability of the constructs of phase 3 (computer simulation) follows from the Cronbach's Alpha coefficient values as summarised in Table 5-12. The results are given for the four different constructs on engagement (e.g. P3Q1 on Computer simulation).

Table 5-12: Cronbach's Alpha Coefficients for phase 3 (computer simulation)

Construct	N	Cronbach's alpha	Reliable?
Cognitive P3Q1	46	0.90	Yes
Affective P3Q2	46	0.86	Yes
Behaviour P3Q3	46	0.92	Yes
Authentic P3Q4	46	0.86	Yes

Just as the first two phases, the constructs of questions relevant to phase 3 (computer simulations) were also found to be reliable. All Cronbach Alpha values reported in Table 5-12. are above 0.85. The constructs were thus measured consistently for individual items.

While the consistency of a measure (i.e. reliability) was described in section 5.4.1, it is followed by a discussion of the accuracy of the measure (i.e. validity) in section 5.4.2.

5.4.2 Construct validity

A factor analysis was done to assure construct validity. The same constructs in the pre-test were used as for reliability in the previous section. The results of the factor analysis are given in Table 5-13 for phase 1 (music), Table 5.14 for phase 2 (context-based inquiry) and Table 5.15 for phase 3 (computer simulation).

The number of factors retained for each of the constructs is 1. Kaiser's measure of sample adequacy (MSA) gave an indication of the inter-correlation among variables (Tabachnick & Fidell, 2007). This index ranges from 0 to 1, reaching 1 when each variable is perfectly predicted by the other variable. The measure can be interpreted with the following guidelines: MSA of 0.80 is meritorious, 0.70 is middling, 0.60 is mediocre, 0.50 is miserable, while a value below 0.50 is unacceptable (Hair *et al.*, 1998).

An assessment of how well these strategies perform can be obtained from the communalities, the measure of variance. The communalities indicate the extent to which an individual item 'relates' to the rest of the items.

Table 5-13: Factor analysis for phase 1 (music) for pre-test

Construct	N	MSA	Number of factors Retained	Percentage variance explained	Cummunalities vary between
Cognitive P1Q1	45	0.87	1	73.96	0.67 and 0.80
Affective P1Q2	45	0.67	1	67.44	0.61 and 0.74
Behaviour P1Q3	45	0.79	1	61.47	0.74 and 0.86
Authentic P1Q4	45	0.78	1	63.38	0.76 and 0.86

As seen from Table 5-13, the number of factors retained by the Mineigen criterion is one for each construct (Music cognitive; Music affective; Music behaviour and Music authentic). All MSA values are about 0.7 or above. The communalities that measure the amount of variance shared among the construct questions confirm interrelatedness. Thus, construct validity for the different constructs on music was assured.

Table 5-14: Factor analysis for phase 2 (context-based inquiry) for pre-test

Construct	N	MSA	Number of factors Retained	Percentage variance explained	Cummunalities vary between
Cognitive P2Q1	45	0.79	1	73.60	0.74 and 0.87
Affective P2Q2	45	0.69	1	84.85	0.64 and 0.77
Behaviour P2Q3	45	0.81	1	91.54	0.75 and 0.89
Authentic P2Q4	45	0.79	1	97.67	0.76 and 0.84

Table 5-14 shows the factor analysis on phase 2 (context-based inquiry) yielding one factor for each engagement component. The high MSA values and low variation in communalities indicate that the constructs contain interrelated questions and construct validity is thus confirmed.

Table 5-15: Factor analysis for phase 3 (computer simulation) for pre-test

Construct	N	MSA	Number of factors Retained	Percentage variance explained	Cummunalities vary between
Cognitive P3Q1	45	0.80	1	72.57	0.76 and 0.84
Affective P3Q2	45	0.80	1	85.37	0.77 and 0.84
Behaviour P3Q3	45	0.85	1	92.50	0.80 and 0.89
Authentic P3Q4	45	0.77	1	97.10	0.74 and 0.79

The factor analysis on the constructs of computer simulations (phase 3) also relates to each of the four engagement components (Table 5-15). The variations in communalities are small. Consideration of the MSA values (0.80, 0.80, 0.85 0.77) which are all above 0.76, the validity of the different constructs on computer simulation was assured.

The results of sections 5.4.1 and 5.4.2 above showed that each construct of related sub-questions in the pre-test was reliable and valid. The constructs could thus be statistically processed and compared to each other, as reported in section 5.5.

5.5 INTERFERENTIAL STATISTICS

5.5.1 Comparison of construct means between pre- and post-tests

Table 5-16 shows the number N of participants who answered each construct, the mean (average scores) obtained and the standard deviations. These were calculated for both the pre-tests (i.e. before the intervention) and the corresponding post-tests written after the intervention. Note that the mean scores are given as a value out of four. Marks were allocated according to the choice of options on the Likert scale, i.e. 1 mark for strongly disagree, 2 for disagree, 3 for agree and 4 for strongly agree. The midpoint on a Likert scale from 1 to 4 is at 2.5.

Table 5-16: Descriptive statistics of constructs for pre-and post-test

			Before intervention		After intervention	
Constructs		N	Mean	Std deviation	Mean	Std deviation
MUSIC	Cognitive P1Q1	47	3.22	0.55	3.53	0.47
	Affective P1Q2	45	3.37	0.50	3.43	0.60
	Behaviour P1Q3	45	3.23	0.54	3.48	0.55
	Authentic P1Q4	47	3.34	0.48	3.42	0.58
CONTEXT-BASED	Cognitive P2Q1	45	3.39	0.47	3.38	0.73
	Affective P2Q2	46	3.26	0.64	3.38	0.59
	Behaviour P2Q3	46	3.43	0.48	3.43	0.67
	Authentic P2Q4	47	3.34	0.42	3.37	0.60
COMPUTER SIMULATION	Cognitive P3Q1	47	3.49	0.49	3.73	0.39
	Affective P3Q2	46	3.35	0.46	3.54	0.48
	Behaviour P3Q3	46	3.41	0.46	3.54	0.55
	Authentic P3Q4	45	3.29	0.50	3.60	0.54

According to the results displayed on Table 5-16 the mean scores for all the constructs in the pre- and post-tests on all the three strategies were above 3, leaning towards an average of 4, showing that the degree to which the teachers agreed with the statements is between the options Agree and Strongly agree.

Similar mean values were obtained in the pre- and post-tests for two context-based constructs, namely cognitive (P2Q1) and behaviour (P2Q3). For all other constructs, the mean values increased, i.e., the students agreed more strongly with the statements after the intervention. In order to determine the practical significance of the changes in means, Cohen effect sizes were determined.

5.5.2 Cohen effect size d

Cohen's effect size d for dependent groups were used to compare the means of the constructs before and after the intervention and determine the significance thereof. The two matched groups were the pre-test and post-test results for each engagement component assessed for the different intervention strategies (music, context-based inquiry, computer simulation as engagement strategies). Since random sampling was not done, Cohen effect sizes (d) was used to indicate whether practical significance was achieved (Steyn & Ellis, 2003; Cohen, 1988). Practical significance is the degree to which the difference is big enough to have an impact in practice. This includes interpretation of comparisons between the construct means, as illustrated in Table 5.17.

The interpretation of the d-values regarding mean differences in Table 5.17 is as follows: small effect: $d = |0.2|$; medium effect (noticeable with the naked eye): $d = |0.5|$; large effect (practically significant): $d \geq |0.8|$ (Cohen, 1988).

Table 5-17: Effect sizes for differences in pre-and post -test results

Constructs		N	Mean- of difference between pre-and post-test	Std deviation of mean Difference	p-value (in case of random sampling)	d-value
MUSIC	Cognitive P1Q1	44	0.319	0.619	0.001*	0.58 ^Δ
	Affective P1Q2	41	0.117	0.579	0.203	0.24
	Behaviour P1Q3	42	0.273	0.584	0.004*	0.51 ^Δ
	Authentic P1Q4	44	0.10	0.591	0.267	0.21

Constructs		N	Mean- of difference between pre-and post-test	Std deviation of mean Difference	p-value (in case of random sampling)	d-value
CONTEXT-BASED	Cognitive P2Q1	36	-0.045	0.743	0.714	0.10
	Affective P2Q2	36	0.083	0.596	0.407	0.13
	Behaviour P2Q3	35	-0.011	0.682	0.922	0.02
	Authentic P2Q4	35	0.006	0.622	0.957	0.01
COMPUTER SIMULATION	Cognitive P3Q1	36	0.25	0.556	0.011*	0.51 ^Δ
	Affective P3Q2	35	0.134	0.428	0.072	0.29
	Behaviour P3Q3	35	0.109	0.532	0.236	0.24
	Authentic P3Q4	35	0.113	0.496	0.187	0.23

* Statistically significant at 0.01 level according to t-test results for dependent groups

Δ Medium effect in practice

As seen from Table 5-17, there was a mean difference (0.319) with a medium effect size ($d=0.58$) between the pre- and post-test mean scores of the cognitive construct of music (P1Q1).

Meaning that the post-test mean score of 3.53 (Table 5-16) obtained for music on the construct cognitive was larger than the pre-test mean score 3.22 (Table 5-16) with a medium effect in practice and that the music intervention thus had a noticeable affect that can be seen with the naked eye on the perceptions of the teachers regarding cognitive engagement skills. Furthermore, if random sampling was assumed, the music intervention could be regarded as statistically significant on a 0.001 level on cognitive engagement skills. Music behaviour produced similar results (refer to Tables 5-16 and 5-17). Therefore, the music intervention also had a noticeable effect with the naked eye on the perceptions of the teachers regarding behavioural engagement skills. Additionally, it is statistically significant at a value of 0.004.

With regard to computer simulations, the results in Table 5-17 show a mean difference of 0.25 with a medium effect size ($d=0.51$) between the pre- and post-test mean scores of the cognitive construct (P3Q1). This implies that the post-test mean score 3.49 (see Table 5-16) obtained for this construct was larger than the pre-test mean score 3.73 (see Table 5-16) with a medium effect in practice. Thus, the computer simulation intervention had a noticeable effect with the naked eye on the perceptions of the teachers regarding the cognitive skills. Furthermore, if random sampling

was assumed the computer simulation intervention could be regarded as statistically significant on a 0.01 level for the participants' perceptions on cognitive skills. The d-value ($d=0.51$) obtained for the cognitive construct of computer simulation indicates that this intervention had a medium effect on the perceptions of the teachers regarding cognitive engagement through computer simulation, while the effects on affective and behavioural were small ($0.2 \leq d \leq 0.5$).

Regarding all other constructs of music, context-based inquiry and computer simulation, there were no or small differences between pre and post-tests, meaning that the interventions did not influence the teachers' perceptions on those other constructs, i.e., P1Q2 music affective; P1 Q2 and Q3 context-based inquiry; computer simulation behaviour.

In summary, the interventions had a medium effect that is noticeable with the naked eye on the following constructs (with $0.5 \leq d \leq 0.8$): P1Q1 music cognitive, P1Q3 music behaviour, and P3Q1 computer simulation cognitive. The constructs under context-based inquiry showed no significant difference between pre and post-test responses, with a consequent low d-value ($d < 0.2$). On the other hand, computer simulations impacted positively with small to medium effect on all four engagement components.

The statistical analysis described in section 5.5 from the numeric quantitative data includes descriptive statistics like the mean and standard deviation. This led to the derivation of important facts from the research data such as MU afford cognitive and behaviour engagement while CS affords cognitive engagement.

In addition, in section 5.6, the qualitative analysis provided details, and gathered more in-depth information to build on the quantitative data collected to address the research questions. The natural responses from all the respondents (participants) and observational and recorded data from the focus group were also analysed and interpreted in this section.

5.6 ANALYSIS OF QUALITATIVE DATA

The qualitative research was concerned with how a particular teacher or group of teachers (participants) think and the meanings they attach to their actions in relations to the learning strategies of the four components of engagement. Hence, the participants actual voices and words are included in the research report enabling this approach as substantial and descriptive (Okeke, 2015:211). Interviews conducted enabled repeated entry into participants (interviewee) space that encouraged valid findings.

The qualitative data sources are worksheets, questionnaire post-tests question six, semi-structured interviews, focus groups, observation, and case study. The data were obtained from the workshops before, during and after the interventions.

5.6.1 Effectiveness of strategies to teach topics: Before-after worksheets

Participants completed worksheets before and after the intervention. The results are displayed in Table 5-18 (see Appendix D). Some of the participants did not complete the worksheet, others left out specific questions and selected only their preferred strategy. Others only responded on the after the intervention but nothing on the before hence the differences in numbers between the before and after responses.

The question asked in the worksheet was: How effective do you think each of the topics can be learned with each engagement strategy? The ratings (1, 2 3 and 4) have the following meaning: 1. Not at all; 2. Not so effective; 3. Effective and 4. Very effective. The results before and after the interventions are summarised in Table 5.18 with examples of participants' comments.

Table 5-18: Effectiveness of engagement strategy for learning topics

HOW EFFECTIVE DO YOU THINK EACH OF THE TOPICS CAN BE LEARNED WITH THE AID OF EACH ENGAGEMENT STRATEGY										
MEANING OF RATING 4 = VERY EFFECTIVE 3 = EFFECTIVE 2 = NOT SO EFFECTIVE 1 = NOT AT ALL										
Concepts		BEFORE				AFTER				PARTICIPANTS' COMMENTS
TOPIC	STRATEGY	1	2	3	4	1	2	3	4	
Elements of the Periodic Table	MUSIC	4	7	4	4	0	0	2	18	Aids learning makes learning enjoyable, fun. Easier to recall, positiveness, enthusiasm, easier for memorization. Understanding. Learners be able to remember. Easily memorized. Learners will be able to memorise fast. Remembrance.
	INQUIRY	3	1	5	0	0	2	4	7	Enhances understanding; gives lesson an interesting approach. Takes lots of time due to different level of knowledge and lack of it
	SIMULATION	3	2	4	1	0	1	3	9	Active engagement; challenges abilities and cognitive levels. Useful. Easier to use
TOTAL COUNT		10	10	13	5	0	3	9	34	
TOTAL %		26.30%	26.30%	34.20%	13.20%	0.00%	6.50%	19.60%	73.90%	
Combustion reaction	MUSIC	4	5	3	0	3	3	8	1	Not much of learning except for learning environment; lesson concept become fun. Knowledge. Interesting, accommodating all learners.
	INQUIRY	2	3	6	0	0	0	3	12	Arouses and creates interest and enjoyment, participation. The group was very inquisitive . Increases and becomes better. Doing experiment with products they are familiar with. You do, you remember.
	SIMULATION	1	3	7	3	0	0	4	12	Engagement: interest in lesson is more, touched on some content. React fast practically.
TOTAL COUNT		7	11	16	3	3	1	10	25	
TOTAL %		18.90%	29.70%	43.20%	8.10%	7.70%	2.60%	25.60%	64.10%	
Atoms and molecules	MUSIC	0	7	4	1	0	0	6	7	Express myself through music; helps concentrate, brought interest in me. Clear understanding. Rhythm can easily get learners interested
	INQUIRY	4	1	4	0	0	3	3	8	Experiment brought out the interest. Doing practical fascinates learners.
	SIMULATION	2	5	4	4	0	0	3	13	Shows how atoms are formed and how molecules are formed, few participants do not know computer.
TOTAL		6	13	12	5	0	3	12	28	
TOTAL %		16.70%	36.10%	33.30%	13.90%	0.00%	7.00%	27.90%	65.11%	

The average ratings of response to worksheet items for music (MU), context-based inquiry (CB) and computer simulations (CS) as engagement strategies are displayed in Figure 5-11, 5-12 and 5-13, respectively, below.

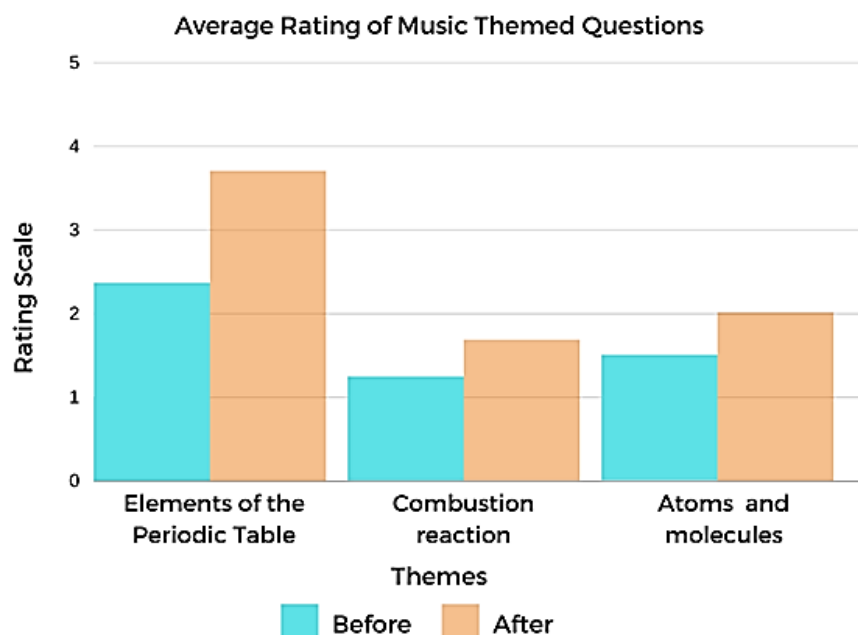


Figure 5-11: The average rating of music themed questions

Theme 1: Elements of the Periodic Table Theme 2: Combustion reaction Theme 3: Atoms and molecules

Figure 5-11 shows the average rating for the effectiveness of learning names, symbols, and basic concepts about PT elements, combustion, atoms, and molecules using music. Theme one shows the highest response rating before and after the intervention. However, the rating for using music to learn combustion (theme 2), atoms and molecules (theme 3) shows very low rating after the intervention, thus not considered as effective.

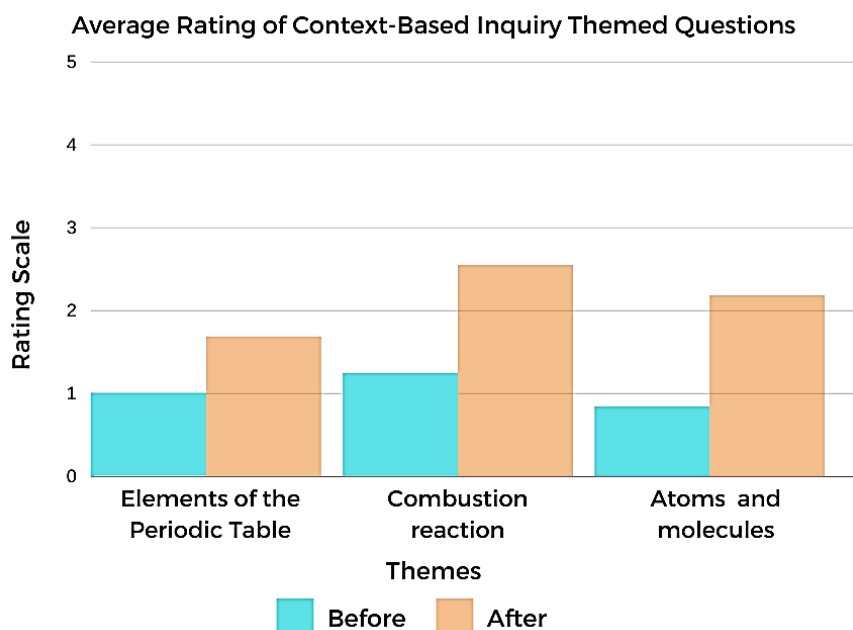


Figure 5-12: The average rating of context-based inquiry themed questions

Figure 5-12 shows the average rating for the effectiveness of learning names, symbols, basic concepts about elements of the PT, combustion, atoms, and molecules using context-based inquiry. The rating for elements of the PT (theme one) shows the lowest response towards effectiveness after the intervention. However, the rating for the use of context-based inquiry to learn combustion, atoms and molecules shows high rating of effectiveness after the intervention. Thus context-based inquiry is the most effective learning strategy to learn combustion followed by computer simulation.

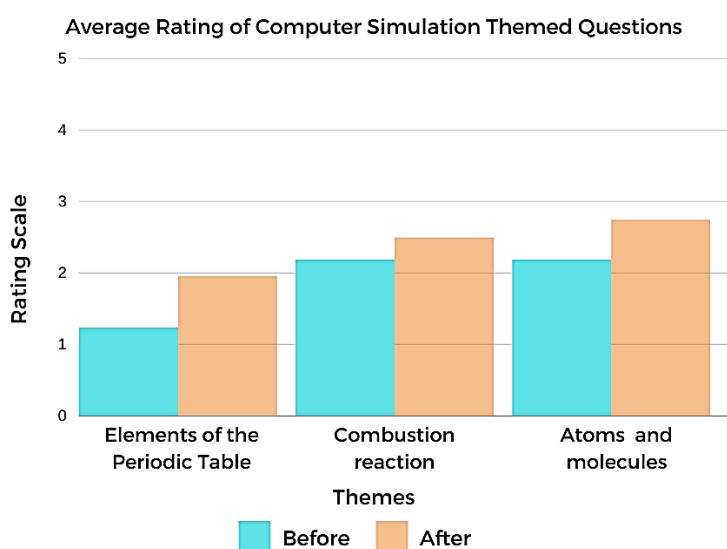


Figure 5-13: The average rating of computer simulation themed questions

Figure 5-13 shows an average rating for the effectiveness of learning names, symbols, basic concepts about elements of the PT using computer simulation. The rating scale for theme number one (1) shows the least rating below two after the intervention indicating it is ineffective. However, the rating for the use of computer simulation to learn combustion (theme 2), atoms and molecules (theme 3) shows a high rating after the intervention. Thus, supporting its effective use as an engagement strategy to learn combustion reactions, atoms, and molecules.

The shift in perceptions is evident from comparing the total percentages for all three topics show similar shifts towards larger effectiveness as followed the quantitative results (Table 5.2, Section 5.3.1). However, after the intervention these results show that context-based inquiry and computer simulation are regarded more effective tools for learning combustion reactions than learning the names and symbols of PT elements.

Furthermore, it is important to choose an appropriate engagement strategy that will boost engagement towards increasing learning performance. Hence section 5.6.2 presents the factors that affect the choice of engagement strategy.

5.6.2 Factors that affect the choice of appropriate engagement strategy

Apart from the effectiveness of the engagement strategy, the interviewees brought out the following factors that may determine the strategy that teachers select and prefer to use. The choice of strategy may also depend on the outcome the teacher is anticipating at the end of the lesson and the intended goals.

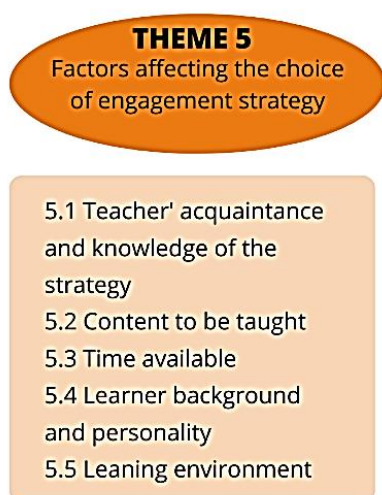


Figure 5-14: Factors that determine engagement strategy

The factors that determine the engagement strategy that teachers may use are stated below and illustrated with a quotation:

- Teachers' acquaintance and knowledge of the strategy: "You need to know it yourself of how you must maneuver it from one side to the other, so you do not flop."
- Content to be taught: "How does one put those calculations of formulae in terms of music?"
- Time available: "It can work ... but the time to create the music will take all your time."
- Learner background and personality: "...the very shy person who you thought was not interested in reading or ... they even have more knowledge than those who actually pass."
- Learning environment: "It arouses and creates interest and enjoyment, participation. The group was very inquisitive".

The general results that follow from this research is that the choice of an appropriate engagement strategy does not only depend on the topic to be taught, but also on other factors, namely teachers' acquaintance with the strategy, the learning environment, the background of the learners, the engagement components that need attention as well as the amount of time available.

Assessment achievement scores of the participants can be found in section 5.6.3 (Figure 5-15), which shows the scores of the content assessment after the use of MU, CB and CS. However, learner engagement is said to be a stronger indicator of learning performance than assessment achievement scores (Taylor *et al.*, 2016).

5.6.3 Knowledge of Periodic Table: Post-test question 6

Participants were tested after the intervention on basic content knowledge of the first twenty elements on the: names, symbols, atomic number and mass number, group, period, metals, and non-metals. Fifty participants completed the questions.

The results, however, do not include participants who answered questions related to only one of either music, context-based or computer simulation. A total of 39 participants that completed the content questions, including questions related to all three phases are reported in Figure 5-15.

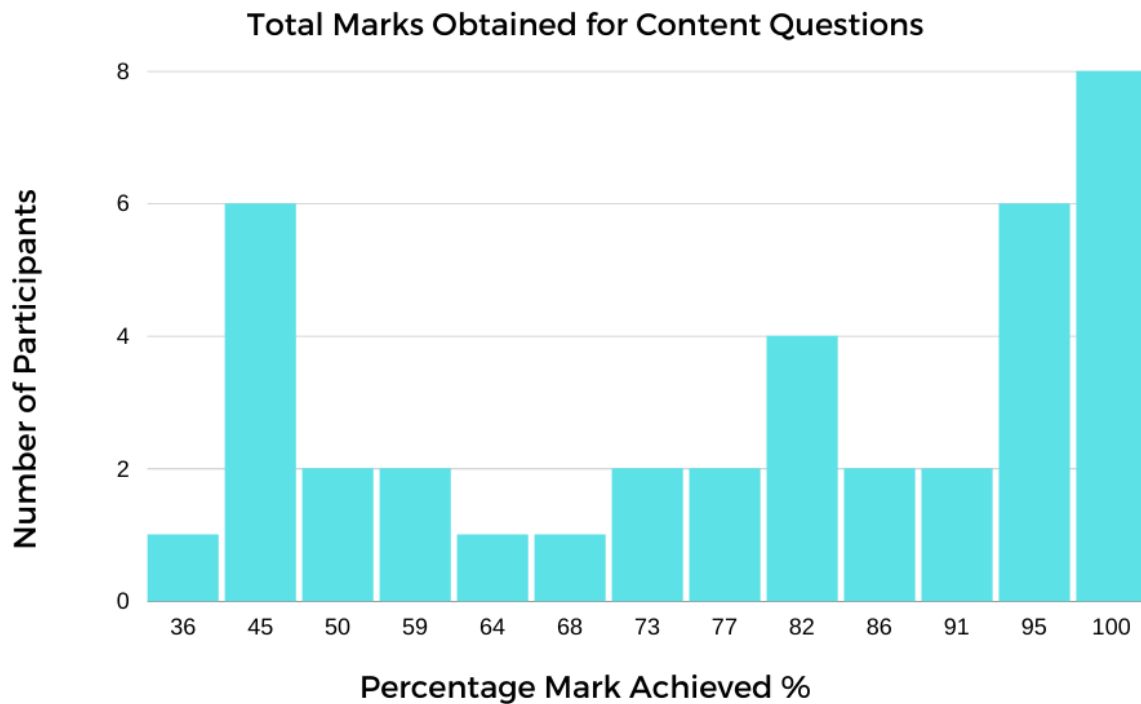


Figure 5-15: Percentage mark obtained

The results show that only 11 out of 39 participants obtained below 60% after the intervention. On the whole, the performance is satisfactory after the intervention with more than half of the participants obtaining a mark of 80% and above (Figure 5.15). A total of 8 out of the 39 participants obtained 100%, and 22 obtained over 80%.

As alluded to the effectiveness of the three strategies in 5.6.1, it is worthwhile to identify themes from the observations, individual interviews and focus group interviews related to the impact of the three engagement strategies, namely: music, context-based inquiry, and computer simulation on the four components of engagement. These are outlined in 5.6.4.

5.6.4 The impact of the three engagement strategies: Observation, Interview, Focus group interviews

The results of the observation, individual interviews and focus group interviews are combined in one document (Appendix D) and are attached for more details. The table (Appendix D) give the qualitative data used to facilitate cross-case comparisons amongst the individual interviews, focus groups interviews, and observations.

Figure 5-16 gives an overview of themes and subthemes that were identified regarding the impact of music, context-based inquiry, and computer simulation as engagement strategies on cognitive, affective, behaviour and authentic engagements accumulated from the qualitative data (interviews, focus groups and observations).

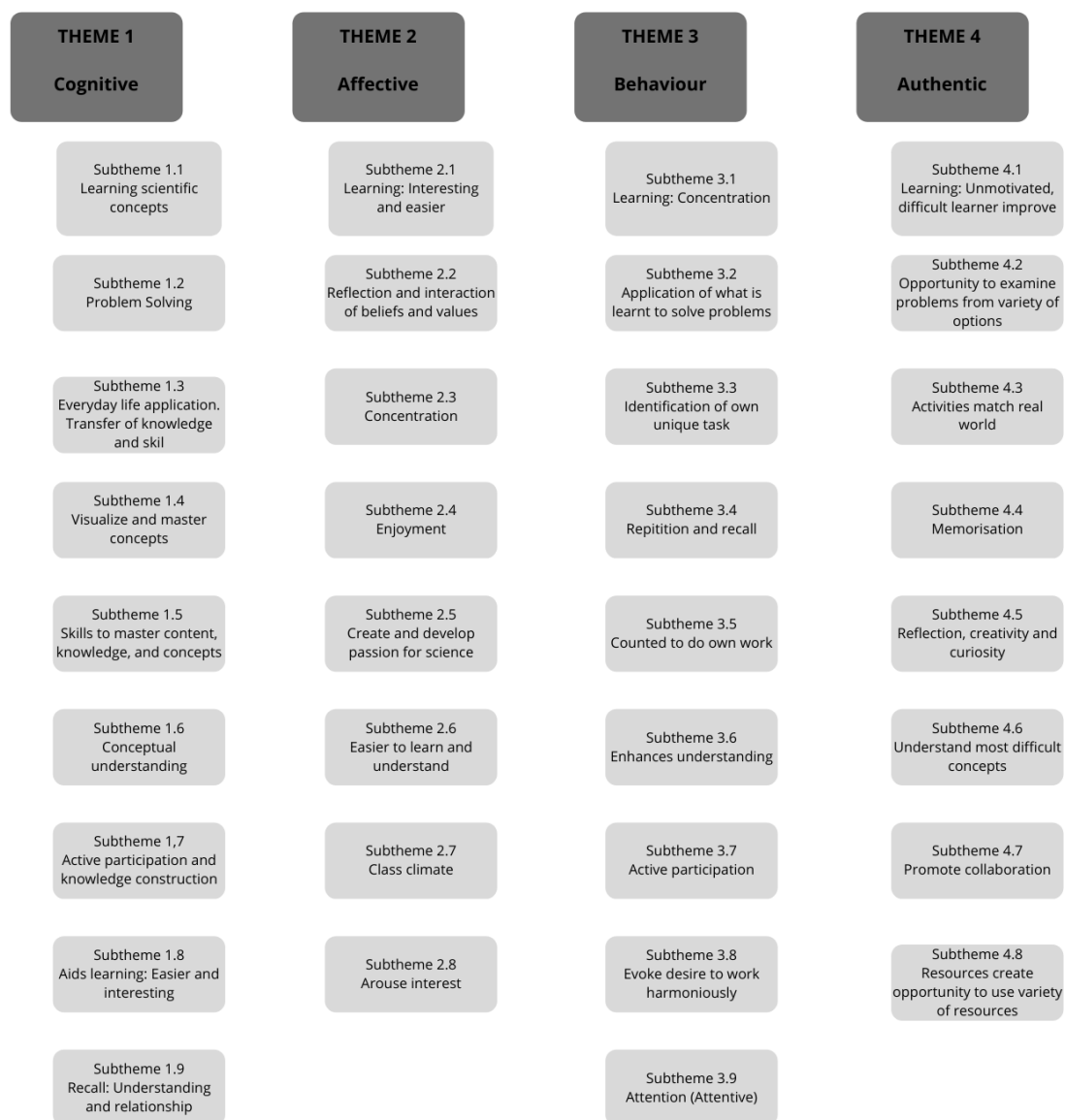


Figure 5-16: Overview of themes and subthemes

With regard to the qualitative results, the following interview quotes by the interviewees provide examples that confirm the quantitative results shown in Table 5-1 to 5-17 concerning the engagement components relevant to the different strategies.

- Music (MU): things “music helps with memorising of facts, definition and like, that.”
- Context-based(CB): “It is also helpful with the concept of the content and abstract.”
- “Experiment brought out the interest. Doing practical fascinates learners.”
- Computer simulation(CS): “Much easier to use.” Do not need lots of preparation.”

- “Do not need a lot of resources.”

The results thus far affirm that MU, CB and CS impact on the themes cognitive, affective, behaviour and authentic (AGAU). Hence the discussions will be focused on the subthemes.

In summary, the subthemes have been formulated under a maximum of nine headings with few quotes stated to support the subthemes mentioned in the flow diagram (Figure 5-16). Numbers are attached to the subthemes. The first numbers correspond to the number given to the theme (a component of engagement), namely, 1 for cognitive, 2 affective, 3 behaviour and 4 authentic(AGAU). For example, subtheme 1.3 means cognitive third subtheme and theme 2.2 refer to the second subtheme of the affective component.

Points i to x are subheadings generated from the subthemes in Figure 5-16.

(i) Belief and value:

Beliefs and values as mentioned in chapter 3, section 3.6.1, have effect on why students engage or do not engage. If the individual believes in his/her own abilities to meet challenges and complete a task successfully, it is easier to invest effort to achieve that outcome (Eccles & Wigfield, 2002). This implies that the three engagement strategies' ability to promote reflection and interaction of student beliefs and values support identification of their unique contribution and task completion (Subtheme 2.2 and 3.3).

The experience of the three engagement strategies during the intervention, enhanced teachers' understanding of their value, as is evident from the words:

“Again, when I first started with the questionnaire, some of the questions I did not have a clear picture so... but after the whole activities (intervention using music, context-based inquiry, and computer simulation) I could now answer with more understanding.” The strategy brought about a shift of mind for the individual belief in their own abilities to successfully complete the task.

(ii) Classroom climate:

Emotional (affect) and cognitive engagement is nurtured by creating helpful, friendly, disciplined, and interpersonal relationships (see section 3.6.2). The creation of a classroom climate that promotes engagement depends on the teacher. Regarding qualitative results (subthemes 2.7,1.8, 3.8), the use of all three strategies, namely MU(music), CB(context-based inquiry) and CS(computer simulation) as engaging strategies, equip the teacher to display the qualities of an engaging teacher. Furthermore, they create a pleasant class climate and a friendly working

environment, evoking the desire to work harmoniously in a team, promote interpersonal relationships. A teacher expressed it as follows:

“Not much of learning except for learning environment.”

“Lesson concept becomes fun, knowledge interesting and accommodating all learners.”

“The group was very inquisitive. Increases and becomes better. Doing experiment with products they are familiar with. You do, you remember.”

Conceptualisation of engagement include good relationships with teachers and other students by being intentional, persistent, interested, and focused on the learning process (Skinner *et al.*, 2009). Creating an effective learning environment enhances learning engagement as clearly depicted in the following two quotes from the teacher participants as evidence after the intervention (Sökmen, 2019).

“I think this is really fantastic. It was very interesting because I found that almost everyone in the group had something to add.” “And no idea of if someone is coming with something new whereas on your own you just keep to your own.” “Creating a conducive classroom that embraces all diversity to get engaged and valued.”

“You get used to it, so I think this kind of approach for as long as you don’t get used to it its gonna (going to) seen as a challenge.”

“ You make sure if you introduce something, you start from grade 8, 9, 10, 11 then 12. These learners when they reached grade 10 they are used to this type of approach.” This emphasises repetition and practice towards acceptance and perfection. Introducing MUCBCS from a lower grade through to grade 12 makes it easier for the learners to accept and get used to a new strategy.

Conceptualisation of engagement as being intentional, interested, and persistent is evident in the words of the participants:

“Learners learn to get used to the system. So, if we can get a scenario having them to adjust to the system, they will stay in the system and give results.” This implies that if learners get used to a system, or strategy which has been intentionally introduced can yield positive engagement and results.

(iii) Resources

In section 3.6.3, it has been stated that resources such as time, attention, effort and learning materials enhance engagement. According to subthemes 3.9, 4.2 and 4.8, MU, CB and CS create opportunities to use various resources with relevant information. They also provide a variety of options with relevant information to examine and solve problems.

The following quotation recognizes the variety of resources provided during the intervention to acquire knowledge, information and skills as the participants engaged in the three strategies.

“I used a variety of resources and practical.”

“Although participants were expected to contribute based on their own level of pre knowledge, some commented on the time it took to bring all the members of a group to the same knowledge level before examining and solving the problems.”

“It took a lot of time due to different knowledge or lack of knowledge we had on the content.”
“takes lots of time due to different level of knowledge and lack of it.”

(iv) Active participation

Active participation is connected to motivation and leads to engagement in education, as well as developing positive attitudes towards learning (Prince 2004; Bonwell & Sutherland 1996). Furthermore, active participation in learning activities sustain interest and releases creativity and curiosity (see section 3.6.4). MU, CB, CS were found to be useful strategies to engage students meaningfully to solve problems and promote collaboration and teamwork (subthemes 1.2; 3.2; 3.7 and 4.7).

The quotes below confirm how the experience of active participation during the intervention contributed to knowledge construction and enhancing interest:

“We dissolved the product.” “We think we overheated it, so it is going to take longer to dissolve.”
“...add more grains so that we must not take long.” “I express myself through music.”

These statements expressed how meaningfully they were engaged. It also highlights teamwork and collaboration (refer to the word “we” used) as well as meaningful contribution to solving the problems.

“Each one of us was interested in giving input and knowing more”. “For example, someone knowledge and putting everything together and taking part each of us”. “They are hands on.” I did play.”

The statement below refers to getting unmotivated and difficult learners to engage in learning (subtheme 4.1).

"You see that the very shy person who you thought was not interested in reading or they even have more knowledge than the ones who actually pass. They just seated there; they just work."

(v) Repetition and memorization

Repetition is important in learning. This is because it facilitates short and long term retention of information and transfer of knowledge (see 3.6.5).

The following quotations from subthemes 1.9; 3.4 and 4.4 by interviewee and focus group responses imply that the three engagement strategies provided opportunities for repetition and memorization.

"But for them, the music helps them to remember by their repetition of things."

"Music helps with memorization of facts, definitions, and things like that makes easier for memorization, understanding and remembrance". "Learners be able to remember, (because it helps with) easily memorized". "Learners will be able to memorise fast."

(vi) Mastery of content

Sufficient repetitions ensure mastery of content. Mastering content is achieved by creating a mastery-oriented classroom (see 3.6.6). The use of MU, CB and CS under subthemes 1.4;1.5; 1.6; 3.6 and 4.6 provide opportunities to improve skills to master the content of the PT. Conceptual understanding and visualisation of abstract content which support mastering scientific content were enhanced.

Participants' appreciation of the strategies in mastering content follows from the following quotations:

"From the perspective of a learner who doesn't know anything of all of this. This is very fantastic."
"Challenges abilities and cognitive levels" 'Enhances understanding.' "Helps to learn fast to retain the elements and can comprehend longer."

(vii) Everyday life application

The subthemes 1.3; 3.2 and 4.3 refer to the activities relating to real-world tasks and transfer of knowledge and skills from the classroom to the real-world environment as illustrated in the quotations:

"Seeing how atoms are built and how molecules are formed." "Experiment is the best teacher."
"Doing experiments with products they are familiar with", it brought positiveness and enthusiasm."
"You do, you remember."

According to the following quotes by some participants, computers are available to simulate real-world environment in the classroom.

"Most schools they have computer labs to help them to ... to use these computer labs for their classes." "This is possible because most schools have computers and internet to simulate real-world in the classrooms."

(viii) Concentration

Learners can be counted on to do their work and complete their tasks due to the concentration on what is at hand (see subthemes 2.3, 3.1 and 3.5). The ability of MU, CB and CS to enhance concentration in class, on the work or task at hand as well as the content is evident in the quotations:

"This is a positive method to get learners involved and pro-active." "Learners will become proactive during sessions."

Intense concentration led to the correction of a concept during the intervention. "no, no, they will never be neutrons, neutrons are neutral." This depicts the participant's concentration on the content to place emphasis on the correct scientific knowledge; neutrons are neutral and have no charge.

(ix) Enjoyment

MU, CB, and CS were perceived to be useful to arouse interest, provide enjoyment and to create and develop a passion for science and related careers (subthemes 2.4, 2.5 and 2.8): "Mmm I really enjoyed the process and where we got to use music, makes learning enjoyable, easy, fun, easier to recall." "Gives lesson an interesting approach." "Creates interest and enjoyment." "They will be happy, interested; they want things that excite them." "It is an interesting document to use." "I enjoyed and understood the content." "Arouses and creates interest and enjoyment."

(x) Learning

Learning scientific concepts becomes interesting and easier with the engagement strategies, since they allow creativity, making of choices, and reflecting on learning both individually and

socially (subthemes 1.1, 2.1, 2.6, 3.1 and 4.5): “Aid and promote learning scientific concepts.”
“The group was very inquisitive and becomes better.”

Reinforcement, conceptual understanding, and visualisation of abstract concepts were heightened: “And that I think it’s very helpful and then you learnt things that you had no idea of”.
“The experiment it also helpful with concepts.”

“I found that the simulation reinforced because when we were here looking through the table I saw the number 6 now I have seen it.” “It is also helpful with concept of more of content and abstract”

Participants reflected on the new learning strategies (MU, CB and CS) which are different from what they were used to and how it can help their learners: “We must not let them learn the way we will learn, actually it is not good.” “I think for this (strategy) it is going to help them.”

Lastly, general comments by the participants on MU, CB and CS as engagement strategies are:

- MU, CB, and CS enhance engagement and excitement: “Yea, totally because we were able to engage with one another. At first, we didn’t know what to do but as soon as we got someone... example or someone knowledge and putting everything together and taking part each one of us was interested in giving their input and knowing more and got excited and the lesson got excited.”
- MU, CB and CS are useful, helpful and make it easier to gain knowledge and understand abstract concepts. “Useful, easier to use.” “It is also helpful with concepts of more of the content and abstract.” “All I can say is that it was helpful to me, and I gained more knowledge that I was not having.”
- Application to South Africa curriculum is possible but it is time consuming. “It can work in all of them (curricula) but the time to create, will take all of your time.”
- The strategies can be implemented in the classroom. “Is very informative in helping the development of teaching and learning.”
- Improvement of academic performance is highlighted here and the need for continuous positive reinforcement. “This strategy can help a lot in improving the performance and participation of learners, let’s keep working hard, stay blessed.”
- Inclusive education, which means real learning opportunities are created. It is the most effective way to give all children a fair chance to learn and develop the skills they need to

thrive. “will work best especially for inclusive education.” “After the whole activities I can now answer with more understanding.” “It will make it easier for learners (learning) and to recall the element.”

- Possible challenges and problems from school setup associated with applying MU, CB and CS in the classroom.

“You get used to it for as long as you don’t get used to it, it’s going to be seen as a challenge as a problem”. “So, I think this kind of approaches at a high school you need it to as seen “The other problem is our curriculum, the structure of schooling is such that you find that a person is life science and is the HOD for physical sciences. He doesn’t have idea of science.” “But if you are HOD of science you make sure if you introduce something you start from grade 8 to 9, 10, 11 then 12. These learners when they reach grade 10 they are used to this type of approach.”

- Teething problems may be experienced. “Teachers may find it difficult to start.” “And again, you need to know it yourself of how you must manoeuvre it from one side to the other, so you do not flop”; “say I know that this might work, but to some learners not all of them it will work.”
- The critical thinking level of participants showed a positive increase in all the dimensions. “Each one of us was interested in giving input and knowing more.” “We are discussing theory about investigative.”

5.6.5 Analysis of lesson observation

The application of music, context-based inquiry and computer-simulation engagement strategies in an actual classroom situation took place in a school in the North-West Province, Potchefstroom. Due to COVID-19 pandemic, visits to schools were restricted, therefore I visited only one school instead of the two schools indicated in chapter 4.

The physical science teacher chronologically presented the lesson to grade 10 using music, context-based inquiry, and computer-simulation engagement strategies chronologically. The lesson was introduced with an exciting greeting and a short clip of the PT.

The observation schedule consisted of five themes (A–E), and each theme was measured against certain criteria (section 3.7.1). The class was observed while the teacher presented the lessons. Table 5-19 shows a summary of the observation of the lesson under the different themes and criteria. The meaning of the numbers 0, 1,2,3 and 4 are as follows : 0 means none of the criteria was observed; 1 (highly ineffective) and 2 (ineffective), 3(effective) and 4 (very effective).

Table 5-19: Recording from the observation of the lesson

A: Lesson design and implementation - effective pacing strategy					
Criteria	0	1	2	3	4
A1 Creating a conducive environment in the classroom-(Affective and Behaviour)					x
A2 Design content divided into smaller units- (Cognitive) Authentic					X
A3 Setting clear learning goals - Catch their attention/(authentic)				X	
A4 Arranging resources learners can engage with-(cognitive				X	
B: Questioning strategy					
B1 Questions focus on content- (cognitive					X
B2 Creative questions- (behaviour , affective)					X
B3 Tasks involve movement for understanding-(Behaviour/Cognitive/Authentic)				X	
C: Learner participation in the lesson					
C1 Answering questions					X
C2 Asking questions				X	
C3 Completing tasks and solving problems				X	
D: Authenticity realistic strategy					
D1 Exposing learners to realistic simulations- Affective/cognitive					
D2 Connect tasks and scenarios to students' own lives-Authentic /Behaviour/Affective /Cognitive					X
D3 Incorporating a variety of information sources				X	
D4 Designing context-based inquiry					X
E: Thoughtful technology usage strategy					
E1 Provides an opportunity for active engagement of learners- Cognitive/Affective/Behaviour					X
E2 Aid visualisation of concepts- Cognitive, behaviour					X
E3 Multimedia activities music, short clips, video- Affective and authentic				X	

5.6.5.1 Discussion of themes identified from lesson observation**A: Lesson design and implementation- effective pacing strategy**

Music was presented too fast, but learners could remember a few elements' names and symbols.

Good interaction with the learners. Pictures, rhythm, and words caught their attention.

B: Effective questioning strategy

The teacher asked questions related to the content, e.g.

"Which element in the presence of oxygen can be helpful towards the community?"

"Can we apply the use of this element in the presence of oxygen to produce a compound plus energy?"

The teacher used creative questions to invoke the learner's creative thinking. Where do we use combustion? How can we relate what we learnt to the word combustion? Where do we use combustion? How can we relate what we learnt to the word combustion?

He made the class to move from their seats to stand in pairs to discuss some questions and then presented their understanding.

C: Learner participation in the lesson

Oral questions were presented by the teacher which the learners answered.

The learners actively contributed to the discussions, with laughter now and then. The learners came up with the answers themselves, which indicated their active class participation.

The learners asked more questions when the teacher was applying the context-based inquiry than when they were busy building the atoms and molecules formed during the combustion reaction using the computer simulation strategy.

The teacher gave his learners time to work in groups to complete the activities and solve the problems.

Only one learner needed extra time to complete the individual task by answering questions on papers.

Overall, the learners were well behaved and focused on the work at hand. One student was playing with a piece of paper when the others were busy with the building of atoms and molecules.

D: Authenticity realistic strategy

A PhET simulation was used to demonstrate combustion reaction.

The teacher asked application questions such as "Where do you see these elements happening in real life". Each learner tried to explain, for example, "helium in balloons".

Notes on power points, information on worksheets, internet sources were available.

Equipment and materials were arranged on the demonstration table.

The connection to the context-based inquiry was made by asking questions like: Where can we relate combustion to?

The teacher led the discussion with explanations in between and guided the completion of practical combustion of carbon (non-metal) and magnesium (metal).

E: Thoughtful technology usage strategy

Each learner had the opportunity to build stable elements and to observe in the simulation of how the number of electrons, neutrons and protons add up to form a stable atom. Other molecules such as magnesium oxide was constructed. A wireless mouse was used, and the rest of the class could follow what was happening on the big screen.

It was explained that one of the compounds formed during the combustion of carbon or coal consists of carbon and oxygen atoms. Since these atoms and molecules are abstract, the teacher introduced computer simulation using PhET. The teacher explained how to form a molecule.

In the absence of other elements, they watched a combustion reaction video online.

In the end, the learners answered the context-based inquiry project question posed by the teacher to the learners, namely "What is the energy from combustion and where is it applied?"

The teacher successfully showed the ability to use the strategies to get the learners engaged in learning the Periodic Table.

The analysis of the questionnaire filled by the learners during the case study indicated that computer simulation had a more significant impact on their engagement during the learning followed by music and not the least context-based inquiry strategy.

5.7 SUMMARY

The research questions were taken into consideration throughout the process of the empirical study. The results were captured according to the research questions which were broadly grouped under phase one: impact of music on the four components of engagement. Phase two: impact of context-based inquiry on the four components of engagement and phase three: impact of computer simulation on the four components of engagement. The research pre and post questionnaire was proved reliable and valid.

The demographic results indicate a wide range of participants with varying educational qualifications and ages between 25 years and 55 years. It also showed that 79% had chemistry or physics, or chemistry and physics or natural sciences at tertiary level. The number of participants currently teaching physical or natural sciences with tertiary qualification was between 77% and 100%. The teaching experience and qualification of the participants contributed towards generating useful information and reliable results.

The quantitative results showed that music as an engagement strategy for learning the first twenty elements of the PT had observable, practical, noteworthy impacts on cognitive and behaviour engagement followed by affective engagement and the least on authentic(AGAU) engagement. Context-based inquiry as an engagement strategy for learning Periodic Table elements like magnesium, lithium, phosphorous, sulphur, carbon, oxygen, hydrogen and linking their use to everyday experiences had observable, practical, noteworthy impact on affective engagement., followed by cognitive engagement, authentic engagement and much less effect on behaviour engagement. Computer simulation as an engagement strategy for learning basic concepts of the PT and linking the use to the elements to everyday experiences had observable, practical, noteworthy impact on cognitive engagement., followed by affective engagement, authentic engagement and much less effect on behaviour engagement.

According to the qualitative results, 100% of participants indicated that MUCBCS is ideal for engaging in learning elements of the PT (phase 1). In contrast, 76% indicated that MUCBCS is effective for learning combustion reaction (phase 2), and 79% agreed that it effectively engages learners to learn about the atoms and molecules (phase 3).

As discussed in this chapter the qualitative and quantitative results confirmed that music enhances cognitive and behaviour engagement. In addition, context-based inquiry positively impacted affective and cognitive engagement. Lastly, computer simulation positively impacted cognitive, affective, authentic (AGAU) and behaviour engagement.

The next chapter discusses the findings, and the argument will be based on the evidence of the results reported, which will be grounded on the thematic analysis and statistical analysis of the results.

CHAPTER 6 DISCUSSION OF RESULTS

6.1 INTRODUCTION

The research study aimed to investigate affordances of music, context-based inquiry, and computer simulation engagement strategies to enhance the four components of engagement (behavioural, emotional, cognitive, and AGAU engagement) in learning the first twenty elements of the Periodic Table(PT). In this chapter, the combined quantitative and qualitative results, which were discussed separately in chapter 5, are interpreted in the framework of the literature study (chapters 2 and 3). The integration of quantitative and qualitative results that include descriptive statistics, inferential statistics, thematic themes, and subthemes, (chapter 5) was used to determine common patterns and findings that are prominent for each of the three engagement strategies music (MU), context-based inquiry (CB) and computer simulation (CS) (sections 6.2 to 6.4). The affordances of the engagement strategies were derived from these results as discussed in section 6.5. The research results confirmed and elaborated on literature studies pertaining to the effect of three teaching strategies on four different components of engagement in the context of learning about the PT.

6.2 PHASE ONE: MUSIC AS ENGAGEMENT STRATEGY

In the intervention, rhythmic songs were used to familiarize participants with the names of the first 20 chemical elements of the PT, their symbols and basic properties (atomic number and mass number). The participants repeatedly listened to pre-composed songs, where after that they composed their own songs in groups.

6.2.1 The impact of music on cognitive engagement

Music as an engagement strategy (MU) was found to have a positive impact on cognitive engagement (sections 5.3.1, 5.3.2 and 5.6.4), especially about learning scientific concepts (C1), understanding of relations between concepts (C3), connecting and integrating knowledge (C4), transfer of knowledge and skills (C5) and active construction of knowledge (C8) (Table 5.6 and section 5.6). The research results confirmed and elaborated on literature studies of the effect of music on cognitive engagement and learning.

According to the pre-test results on music (Table 5-16), the expectations of the teacher participants were lowest for cognitive engagement as compared to the other engagement components. Still, they yielded the largest change of mean in the post-test. In other words, the use of music in the intervention had a positive impact of practical significance (Table 5-17) on participants' perceptions of the effect music can have on cognitive engagement.

Participants acknowledged that the use of music resources provided during the intervention contributed to overcoming difficulties in learning basic concepts related to the PT. Learners' cognitive performance can be improved by using music videos with scientific content-based lyrics. This result agrees with the findings of Crowther *et al.* (2016) that music can enhance learners' scores from simple knowledge questions to more complex questions. While learners listen to music, the brain processes the content effectively and as a result, cognitive processing becomes active (Ellison *et al.*, 2015). The effect of music on brain functioning suggests that the chronological composition in music and rhythm can improve cognitive performance (Thaut *et al.*, 2014) as it enhances and supports learning and cognition (Deasey, 2002; Gershon & Ben-Horin, 2014).

During the intervention, knowledge was actively constructed by composing own songs with names and symbols of elements of the PT, as it activated cognitive interpretative processes. Cognitive interpretative processes, such as appraisals and self-evaluations (Corno & Madinach, 2004:299), were evident as the self-composed songs were appraised by the other participants while they were presented. The use of music also engaged learners in thinking processes, in agreement with Salmon (2010).

Crowther *et al.* (2016) stated that music promotes learners' understanding of scientific concepts, which is crucial to further learning (Franco-Mariscal *et al.*, 2015). The results of this study showed that music was particularly useful for understanding the relationship between the atomic number and mass number of the elements in a group on the PT connecting the names to the symbols of the elements. Improvement of paired word memory through music was reported by Thaut *et al.*, (2014) in a study with multiple sclerosis patients.

There was clear evidence that MU engaged learners meaningfully in transfer of knowledge and skills during composing of songs and the attempts made to learn the pre-composed songs (section 5.6.4 v, vi, 5.6.51) . This encouraged the skill to forge on to overcome learning obstacles and failure, to master and achieve (Connell & Wellborn,1991).

MU plays a supporting role in the learning process to help learners learn different subject content (Bresler,1995). In the music-based intervention, knowledge has been gained about the PT elements that are incorporated in all science subjects. Lazear (1999:118) also confirms that music and rhythms can be used to help learners learn and remember a variety of information, processes, and operations in different subjects.

6.2.2 The impact of music on affective engagement

MU was not found to have a positive impact on the participants' overall perceptions of affective engagement. However, it had a positive impact on some of the affective construct variables. Especially with regards to enhancing interest (Af1), making learning interesting and easier (Af5), enjoying (Af4) and passionate (Af3) and enhancing the class climate (Af2) (see sections 5.3.1, 5.3.3, 5.6.4 and Table 5-7). The research results confirmed and elaborated on literature studies of the effect of music on affective engagement and learning.

According to the pre-test results on music (Table 5-16), the expectations of the teacher participants were highest for affective engagement than the other engagement components and yielded a low positive change of mean in the post-test. In other words, the use of music in the intervention had a small positive impact (Table 5-17) on participants' perceptions of the effect music can have on affective engagement.

In this present study, there was quantitative and qualitative evidence that the use of music arouses interest to study the names and symbols of PT (see section 5.6.4, 5.6.5.1 This result is in accordance with the findings of Crowther *et al.* (2016) that music can enhance interest in learning science concepts. Additionally, sustaining interest over time and maintaining affect influences conceptual understanding in chemistry topics (Nieswandt, 2007: 927-929).

However, some learners may shy away if they do not have good voices making learning PT by composing own songs not any easier. The beat and rhythm of pre-composed songs might not be interesting for some, thus making the learning of PT with such songs boring (section 5.6.4). Music, composing songs and singing may also disturb learners in other classes and may sway learners from complying with class discipline (Murphey, 2013; Kuśnierek, 2016).

Nevertheless, it was evident from the findings that using music as a strategy accomplished engagement, excitement, and creativity, thus promoting learning basic concepts of the PT (see section 5.3.3, 5.6.4 ix). Similar findings were reported by other researchers (Crowther *et al.*, 2016; Salmon, 2010; Miché, 2002) who stated that music is an enjoyable way to activate prior knowledge (see section 5.6.4), which is a crucial aspect of learning. MU sustains interest and maintains affective engagement, which influences the conceptual understanding of chemistry topics (Nieswandt, 2007: 927-929). In support, Pekrun *et al.* (2006:583) contended that affective engagement significantly enhances learning and achievement. Subsequently, MU affords enjoyment that enhances learning.

The results of the present study support the use of MU to create and develop passion for learning chemistry (McCammon, 2008). In a college organic chemistry course (Chemistry 14D), Professor

Neil Garg also used music to create a passion for chemistry and he created 83 new songs using organic chemistry content. A music video, "Chemistry Jock," produced by his students in 2010, is now approaching 60,000 views on YouTube, creating passion for chemistry among more students (<https://newsroom.ucla.edu/releases/chemistry-you-can-dance-to-235026>). The development of satisfaction to use music thus affords passion for learning chemistry.

MU creates a pleasant working climate by providing a friendly and pleasant environment (see section 5.3.3, 5.6.5 ii). This is supported by Salmon (2010), who agrees that music can stimulate an active learning environment.

6.2.3 The impact of music on behaviour engagement

MU had a positive impact on the overall behaviour engagement even though it did not show a large observable impact on certain aspects such as teamwork (see sections 5.3.1 and 5.6.4). The quantitative results showed that MU specifically had a positive impact with regards to the ability to apply acquired knowledge to answer questions (B1), participation helps with concentration (B2), watching pre-composed video on PT enhance understanding of chemistry (B3), increasing active participation in class (B4), and learners can be counted on to do their own work (B5) (see sections 5.3.1, 5.3.4 and Table 5-8). The positive impact aligns with the statement that participation in music activities influences behaviour engagement (Brsler, 1995; Zinn & Finn, 2012).

According to the pre-test results on music (Table 5-16), the expectations of the teacher participants were lower for behaviour engagement than the other engagement components but yielded a larger change of the mean in the post-test. In other words, the use of music in the intervention had a medium observable impact in practice (Table 5-17) on participants' perceptions of the effect music can have on behaviour engagement.

As the participants learned the symbols and names of the PT by singing along and composing songs, they were actively involved in class. Active participation in class enhances the ability of participants to concentrate on their work and role to complete a task (see subtheme 3.5 and section 5.3.4). Individuals concentrating are said to have their attention focused clearly and presently on the task at hand. Therefore, boosting concentration enhances attentively focusing on class and the task. MU thus affords concentration in class by paying attention and putting in effort. For instance, during the intervention, effort and attention were placed on composing a song and learning the existing pre-composed music on the PT downloaded from YouTube (see subtheme 3.9, section 5.3.4, 5.6.4 iii, 5.6.5.1). Participants' commitment, time, attention, and effort to support the activity and task at hand increases behavioural engagement (Fredricks *et al.*, 2016;

Schlechty, 2011). Although commitment as such was not determined in this study, it goes hand in hand with concentration and putting in an effort.

MU enhanced persistence in the application of knowledge acquired to solve problems and skills to answer questions related to the PT. MU thus affords attention while applying knowledge in problem solving (see subtheme 3.2, section 5.3.4, 5.6.4 vii). The use of MU to learn about PT also induces an understanding of chemistry by attentively watching pre-composed content-rich music videos (see sub-theme 3.6, section 3.3.3.2, 5.6.5). According to MIT (see section 2.6), musical intelligence increases understanding of chemistry through expressing oneself through music and rhythmic movements, dance, composing, playing, and conducting music (Dickinson *et al.*, 2002). However, MU could not sufficiently evoke the desire to work harmoniously in a team to complete a task and contribute positively to teamwork. This followed both quantitative and qualitative results (see section 5.3.4, 5.6.4). The activity that involved composing own PT songs can be a challenge in a group due to individuals having different tastes for rhythm, beats and type of music. The differences may drag group decision making, taking more time and tasks may not be completed within the time frame in the school set up.

In summary, behaviour engagement is a measure of observable behaviour, participation, and involvement in the music activities (see section 1.4, 4.3.51, 4.5.6.1) and contributes towards learning (Wang *et al.*, 2016). Music is a participative activity that needs commitment of mind and hence it encourages active participation and commitment to do and complete work.

6.2.4 Impact of music on agentic/authentic (AGAU) engagement

Music as engagement strategy did not have a positive impact on the overall perceptions of the participants on agentic/authentic engagement, since the intervention did not significantly change the pre-test results (Table 5-16 and 5-17). However, a slight impact was found on the following specific construct variables: Au6 and Au7. Whereas Au4 and Au5 already showed a high percentage of the participants' perceptions in the pre-test that remained the same in the post-test results. The abbreviations Au4, Au5, Au6, and Au7 means; provide an opportunity to create and use variety of resources (Au4), opportunity to examine problems (Au5), make connections (Au6), allow creativity and reflection on learning (Au7) (see Table 5-9, section 5.3.5).

MU provide learners/participants the opportunity to make choices and examine problems related to the PT. The participants examined a given problem of how to create their own song. This includes selecting their choice of lyrics from relevant PT information and the rhythm (see section 2.5.3, 3.5.4, 5.3.1, subtheme 4.2). Through these authentic tasks and activities learners learn

science as they engage in scientific writing, composing and memorizing the lyrics of content songs (Taylor *et al.*, 2016) while applying critical thinking.

The use of music provides opportunity for learners to connect knowledge between subjects that involve integration of different concepts across different subject areas. The application of different subjects, such as language, art, mathematics, music, was incorporated in the composition and learning of the first twenty elements of the PT. Deasey (2002), Gershon and Ben-Horin (2014) noted that music enhances and supports the process of learning different subjects, and general cognition and affect. Moreover, creating own songs allowed the opportunity to reflect on learning (see section 5.3.5 and 5.6.4).

MU afforded creative ways to learn the PT. Participants were allowed to choose their own rhythm, beats and lyrics when they wrote their own PT song (see Figure 4-7). and presented it (see Figure 4-8). Some had theme songs while others had movement associated with the content of PT (see Figure 4-8)

MU promotes learning engagement by reaching out to difficult learners, these are learners who struggle to engage in learning (section 5.6.4). This is accomplished by inducing a positive effect on science achievement (Cappella *et al.*, 2014). As learners spend more time engaged, behavioural difficulties become insignificant.

6.3 CONTEXT-BASED INQUIRY AS ENGAGEMENT STRATEGY

In the intervention, a context-based inquiry project was used to investigate in groups the combustion of magnesium (Mg), carbon(C), lithium(Li), sulphur(S) and phosphorous(P) as applied in the industry and domestic use (see Figure 4-9). There after solved the context-based problem using inquiry by explaining how the combustion reaction of a metal or non-metal can be used to generate energy for communities in South Africa. The research results confirmed and elaborated on literature studies related to the effect of context-based inquiry on engagement and learning (see Chapter 5).

6.3.1 The impact of context-based inquiry on cognitive engagement

Context-based inquiry as an engagement strategy (CB) did not positively impact the overall cognitive engagement. However, it impacted on the following specific construct variables, especially with regards to learning scientific concepts (C1), transfer of knowledge and skills in everyday life application (C5), the ability to master scientific content and visualise abstract concepts (C6), improve skills to master content knowledge (C7) and thus promote active construction of own knowledge (C8).

According to the pre-test results on context-based inquiry (Table 5-16), the teacher participants' expectations were highest for cognitive engagement compared to the other engagement components but yielded the lowest change of the mean in the post-test. In other words, the use of context-based inquiry in the intervention did not have a positive impact of practical significance (Table 5-17) on participants' perceptions of the effect context-based inquiry can have on cognitive engagement.

According to the results, CB as an engagement strategy aids in learning scientific concepts related to the PT elements magnesium, lithium, phosphorous, sulphur, carbon, oxygen, and hydrogen. Using CB to learn scientific concepts is important because it enhances learners' knowledge and performance in chemistry (Demircioğlu *et al.*, 2009:245-246). Because the contextual activity of CB includes finding solution to the CB problem (section 5.6.4), it helped the participants to give meaning to the PT scientific concept which is in line with (Gilbert, 2006; De Jing, 2008).

The participants indicated in the focus group discussion and the responses from the questionnaire that CB provided an opportunity to integrate theory and practice and make connections of knowledge between subjects and everyday application (see section 5.3.2). As such, CB as a learning strategy bridges the gap between learning in class and everyday life (Herranen *et al.*, 2019; Gilbert, 2006).

Active involvement occurred while participating in the context-based inquiry project that engaged participants in applying and understanding the combustion of magnesium, lithium, phosphorous, sulphur, carbon, and hydrogen in oxygen to everyday life experiences (see section 5.3.2, 5.6.5.1, subtheme 2.1). Therefore, CB enhances the effective transfer of knowledge, skills and abilities from the classroom to the real-world by relating the knowledge and skills to everyday life, such as combustion of carbon (coal, charcoal) to generate energy.

The use of CB enhances the skill to master scientific content. This assumption is based on the results that AG (i.e. the percentage agreement with the statement) was as high as 97% after implementing the CB strategy. The idea is that cognitive engagement uses a combination of thoughtfulness and readiness to apply a degree of determination needed to understand complex concepts and master difficult skills (Fredricks *et al.*, 2004:61-63). CB strategy included observing the colour of flame during combustion of carbon, lithium, magnesium and sulphur in oxygen and provided an opportunity to visualise the abstract concept of combustion reactions.

Understanding the application of these elements in everyday life enhances active learner involvement in constructing knowledge.

6.3.2 Impact of context-based inquiry on affective engagement

Context-based inquiry allows projects that promote more significant academic successes, including overcoming cognitive and affective challenges (Doppelt & Barak, 2002: 22-26). The empirical study revealed that CB had a positive overall impact on the participants' perceptions on affective engagement in general as well as individual construct variables especially with regards to interest (Af1 and Af7), class climate (Af2), enjoyment (Af4), easier to learn and understand (Af5), belief and values (Af6) (see section 5.3.3, 5.6.4, Table 5-7).

According to the pre-test results on context-based inquiry (Table 5-16), the expectations of the teacher participants were lowest for affective engagement compared to the other engagement components but yielded the largest change of the mean in the post-test. In other words, the use of context-based inquiry in the intervention had a positive impact (Table 5-17) on participants' perceptions of the effect context-based inquiry can have on affective engagement.

The participants regarded CB useful to arouse interest in learning the properties in relation to the combustion reaction. It also makes learners interested to learn about the PT and makes combustion reactions easier to understand (see section 5.3.1, 5.3.3, subthemes 1.1, 2.1). This is in accordance with Walan (2016) finding that CB improves interest.

CB include a process of implementing ideas to illustrate the significance and use of PT concepts to stimulate interest in learning combustion reactions of the selected elements and thus creates a pleasant and friendly environment (see section 5.6.4 ii). The CB learning environment allows learners to do projects that enable them to attain greater academic successes and overcome affective challenges which aligns with (Doppelt & Barak, 2002).

Investigating how combustion reactions are applied in domestic and in the industry proved to provide enjoyment (see section 2.6.4, 3.2.2, 3.3.4, 5.3.3, 5.6.4 ix). Participants were amused by their active involvement in finding solutions to the CB problem on generating energy from combustion reactions in everyday life (section 5.6.4). A sense of satisfaction with the lesson was obtained because it becomes easier to learn and understand the combustion reactions and their applications, allowing learners to develop a feeling of enjoyment while they investigated combustion. CB further provided the opportunity to reflect and interact with one's own beliefs and values (see section 5.3.3, Table 5-7).

The CB strategy included effective use of the body with a strong sense of awareness involving hands-on activities and tasks. This supports learners with bodily-kinaesthetics intelligence since they enjoy creating things with the hands and maintains a high sense of memory by doing, moving, making and touching things (Cherry, 2018; Lane, 2000). Although the quantitative results

did not indicate a positive impact on perceptions regarding concentration (see section 5.3.1), this variable was indicated in the qualitative results (see subtheme 2.3, section 5.6.4 xiii).

Participants indicated that CB enhanced their conceptual understanding of combustion reaction of the selected elements of PT. Context-based inquiry therefore can promote a passion for learning chemistry (De Jong, 2018; Pilot & Bulte, 2006). And the ability to create and develop passion for science, chemistry, and careers in the field of chemistry (see section 5.6.4 ix, theme 2.5). Context-based inquiry thus promotes learning, stimulates intrinsic motivation and interest in chemistry (King *et al.*, 2011; Herranen *et al.*, 2019).

6.3.3 Impact of context-based inquiry on behaviour engagement

CB did not have a positive impact on the overall perceptions regarding behaviour engagement, although it did show an observable positive impact on some of the construct variables, with regards to; participation in CB helps with concentration (B2), active participation (B4), each one can be counted on to do their work and complete given task (B5), while contributing to harmonious teamwork (B6, B7) (see section 5.3.4, 5.6.4, Table 5-8).

According to the pre- and post-test results on context-based inquiry (Table 5-16), the expectations of the teacher participants remained the same for behaviour engagement and yielded no observable change of the mean. In other words, the use of context-based inquiry in the intervention did not show an impact of practical significance (Table 5-17) on participants' perceptions of the effect context-based inquiry can have on behaviour engagement.

Participating in CB investigation activities on combustion reactions helps with concentration on the content (see subtheme 3.1, section 5.3.1, 5. 6.4 xiii). The reason been, CB emphasised gaining knowledge through science process skills. Application of knowledge acquired using CB, enhances problem solving and skills to answer questions (see section 5.3.4) at different levels (Duran & Dökme, 2016). Since creating an active learning environment is essential for engaging learners (Voelkl, 1996).

The context-based inquiry project required learners to identify their unique tasks and sub-tasks in order to complete a major task. In addition, learners could be accounted on to concentrate on their own work in the learning process even when working within a group. CB thus enhanced the completion of tasks within a group project which affords accountability to work independently to complete a task (see section 5.3.4, 5.6.4, Table 5-8).

Working harmoniously in a team to complete the context-based inquiry project indicated a positive impact on the identification of the task at hand and contribution in teamwork as each member

could be counted on to complete their part in a group. CB affords active contribution to teamwork and collaboration within the team (section 5.6.4 iv). Behavioural engagement thus increases cooperation (see section 3.3.2.2, 5.3.4, Table 5-8) and working effectively in groups (Duch *et al.*, 2001:7).

The use of CB to learn by investigating what happens when the selected elements undergo combustion reaction, enhances understanding of chemistry (see section 5.3.4, 5.6.4, 5.6.5). This is because context-based inquiry promotes curiosity in the learners, which is essential for learning to take place (Pluck & Johnson, 2011).

6.3.4 Impact of context-based inquiry on agentic/authentic (AGAU) engagement

CB did not have a positive impact on the overall perceptions regarding authentic engagement even though it showed significant positive impact on some of the construct variables, with regards to activities related and matched to real-world tasks (Au1), promote collaboration (Au2), opportunity to create and use variety of resources (Au4) and opportunity to examine problems (Au5) (see Table 5-9, section 5.6.4, 5.6.5.1).

According to the pre-test results on context-based inquiry (Table 5-16), the expectations of the teacher participants were lowest for AGAU engagement but yielded a slightly larger change of the mean in the post-test. In other words, the use of context-based inquiry in the intervention had a small positive impact (Table 5-17) on participants' perceptions of the effect context-based inquiry can have on AGAU engagement.

CB promotes activities related and matched to real-world tasks of professionals in practice (i.e. scientists) and are not just classroom-based tasks. CB thus promotes authenticity (5.6.5.1). Authenticity refers to the extent to which tasks or activities require students to solve real-world problems which have value beyond the class and school (Lombardi, 2007; Newmann *et al.*, 2001). These authentic activities used the combustion reaction learnt in class to solve life application problems of generating energy. Through authentic tasks and activities, learners learn science by memorizing facts and by following the scientific context-based inquiry procedures (5.6.5.1). In support, they engage in scientific discourse that uses science in the way scientist would (Taylor *et al.*, 2016:4-5). The CB intervention activities matched real-world tasks of professionals in practice better than classroom-based tasks (see section 5.3.5). CB was used to solve real-life design problems that improve engagement and achievement which is according to (Doppelt *et al.*, 2008) findings.

Authentic collaboration was integrated into the task, which including responsible interaction within the classroom or the real-world. CB promotes collaboration by creating an environment that allows

the participants to constructively contribute within the groups to determine the solution to the context-based inquiry project problem (section 3.3.5.4 ii and iv) .

CB affords the opportunity to examine the problem from various options and resources to make appropriate choices, rather than allowing a single view that learners must imitate to be successful (see section 3.4.3, 3.6.5, 5.6.4, 5.6.5 iii). The resources used include worksheets, equipment, and materials while hypothesizing, testing, observing and experimenting. This implies that CB afforded relevant resources to work with, solve a problem, make decisions, hypothesise, and investigate using content previously learnt in class (names, symbols of the elements). As learners become more engaged with learning materials (resources), their learning gains increase (Chi & Wylie, 2014).

It is worth noting that there was no significant difference in the participants' perception before(pre) and after(post) the CB intervention on the four components of engagement. This implies that context-based inquiry as an engagement strategy did not have an overall positive impact on their perceptions on the effect of context-based inquiry on the four components of engagement. This may be attributed to science teachers' regular use of inquiry and experiments in their teaching environment.

6.4 PHASE 3: COMPUTER SIMULATION AS ENGAGEMENT STRATEGY

PhET computer simulations were used to build stable Na, Cl, O, S, H and C atoms and NaCl, H₂O, SO₂, CO₂, HCl molecules during the intervention. After, the participants completed the open ended challenge "how does the use of computer simulations impact on learning the basic concepts of the PT and their use in our everyday experiences?" The research results confirmed and elaborated on literature studies pertaining to the effect of computer simulations on engagement and learning.

6.4.1 Impact of computer simulation on cognitive engagement

Computer simulation (CS) as engagement strategy had a positive impact on perceptions regarding all four components of engagement. Regarding cognitive engagement, CS specifically had a positive impact on the following construct variables with regards to learning scientific concepts (C1), problem solving (C2), relational and conceptual understanding (C3), the ability to master scientific content and visualise abstract concepts (C6), improve skills to master content knowledge and skills (C7), active construction of knowledge (C8) (see Table 5-6, section 5.3.2, 5.6.4).

According to the pre-test results on computer simulation (Table 5-16), the expectations of the teacher participants were low for cognitive engagement but yielded the largest change of the mean in the post-test. In other words, the use of computer simulation in the intervention had a positive impact of practical significance (Table 5-17) on participants' perceptions of the effect computer simulation can have on cognitive engagement.

The participants agreed that CS is an important strategy to use in teaching and learning scientific concepts. CS aided in learning scientific concepts through building stable atoms for Na, Cl, O, S, H and C using PhET computer simulation. Then more complex molecules composed of different elements (NaCl, H₂O, SO₂, CO₂, and HCl) were built (see 3.3.3.2, 5.6.4). CS is effective in using PhET technology in transferring knowledge (Koller *et al.*, 2006). This implies that the use of CS affords stimulating learning scientific concepts of the PT.

CS is a valuable strategy for learners to engage in scientific problem solving in a meaningful manner that is impossible with a traditional approach (see section 5.3.1, 5.6.4, 5.6.5). CS can give a good picture of a problem and as such improve problem solving scores by improving problem solving skills (Avramiotis & Tsaparlis, 2013). This is evident in the CS activities during the intervention that included solving open ended challenge, scaffolding with tables by classifying the atoms and molecules and the debriefing session (see section 4.4.4).

The use of CS is beneficial for learners because it assists them to understand concepts of the PT and the relationship between atoms and molecules. This present study results indicate that CS is useful for the conceptual understanding of PT as the simulation tasks reinforced concepts taught earlier in line with (Frederking, 2005) as well as understanding new concepts. Moreover, CS enhances learners' ability to master scientific content since it provides an opportunity to visualise abstract concepts. This allows learners to clearly understand the connections between sub-microscopic, macroscopic, and symbolic levels of chemistry (Stieff & Wilensky, 2003). From the results of this study, only CS could assist learners to understand more difficult abstract concepts. Therefore, CS affords engagement capacity to master content related to the PT (see section 4.4.4, 5.3.2, 5.6.4x, 5.6.4vi). Since CS enhances understanding of scientific and chemistry concepts, it improves performance in exam scores, substantial knowledge and mastery of content are enhanced (Kunnath, 2017; Avramiotis & Tsaparlis, 2013; Asal & Blake, 2006).

Besides mastering content knowledge, CS also improves technical and process skills (see section 5.3.1, 5.6.5). CS can also give a good picture of a problem to improve problem solving skills (Avramiotis & Tsaparlis, 2013). Additionally, CS assist learners to actively construct knowledge by exploring the simulation. The active involvement of participants/learners to explore PhET in a variety of simulation activities to figure out how to build stable atoms and molecules

assisted them to construct their own knowledge (see 5.6.4vi, 5.3.2). CS affords visualisation of relationships between variables in scientific context (Wu & Puntambekar, 2012:756). On the whole, CS thus had a positive impact on cognitive engagement.

6.4.2 Impact of computer simulation on affective engagement

The empirical study revealed that CS had an overall positive impact on affective engagement as well as individual construct variables, especially with regards to interest (Af1 and Af7), class climate (Af2), passion (A3) enjoyment (Af4), easier to learn and understand (Af5), (see section 5.3.3, 5.6.4, Table 5-7).

According to the pre-test results on computer simulation (Table 5-16), the initial expectations of the teacher participants were low for affective engagement but yielded a change of the mean in the post-test. In other words, the use of computer simulation in the intervention had a positive impact of medium practical significance (Table 5-17) on participants' perceptions of the effect computer simulation can have on affective engagement.

The study findings show that CS arouses interest in learning and enhance interest in using PhET simulations to learn the PT. Affective engagement focuses on making learners feel good, happy, and excited. Therefore, the management of emotions improve affective engagement. This is why the application of computer simulation discussions excite learners to talk about their feelings and emotions about an activity (Bouvier *et al.*, 2014).

CS enhances a pleasant class climate conducive working environment that makes it easier to talk about how they felt about the computer simulation activities during the debriefing. Thus, CS affords a pleasant and improved class environment (see section 5.33, 5.6.5ii, Table 5-7). A friendly, enjoyable, pleasant and exciting environment strengthens affective engagement (Skinner *et al.*, 2008; Aslop & Watts 2003).

The pleasant environment in which the use of PhET simulations was created to build atoms and molecules proved to provide enjoyment. In the same manner, CS provided opportunities to manipulate variables in science which enhances, critical and analytical thinking skills in educational experiences that are fun and memorable (Avramiotis & Tsaparlis, 2013; Glezou & Grigoriadou, 2010;).

The results of the empirical study favourably indicated that learning the PT was easy and interesting using CS. Interest afforded satisfaction because abstract concepts (such as building of atoms and molecules) became easier to learn and understand. The reason is that CS aids to visualise these abstract concepts (Abla & Fraumeni, 2019).

CS's ability to enhance enjoyment and satisfaction making learning easier resulted in creating and developing passion for science, chemistry and careers in the fields of chemistry. Using simulations to gain an in-depth understanding of the PT in chemistry affords the learning process and creates passion for pursuing chemistry-related careers (see section 3.3.3.2, 5.3.3, 5.6.4 x, 5.6.4 ix, 5.6.5).

The results suggested that CS can promote concentration (see section 3.4.5, 3.3.4.2, 5.6.6 xiii). This implies that CS's ability to promote affective engagement include management of emotions with which learners gain better control over their emotions as related to concentration to learn (Sadighi & Zarafshans, 2006) and paying more attention in class (Skinner *et al.*, 2008).

Engagement can be enhanced by combining various kinds of visualisations, with no specific order (Jones *et al.*, 2005). Therefore, using different visualisation in a computer-simulated lesson to determine learners' understanding of chemistry concepts showed improvement after each visualisation. The intervention did not allow reflection and interaction with individual beliefs and values. The reason been that the debriefing focused on how the CS activities affected the individual and was not about the individual belief, nor how the individual influenced the CS activities.

6.4.3 Impact of computer simulation on behaviour engagement

CS had a positive impact on the overall perceptions regarding behaviour engagement even though it did not show an observable positive impact on team work (B6) and (B7) (see section 5.3.4, 5.6.4, Table 5.8).

According to the pre-test results on computer simulation (Table 5-16), the expectations of the teacher participants were highest for behaviour engagement compared to the other engagement components and yielded the largest change of the mean in the post-test. In other words, the use of CS in the intervention had a positive impact of medium significance (Table 5-17) on participants' perceptions of the effect simulations can have on behaviour engagement.

Knowledge acquired through PhET interactive simulation activities on PT was applied to answer questions and solve problems related to PT (see section 3.3.3.1). CS affords cooperation and enthusiasm while interacting in the groups and with the simulations while answering questions and solving problems aligns with (Luo *et al.*, 2009; Hughes *et al.*, 2008).

CS promotes concentration in class by consolidating knowledge and concentration on doing the work by focusing on the content. This finding agrees with the literature (see section 3.3.3, 3.4.3.1). CS's ability to promote the management of emotions assist learners to gain better control

over their concentration to learn (Sadighi & Zarafshans, 2006) and pay more attention in class (Skinner *et al.*, 2008). However, there is a need for further studies on improving concentration and eliminating anxiety for first-time users.

Furthermore, using CS to learn about the elements of the PT supported active participation in class through participating in manipulating the simulation, completing the activities, and participating in the discussions and debriefing. During the debriefing learners evaluated the simulation, gave their views on what they have learnt and mentioned what they would modify, with an overall positive evaluation of the simulation, in accordance with Frederking (2005). CS proved to support active engagement, thus strengthening effective learning (Glezou & Grigoriadou, 2010).

Active participation enhanced by CS increase completion of task and working independently to complete a task successfully in the learning process with the effective instructional resources and activities at the preparation, interaction, and debriefing stage (sections 5.3.4, 5.6.4, Table 5-8). Therefore, for simulation-based teaching to be beneficial to learners, simulation developers should use effective instructional resources and direct activities to develop tasks that engage students and provide healthy learning opportunities at the preparation, interaction, and debriefing stages (section 3.3.3.2).

The results indicated that CS had a positive impact on identifying the task at hand and contribution in teamwork. This implies that CS affords identification of individual contributions towards a task performed by teamwork. Involvement in teamwork offer opportunities for behavioural engagement as reported (Alexe, 2013; Sauter *et al.*, 2013). This can contribute towards achievement in chemistry (Udo, 2010; Udo & Etiubone, 2011:212-215).

6.4.4 Impact of computer simulation on authentic (AGAU) engagement

CS did not have a positive impact on the overall perceptions regarding authentic engagement even though it showed positive impact on some of the construct variables, with regards to activities related and matched real-world tasks (Au1), promote collaboration (Au2), help learners understand most difficult concept (Au3), opportunity to create and use variety of resources (Au4), opportunity to examine problems (Au5), allow reflection on learning and creativity(A7), promote engagement in learning (Au8) (see Table 5-9, section 5.3.5, 5.6.4, 5.6.5.1).

According to the pre-test results on computer simulation (Table 5-16), the expectations of the teacher participants were the lowest for authentic engagement compared to the other engagement components but yielded a small change of the mean in the post-test. In other words, the use of computer simulation in the intervention had no impact of practical significance (Table

5-17) on participants' perceptions of the effect computer simulation can have on authentic engagement.

CS strategies can be used to transfer scientific knowledge and skills effectively. Making connections between subjects through CS activities can afford integrating knowledge acquired in class to the real-world. These results align with the findings of Alexe (2013), Rackaway and Goertzen (2008) as stated in section 3.4.4, namely CS enhances the transfer of knowledge, skills, and abilities from the classroom to real-world environments. Exposing learners to simulations and tasks relevant to them in real-life provides a feeling of purpose and responsibility for their own learning progress and reinforces concepts taught earlier (Frederking, 2005). An application example is that the element carbon is present in coal and charcoal used daily.

Therefore, it helps to reach out to unengaged learners to engage in learning and to induce a positive effect on chemistry achievement. In the intervention, CS increased AGAU engagement by providing appropriate understandable science activities involving an active discussion in groups to get difficult unmotivated learners engaged in the learning (see section 5.3.4, 3.3.3.1). Working in groups to complete the simulation activities provided on PhET and the worksheet promoted collaboration within the class leading to retaining and remembering both content and context, aligns with (Pinel 2017, Schlechty, 2011).

CS afforded an opportunity to use a variety of resources rather than a limited number of preselected references that require deleting irrelevant information (section 5.6.4 iii). CS also provides a variety of resources to make choices for solving problems. CS provides contextual activities and practices, including finding solutions to related problems, help learners to give meaning to scientific concepts (Gilbert, 2006; De Jong, 2008). According to Chi and Wylie (2014), the more engaged you are with resources the greater the learning gain. This implies that learning resources are essential factors for increased behaviour engagement (see section 3.4.3, 3.4.3.2, 3.5.3).

The results show that CS apply assessment of the activities as integration within the major task in a manner that reflects real-world assessment rather than a separate artificial assessment. This implies CS create opportunities to reflect on learning and real-world assessment. Moreover, the results indicate CS activities matched as nearly as possible real-world tasks of professionals in practice (see section 3.3.3, 3.3.3.1, 3.4.2.2).

6.5 AFFORDANCES

Affordances can be detected from the responses of participants (Broman *et al.*, 2018). In this study, responses to the questionnaire, focus group interviews and individual interviews, class and

lesson observation, the worksheet activities and questions were used to determine the affordances of the engagement strategies music, context-based inquiry, and computer simulation. This section discusses the realized affordances identified from the qualitative and quantitative results in terms of affective, cognitive, AGAU(agentive/authentic), and behavioural engagement. It revealed that having valuable engagement strategies within a learning environment afford advantages for learning the PT.

6.5.1 Affordances of music

Musical affordances are the specific things we can do with music (Krueger, 2014). These specific things in this study include learning the names, atomic numbers, symbols of the first twenty elements of the PT, maintaining affect influences, enhancing active involvement and responsible interaction with song and resources (see section 1.2, 4.5.1, 5.3, 5.6, 6.2.1 to 6.2.4).

Affordances presented by music as a learning engagement strategy in this study provided new opportunities to engage in the composition of songs in the classroom. The technological affordance (use of the internet, YouTube videos and other software) allowed individual learners or groups at the computer to take control of their own time (Gall & Breeze, 2005). This is in accordance with constructivism learning theory (CLT) (see section 2.4, 2.4.1, 2.5).

The usefulness of MU engagement affords cognitive, behaviour and, to a lower extent affective and authentic engagement. Cognitive engagement is afforded in learning basic concepts related to the PT. More specifically, MU affords active construction of knowledge through repetition and memorization of existing songs, as well as through freedom and creativity of composing own songs. In this way, music affords mastering and integration of content knowledge to improve performance and achievement in chemistry and other scientific subjects.

The ability of MU to arouse and enhance interest affords affective engagement in learning the names and symbols of the PT easily. The MU intervention afforded enjoyment while composing own songs using PT concepts as lyrics and singing along pre-recorded PT songs. The affordances of enjoyment activate prior knowledge which enhances learning the PT. Enjoyment affords a pleasant, friendly working atmosphere which activates an effective learning environment. This develops satisfaction and creativity and consequently affords passion for learning chemistry.

MU affords participation which helps with concentration in class on doing and completing the task. Participation in music activities affords behaviour engagement and influences behaviour positively. MU enhances collaboration, working together to compose a song using PT content, and affords corporation to complete the task. Concentrating and attentively watching the pre-

composed PT video songs affords attention and focusing on the content. Furthermore, affordances of behaviour engagement (concentration, active participation, and focusing on learning) induce understanding. What is more MU's ability to induce understanding a topic affords understanding of chemistry through active involvement in the MU activities.

Music-based activities afforded meaningful, valuable, significant tasks relevant to learners. Therefore, MU affords the opportunity to take responsibility of their own learning by composing the PT song. This affords AGAU engagement especially regarding selecting their own lyrics and rhythm as part of the learning activities, increasing learning engagement. A variety of resources (effort, time) and relevant information (PT chart, information sheets) available for /provided by MU affords engagement with relevant content and resources.

6.5.2 Affordances of context-based inquiry

The context-based inquiry problem and other learning tasks such as the combustion reaction investigation, experiment, and other approaches (see section 4.5.2, 5.3.2, 6.2) resulted in different affordances. For instance, planning and investigating context-based inquiry (CB) allowed designing and conducting investigations within a real-world context that affords cognitive engagement. The use of investigative laboratory activities in CB provides cognitive and social affordances that support construction of knowledge and understanding of scientific phenomenon (Kozima, 2003:200-224).

CB provides opportunities to identify and investigate real-world problems that make learning more meaningful. Activities that relate to real-world scenarios (included in context-based problems and context questions) affords scientific values and beliefs. The ability to complete the CB project and solve the context-based inquiry problem created satisfaction and a sense of positive emotion. Hence affective engagement was afforded.

CB activities and tasks on PT have affordance of active participation of learning the PT, especially on problem solving and working harmoniously in a team to complete the tasks affords problem solving skills and active involvement. Therefore, CB affords active participation regarding involvement, concentration and focusing on finding the solution to the context-based problem. Focusing, cooperating and concentrating attentively in class affords behaviour engagement. Affordances of the planning and carrying out the investigations affords experiencing a phenomenon physically, for instance, observing the colour of flames during the combustion of elements. Additionally, through the use of the worksheets the context-based project procedure affords manipulating facts manually, as in accordance with the findings of (Wu & Puntambekar, 2012).

Affordances of the CB project were identifying factors from the real-world scenario that are important for demonstrating combustion and applying combustion reaction of magnesium, lithium, phosphorous, sulphur, carbon, hydrogen in everyday life affords curiosity. This affords authentic engagement, especially with regards to real-world application of the knowledge acquired to solve the context-based inquiry problem. The interaction within the team to investigate and find solution affords responsible constructive contributions.

6.5.3 Affordances of computer simulation

Computer simulations allow conducting investigations by changing variables that are difficult or impossible to manipulate in the physical world (Wu & Puntambekar, 2012) for instance, building atoms and molecules. Additionally, CS afforded interpretation of data using charts, graphs, and vectors from the PhET interactive simulation.

Affordance of CS activities (see section 4.5.6, 5.3.1, 6.4.1) enabled visualisation of abstract concepts which enhances learning scientific concepts. Effective use of technology through PhET afforded understanding building and identifying stable atoms (Na, Cl, O, S, H and C) and molecules (NaCl, H₂O, SO₂, CO₂ and HCl). Visualising these stable atoms and molecules affords conceptual understanding towards understanding concepts of the PT. Therefore, affordance of CS enhances the ability to master the PT by providing opportunity to visualise abstract concepts. Therefore, CS activities afford learners to work at higher cognitive levels (Wu & Puntambekar, 2012) thus, affords cognitive engagement.

Simulating the abstract concept of atoms and molecules aroused interest to learn. The abstract concepts were visualised using different visualisation by computer simulations. This affords fun and memorable experiences which provide enjoyment. Consequently, CS affords managing emotions to improve affective engagement. The affordances of the simulated visualised abstract concepts afford easy learning of PT, feeling of satisfaction and enjoyment. Hence, affordances of affective engagement are to create and develop passion for chemistry using CS due to the in-depth understanding of PT.

CS activities and tasks on PT have affordance of active participation in learning, especially about problem solving. This affords problem solving skills and active interaction hence, CS affords behaviour engagement. This implies that behaviour engagement affordances support active involvement when manipulating the simulations and completing the activities which affords active engagement to enhance learning.

The simulation tasks and activities also provide affordances that facilitate interaction in practice. Manipulating the variables to build the atoms and molecules affords exposure to meaningful, relevant information. That is to say CS affords AGAU (agentic/authentic) engagement.

The study showed that CS provided new affordances that enabled learners to gain a wide range of experience relating to science in the real-world, including active participation, teamwork and collaboration, which were useful for learners to engage in meaningful learning and improve achievement in chemistry. Activities using CS thus afford learning and understanding scientific concepts that can bring about conceptual change in accordance with the constructivist theory.

6.5.4 Affordances of the combination of music, context-based inquiry, and computer simulation (MUCBCS) as an engagement strategy

Each of the three strategies (MU, CB and CS) have unique affordances that made special contributions to learning about the PT. Where similar affordances occurred, the combined use of the strategies (MUCBCS) strengthened the effect and impact. Affordances of MUCBCS follow from the results, namely:

- (i) MUCBCS affords improvement of knowledge and skills to master content which may even get unmotivated learners engaged in learning.
- (ii) MUCBCS affords enhancing learners' ability to engage in effective acquisition of chemistry content, knowledge, and skills.
- (iii) MUCBCS affords a pleasant and a friendly working climate. Thus, creating a conducive class environment for learning.
- (iv) MUCBCS affords active participation, curiosity, and completing tasks in teamwork (interpersonal, work harmoniously in a group, counted on to do part in a group).
- (v) MUCBCS affords repetition and memorisation, contextualisation and conceptualisation and visualisation of content knowledge.
- (vi) MUCBCS affords increase in learners' ability to understand and apply abstract concepts.

MUCBS thus affords cognitive, affective, behavioural, and AGAU engagement for learning and achieving in chemistry.

6.6 SUMMARY OF FINDINGS

Considering all the intervention results, MU had the highest impact on participants' perceptions regarding cognitive engagement, followed by behaviour then affective with agentic/authentic (AGAU) engagement as the least. CB had the highest impact on affective, followed by cognitive, authentic and the least behaviour engagement. For CS, cognitive had the highest impact, followed by affective, then behaviour with authentic engagement as the least. Figure 6-1 combines all the results to determine the impact of the combined strategies MUCBCS on the four components of engagement.

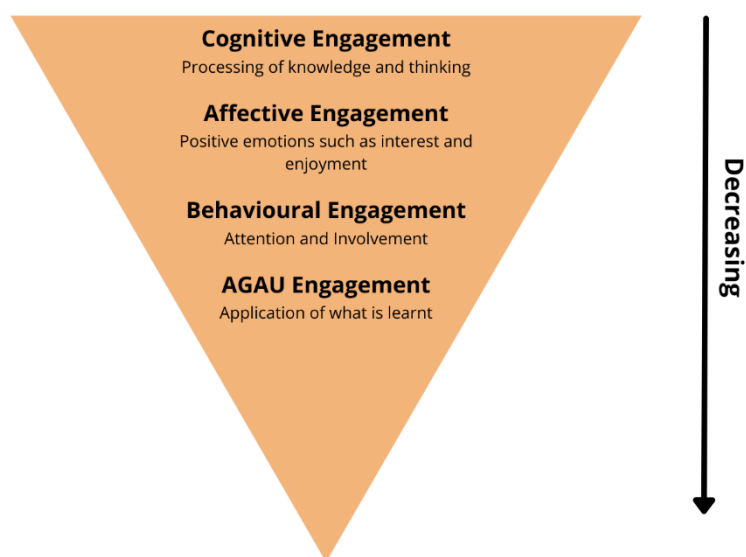


Figure 6-1: Impact of MUCBCS on the four components of engagement.
(Image by author)

Figure 6-1 illustrates the impact of MUCBCS from the highest to lowest impact: Cognitive engagement, affective, behavioural and AGAU engagement due to the intervention. The arrow shows decreasing, descending order.

The literature study, results, interpretation of results and findings clearly shows that the meaningful learning of chemistry, mastery, understanding of scientific concepts, performance, and achievement in chemistry can be obtained through engagement that is, active involvement and participation. For this reason, a model of teaching and learning with more focus on the learner and learning is ideal for achieving the aforementioned characteristics of effective learning, academic performance, and achievement in chemistry. MUCBCS fits into this model because MU, CB and CS enhances engagement to the development and maximum implementation of the affordances of this strategy and maximise the affordances in order to learn the PT towards achievement in chemistry.

In conclusion, an engagement wheel for MUCBCS as an engagement strategy that can be applied in South African school chemistry curriculum is illustrated below in Figure 6-2.

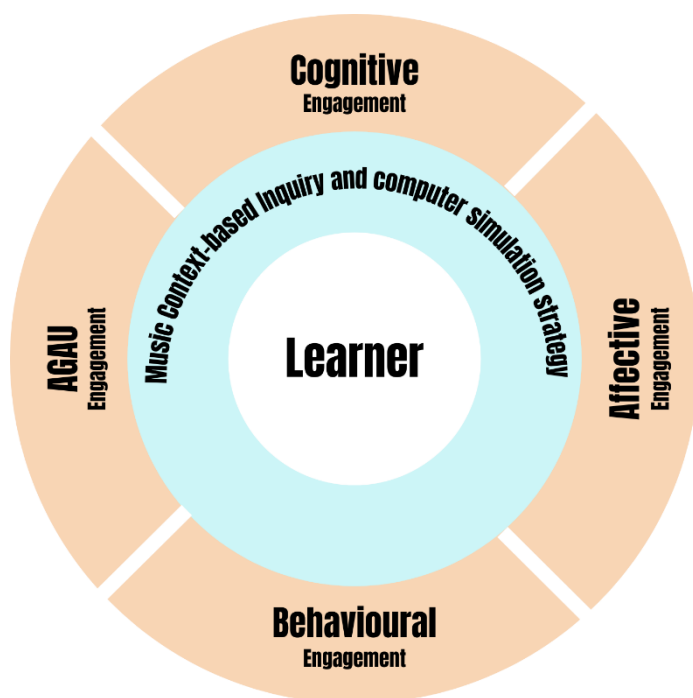


Figure 6-2: Engagement wheel for MUCBCS as an engagement strategy
(Image by author)

The summary, conclusion and recommendation from the empirical results and analysis of the affordances of the engagement strategy music, context-based inquiry, and computer simulation (MUCBCS) on the four components of engagement in learning the first twenty elements of the Periodic Table (PT) is reported in chapter 7.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This study was conducted in order to address the primary aim of investigating and analysing the affordances of the engagement strategies music, context-based inquiry, and computer simulation based on their impact on the four components of engagement (behavioural, emotional, cognitive, and AGAU engagement) in learning the first twenty elements of the Periodic Table (PT). The reason for pursuing this aim is contained within the research problem that the current method of learning the PT of elements at grade 7-12 level is not sufficiently engaging the learners. Thus, the motivation for undertaking the current study was to devise a guideline for creating and enhancing engagement to be made available to teachers of the South African chemistry curriculum.

This chapter presents summaries of previous chapters, key findings of the empirical study, conclusions and recommendations. The chapter commences with an introduction (section 7.1), an overview of the chapters (section 7.2), and the implementation of the theoretical framework in the study (section 7.3). Thereafter, answers to the research questions were addressed (section 7.4). This chapter continues to present the conclusion (section 7.5), limitations of the study (section 7.6), recommendations for policy, practice and future research (section 7.7).

7.2 OVERVIEW OF THE CHAPTERS

In order to provide a context pertaining to the answers to the research questions, conclusions and recommendations are discussed in sections 7.3 to 7.7, a summary is given of the study's objective, the main concepts are addressed (Chapters 2 and 3), the research methodology (Chapter 4), the findings (Chapter 5), discussions and interpretation of the findings (Chapter 6).

Chapter 1 introduces and summarises the research study. Core to the study are the statement and motivation of the research problem and research questions. The method followed in the empirical study to answer the research questions was described with ethical considerations.

Chapter 2 provided background to the learning concept by discussing learning theories within a school context, specifically focusing on the constructivist learning theory (CLT) and multiple intelligence theory (MIT). The chapter highlighted the importance of the interrelation between constructivism and multiple intelligence to the study (section 2.5 and 2.7). Research has shown that MIT and CLT are based on the premise that each learner is unique and needs a strategy of learning that suits the individual intelligence towards engagement and mastery learning. Hence to embrace each individual learner's uniqueness and intelligence, a literature study of

engagement, learning strategies, their importance, and practical tactics that can be applied in the classroom by the teacher to enhance learning engagement is elaborated in chapter 3.

Chapter 3 continues to explore different learning engagement strategies, the properties, and importance of the PT in chemistry, the characteristics of music, context-based inquiry, computer simulation and the four components of engagement, namely agentic/authentic(AGAU), affective/emotional, behaviour and cognitive engagement.

There are many important aspects and benefits of engagement in learning as well as some challenges (see section 3.4 to 3.6). However, these barriers to engagement can be eliminated using simple, workable, effective learning engagement strategies (Abla & Fraumeni, 2019; Marzano & Pickering 2010). This led to investigating the use of music, context-based inquiry, computer simulation as learning engagement strategies.

Chapter 4 provides an overview of the research and describes how the research method was implemented. A variety of approaches was implemented in this study as discussed in sections 4.4 to 4.7, leading to various results that made the findings authentic and acceptable. The sequential explanatory mixed method design include qualitative and quantitative approach. The theories behind the selected approaches, methods and principles are outlined (see section 4.3.1-4.3.6). Furthermore, findings from literature emphasis the important role of a teacher, as well as teacher intervention in the improvement of engagement (Nueva & Calica, 2018:123). For this reason, the participants that took part in this research intervention workshops were teachers (see section 4.4.1-4.4.4).

Chapter 5 critically examined and analysed the quantitative data generated from the administration of the questionnaire and the qualitative data gathered by the use of semi-structural interviews, focus groups, worksheets, intervention, observation, and classroom observation of selected teacher. The quantitative data was examined to discern what perceptions are reflected in the teachers' responses to the items in the questionnaire and to statistically seek any patterns or contradictions that emerge with respect to their views on the use of music, context-based inquiry, and computer simulation as engagement strategy on the four components of engagement: cognitive, affective, behaviour and AGAU engagement.

The focus group interview, worksheets, observations, and individual interview data (qualitative) were analysed to see if the participants' views of the impact of music, context-based inquiry, and computer simulation on cognitive, affective, behaviour and authentic/agentic (AGAU) engagement are consistent with the views indicated in their responses to the questionnaire

(quantitative) and to probe for affordances and guidelines useful for implementing these engagement strategies in South African chemistry curriculum.

In the discussion of results in Chapter 6, it was indicated that the results of the study suggest that Music (MU), context-based inquiry (CB) and computer simulation (CS) as learning engagement strategies can be used to promote learning engagement in different ways. Therefore, it helps to reach out to learners with different backgrounds struggling to engage in learning and to ultimately induce positive effect on chemistry achievement.

7.3 IMPLEMENTATION OF THEORETICAL FRAMEWORK IN THE STUDY

The empirical study is based on two theories related to learning engagement, namely constructivist learning theory (CLT) and multiple intelligence theory (MIT).

CLT emphasises that learners' knowledge is constructed from their existing knowledge (Novodversky, 1997:242; Barkley *et al.*, 2005:28; Fernando & Marikar, 2017; Jacobs, 2004:46). Moving from basic knowledge to more complex and abstract knowledge (Fauziati, 2016; Budiman, 2017). Therefore, the intervention started with the basic concepts of the elements in the PT (phase 1), commenced with the combination of elements in chemical (combustion) reactions (phase 2). Knowledge obtained in phases 1 and 2 were affirmed, explained, and broadened in phase 3 which used visualisation to simulate more abstract concepts and processes.

Social constructivism also emphasises the importance of cognition, affection, social behaviour and authentic in meaningful learning, which were the components of engagement studied.

According to the MIT, individual learners have different dominant intelligence(s) (Blythe & Gardner, 1990; Stanciu *et al.*, 2011). Therefore, variety of engagement strategies and different learning styles to suit the different dominant intelligence(s) and learning style should be introduced in the classroom to accommodate MIT and CLT views as discussed under (section 2.4, 2.4.2-2.6.4, 2.7, 2.7.1- 2.8). Hence, the three strategies applied in this study were chosen because learners with good rhythm react more positively to music. Those who are more investigative of nature may learn more from inquiry strategies while visual-orientated learners may prefer computer simulations. Linguistic oriented learners get to communicate as they discuss the PT content to use as lyrics, how to solve the context-based inquiry problem, and during the debriefing after the computer simulation activities. Body-kinaesthetics oriented learners get to skilfully handle and use apparatus in the context-based inquiry. Moreover, MU portray body-kinaesthetics intelligence, participants dancing using movement as they presented their composed PT song (Figure 4-8). Using the atomic number 1 to 20 in the songs, measuring chemicals as part of CB

activity, and CS, identifying the precise number of atoms to build for example, O₂, NaCl molecules are portraying logical-mathematical intelligence.

Affordance of MUCBCS (i.e., the combination of the three strategies MU, CB and CS) is the ability to reach several different learner types at varying cognitive levels and learning styles and academic backgrounds. Affordance of reaching varying types of learners is due to how MUCBCS is designed and presented. It is designed and implemented within the context of MIT (Multiple Intelligence Theory) and CLT (Constructivist Learning Theory). MUCBCS affords effective use of verbal and written words (Linguistic intelligence), numbers (Logical-mathematical intelligence), Musical intelligence (ability to express ideas in music), Interpersonal intelligence (the interaction and understanding among individuals), Intrapersonal intelligence (mainly self-knowledge). To achieve all these affordances in answer to the research questions, the study was guided by MIT and CLT.

7.4 ANSWERS TO RESEARCH QUESTIONS

The primary research question to be answered in this study was:

What can music, context-based inquiry, and computer simulation activities afford towards increasing learner engagement within the classroom to improve academic progress and performance on the Periodic Table? To find an answer to the primary research question, five secondary research questions guided the study. The answer to the primary research question follows from the combined perspectives of the answers to the secondary research questions.

The secondary research questions were answered through an empirical study. The empirical research provided an answer to the primary research question, and recommendations regarding the effect of music, context-based inquiry, and computer simulation as engagement strategies on the teaching and learning of the first twenty elements of PT follows from section 7.4.1 to 7.5.

7.4.1 Answer to research question 1

What is the impact of music activities on the four components of engagement (behavioural, affective, cognitive, and authentic (AGAU) engagement) in learning the first twenty elements of the Periodic Table?

Music as a learning engagement strategy (MU) resulted in achieving an increase in engagement, improved test scores, making new information meaningful, developing interest, learning and memorisation. Although this study did not attest to improving post-test scores for all the construct variables (see section 3.3.1, 5.3, 5.6, 6.2), most of those pre-test scores were already high (above 80%). MU activities as described in chapter 4 (see section 4.2.4.1) and results from the empirical

study (see section 5.3-5.5, 6.1, 6.4.1.1) are summarised in figure 7.1, showing cognitive behaviour as having the highest impact with medium effect in participants' perceptions. The impact was measured quantitatively with Cohen's effect sizes (section 5.5.2) and supported by the qualitative data.

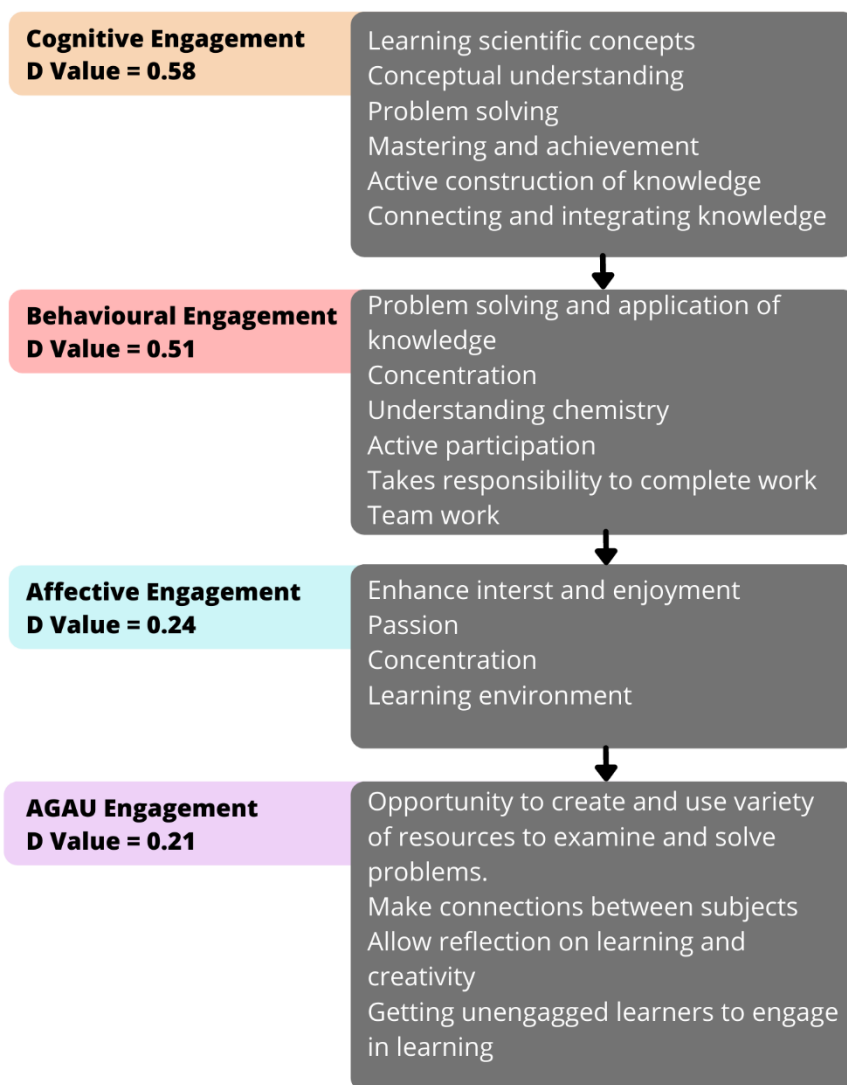


Figure 7-1: Hierarchical impact of MU on the four components of engagement
(Image by author)

MU had an impact on the four components of engagement, with cognitive engagement recording the highest and authentic the lowest (Figure 7.1). With regards to cognitive engagement, the active construction of knowledge, using MU increased engagement to learn the scientific concepts, names and symbols of the first twenty elements of the PT, assist in mastery learning of PT. Mastery and meaningful learning of PT bring about conceptual understanding ultimately conceptual change and the endpoint is academic achievement in chemistry. These findings are

based on the theoretical framework, which states that verbal intelligence represents sounds, rhythms, different functions of language, which allows an individual to portray mastery by asking, describing, writing, explaining and remembering information, in this case, related to the first twenty elements of the PT. Learning the elements sequentially according to their atomic numbers from one to twenty also draws on MIT and supports mathematical-logical intelligence. Furthermore, the use of MU to enhance cognitive engagement affords active involvement in constructing own knowledge of scientific concepts (PT) as backed by CLT (section 2.4).

MU promoted behavioural engagement by providing opportunity to watch music videos which afforded paying attention in class attentively. Watching music videos increased visual intelligence since it embraced spatial/visual learners who love music and whose sense of enjoyment is in writing and visuals. Behavioural as the engagement with the second highest impact of MU includes engaging in active participation while taking responsibility to complete work. In addition, working harmoniously and being counted upon to contribute to the completion of the given task within a teamwork was afforded by MU towards behaviour engagement (6.2.3).

Furthermore, MU compelled learners to participate actively in class by engaging with the PT. This includes selecting content to compose own song from the first twenty elements of the PT or sing and learn the pre-composed song as evidence of concentrating on the task. Learning as observable change in behaviour (Ertmer & Newby, 2013) is displayed to demonstrate problem solving skills towards understanding chemistry. Learning as an observable change and active participation complies with CLT while working harmoniously with others reflect MIT interpersonal intelligence.

The impact of MU on affective engagement is reflected in the ability to create a favourable learning environment for bodily-kinaesthetics intelligence in learners who enjoy creating things, movement and maintaining a high sense of memory by doing (see 2.7.4.). MU provided resources for composing their own song about names, symbols, atomic numbers of the first twenty elements of PT, affording the opportunity to sing and dance. This increased interest and enjoyment among learners (see section 6.2.2) with musical intelligence who enjoy composing songs, singing and dancing (Cherry 2018; Dickinson *et al.*, 2002; Lane, 2000). And also increased passion for pursuing chemistry. What is more, engaging those with musical intelligence produce forms of musical emotions that enhance affective engagement.

Authentic engagement provided an opportunity to create and use a variety of resources to examine and solve problems and make connections between subjects that allow reflection on learning and creativity. According to radical constructivism, the availability of multiple resources

and engaging with these resources creates an appropriate learning environment for constructing unlimited and unrestricted knowledge (see section 2.5.3).

Consequently, learners struggling to engage in learning got involved in learning the names, and symbols of the first twenty elements of the PT.

The investigation on the impact of music activities on the four components of engagement (behavioural, emotional, cognitive, and authentic/agentive (AGAU) engagement) in learning the first twenty elements of the PT shows that MU affected all four components, with a major impact on cognitive and behavioural engagement and much lower impact on affective and AGAU engagement. The reason may be that the teachers expected music to afford affection and authentic (with highest pre-test scores). They may not have thought that music could be as effective for cognitive learning and expected behaviour problems. However, the intervention seems to have shown them the value of cognitive engagement with MU and seems to have increased their perceptions about behaviour problems (or at least aspects thereof). Therefore, significant higher scores were given in the post-test than the pre-tests for these two.

7.4.2 Answer to research question 2

What is the impact of context-based inquiry activities on the components of engagement in learning about the Periodic Table elements magnesium, lithium, phosphorous, sulphur, carbon, oxygen, hydrogen and linking their use to everyday experiences?

Context-based inquiry as an engagement strategy enhanced students' knowledge of elements of the PT, enjoyment, beliefs and values, interest, skills to solve problems, create passion, and increase performance in chemistry. The challenge given to the participants in CB project challenge was to identify a metal or non-metal and to explain how the combustion of that element can be used to generate energy for communities in South Africa (see section 4.5.2). The context-based inquiry project included knowledge about combustion of magnesium, lithium, phosphorous, sulphur and carbon in oxygen. It also involved skills such as measuring chemicals, handling equipment, formulating hypothesis, and conducting experiments (touching and doing).

That is to say, CB promotes engagement (see sections 3.3.2, 5.3, 5.6, 6.3). CB activities as described in chapter 4 (see section 4.2.4.1) and the results from the empirical study (see section 5.3-5.5, 6.3.1-6.3.4) are summarised in Figure 7.2.

CB had the highest positive impact on the affective construct, on participants' perceptions and the least impact on behaviour. Attainment of scientific beliefs and values were specifically highly favoured under CB.

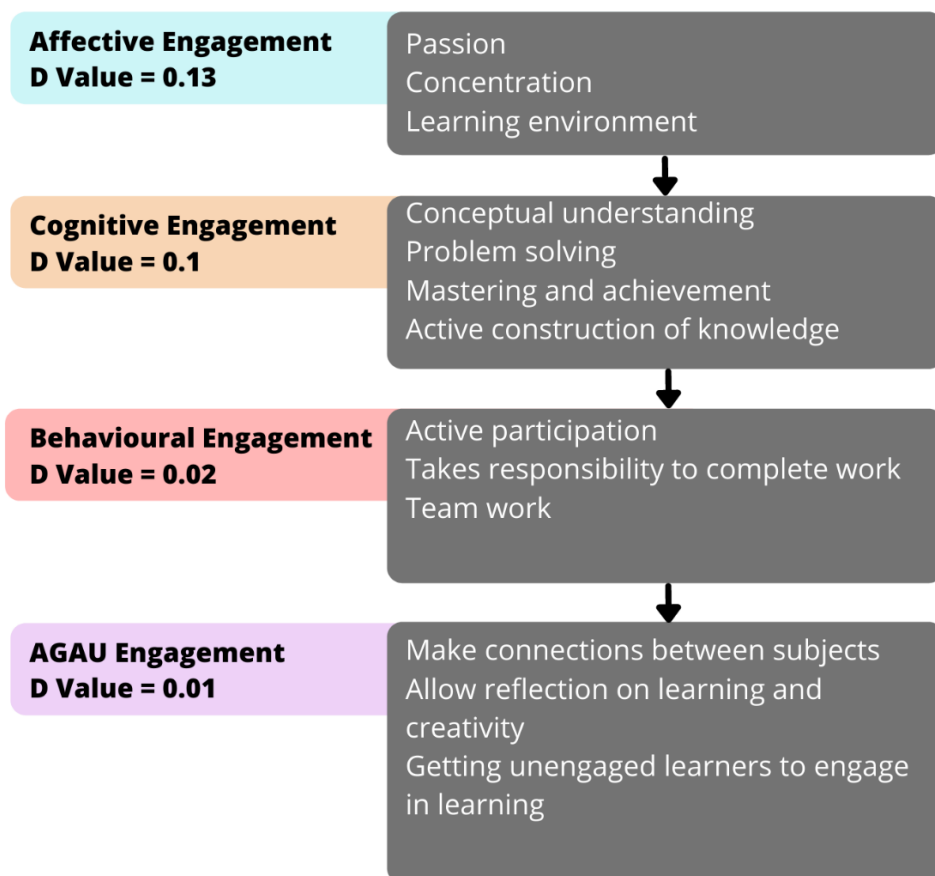


Figure 7-2: Hierarchical impact of CB on the four components of engagement
(Image by author)

The impact of CB on affective engagement is reflected in creating a pleasant learning environment by concentrating on investigating magnesium, lithium, phosphorous, sulphur, carbon, oxygen, hydrogen and linking their use to everyday experiences through a context-based inquiry project activities (see Figure 4.9, section 5.3.3, 5.6.4, 6.3.2). The activities apply logical mathematics and bodily-kinaesthetics intelligence. The active involvement in constructing knowledge through a CB project stimulates excitement (Shamsudin *et al.*, 2013). CLT is thus also applied in the enjoyment of doing the CB project, while constructing knowledge making learning PT fascinating and easier thus improves interest (see section 5.3.3, 5.6.4). Therefore, CB promotes learning engagement and interest in chemistry (King, 2011; Herranen *et al.*, 2019).

Using CB to learn scientific concepts related to PT (see 5.3.1, 5.6, 6.3.1) increased cognitive engagement. It afforded active involvement in constructing knowledge through the context-based project that presented challenges and opportunities to develop scientific process skills and related the problem to real-life scenarios. CB follows inquiry-based learning which is in accordance with CLT (see 2.6).

This implies that the impact of CB on cognitive engagement was reflected in the active constructing of scientific concepts in the context of the PT. This promoted a positive attitude towards learning chemistry, enhanced scientific skills, knowledge, and performance in chemistry (see section 6.3.1). CB role in cognition related to logical-mathematics (MIT) is the opportunity to handle reasoning and think logically to solve the context-based inquiry problem.

Authentic engagement was impacted by CB through activities that required solving a real-world problem within the context-based project making connections between other subjects. These authentic activities afforded following scientific procedure and engaging in scientific learning process that used science in the way real scientist would do (Taylor *et al.*, 2016). Which allowed reflection of the learning process. Using CB to solve real-life problems improves authentic engagement and achievement (Doppelt *et al.*, 2008) which can open up active discussions to get unmotivated and difficult to engage learners to engage in learning (see 3.3.3.1, 6.3.4).

Concentrating on the process skills to solve the context-based inquiry problem improved active participation. The continuous participation, identification of individual contribution and working harmoniously in the team to complete the structured problem solving activities afforded increase in behavioural engagement. The communication and interaction with one another increased corporation within the team and embraced verbal intelligence, social constructivism, and interpersonal intelligence.

The impact of context-based inquiry activities on the components of engagement in learning about the PT elements magnesium, lithium, phosphorous, sulphur, carbon, oxygen, and hydrogen and linking their use to everyday experiences shows that CB had an impact on the participants' perceptions regarding affective engagement, followed by cognitive engagement and much lower impact on authentic and behaviour engagement. According to the Cohen's d-values, the impacts of all four components were small. The reason may be that the participating teachers already had a good idea before the intervention about CB's effect on engagement due to their familiarity with inquiry learning. The intervention confirmed their expectations.

7.4.3 Answer to research question 3

What is the impact of computer simulations on the components of engagement in learning basic concepts of the Periodic Table?

Computer simulation as a learning engagement strategy can improve problem solving skills, enhance the learning environment and give learners opportunities to manipulate variables in science. These affordances were indicated to allow learners to apply and test what they learn, increasing understanding of theories and concepts and improving performance in chemistry. It

may further result in a substantive gain in knowledge, critical thinking skills while it provides fun and memorable educational experiences (see sections 3.3.3, 5.5, 6.4.1-6.4.4, 6.5.3

Computer simulation as an engagement strategic tool (CS) promoted perceptions of three out of the four components of engagement. These are behaviour, affective and cognitive engagement with small to medium changes in participants' perceptions. CS presented an increasing impact from authentic (the least) to cognitive the highest impact on engagement. Computer simulation as an engagement strategic tool, from the participants' perceptions, promoted the four components of engagement during the intervention at varying degrees, as displayed in Figure 7-3 in descending order.

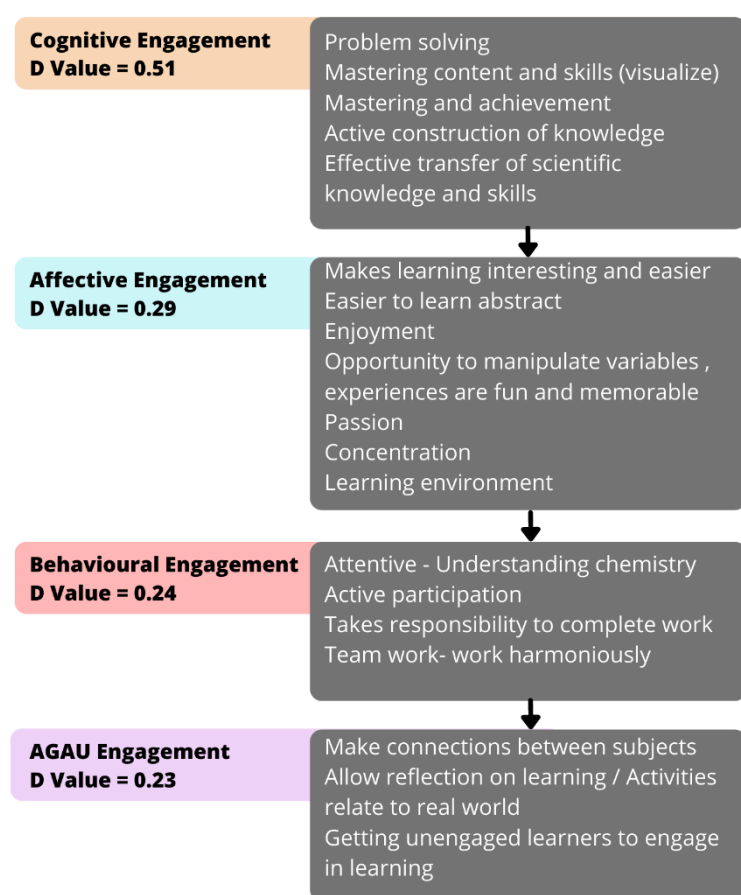


Figure 7-3: Hierarchical impact of CS on the four components of engagement
(Image by author)

Cognitive engagement increased with CS activities through building stable atoms for Na, Cl, O, S, H and C using PhET computer simulations. Additionally, more complex molecules composed of different elements (NaCl, H₂O, SO₂, CO₂, and HCl) were also constructed (see 3.3.5.2, Figure 4.11). The results indicated that the aforementioned CS activities created an atmosphere for effective learning of scientific concepts and conceptual understanding. The efficient use of CS to

transfer scientific knowledge and skills enhances the ability to master chemistry content (PT) since it visualises abstract concepts (see section 3.3.5.2, 5.3.2, 6.4.1).

In addition, logical-mathematical intelligence empowers individuals to use and appreciate abstract relations (Cherry, 2018). The following present study findings are in accordance with MIT and Cherry's, (2018) results. CS's ability to provide a good picture of a problem improve problem solving skills and the opportunity to visualise abstract concepts, and relations affords a positive impact on learning and achievement while increasing cognitive engagement (see section 2.7.2, 3.3.3.2, Table 5.6, 6.4.1 to 6.4.4).

Using visual technology-based simulations (PhET) afforded opportunities to allow viewing, visualising, virtual manipulating, and interacting with objects and variables. Visualisation with CS afford improvement in understanding chemistry (Jones *et al.*, 2005). CS involve kinaesthetics such as hand-eye coordination and manipulation during visual observation and manipulation of variables, animations and pictures of the atoms and molecules. Through visualisation and hand-eye coordination included in CS PhET activities, spatial-visual and kinaesthetics intelligence are enhanced. Creating mental images, strengthening effective learning of scientific concepts, and increasing conceptual understanding increased understanding of chemistry (see section 2.7.4, 2.7.6, 3.3.3.1, 3.3.3.2, 5.3.2, 6.4.1).

Affective engagement is improved by managing emotions. On this note, CS discussions, including debriefing, created excitement (see section 5.6.4, 6.4.2) in anticipation to talk about emotions and how a learner feels about the CS activities aligns with (Bouvier *et al.*, 2014). The excitement flows through the activities creating a pleasant, exciting environment that strengthens affective engagement which, is in line with (Skinner *et al.*, 2008; Aslop & Watts, 2003) results. CS afforded a friendly conducive learning environment creating interest to learn and gain an in-depth understanding of the PT in chemistry, stirring passion for pursuing chemistry related career. Building the atoms and molecules and manipulating other variables enhanced critical skills in educational experiences that are fun and memorable (see section 3.3.3.1, 3.3.3.2, 6.4.1.2, 6.4.2.2). This built-up enjoyment, aroused interest and afford satisfaction making learning the PT with CS easier. Concentrating on building the atoms and molecules of PT elements while learning, thus promoted affective engagement.

Computer simulations create opportunities for learners to experience interactive activities. According to constructivists (CLT), these interactive activities create positive affect (Jia, 2010). With regards to MLT discussions in teams promote verbal, visual, and bodily-kinaesthetics intelligence. CS provides opportunities for representing affective and behavioural engagement (Alexe, 2013).

Behaviour engagement increases when CS afford active participation through manipulating the simulation, completing CS activities, visualising relationships between variables and answering questions (section 6.4.3). Learners with dominant kinaesthetics, visual and verbal intelligence are catered for. During the debriefing verbal and interpersonal intelligence came into force demonstrating the ability to communicate and interact with others.

The effectiveness of CS on behaviour engagement is affording the opportunity to ask and answer questions while solving problems related to CS activities on the PT. The affordance of CS is to allow learners to generate and present questions, visualise, and present findings, evaluate PhET simulation used to build the atoms and molecules, and to complete tasks independently and in a group. CS thus created the opportunity to increase behavioural engagement by allowing interaction with effective instructional resources, paying attention (Skinner *et al.*, 2008) and concentrating on completing the given task and activities on the PT. Furthermore, it developed enthusiasm and corporation to support active engagement that strengthen effective learning of the PT.

Authentic and agentic engagement (AGAU) increased when activities relate to solving problems related to the real-world and making constructive contributions to arrive at the solution. CS afforded integration of knowledge acquired in class with the real world for instance, coal and charcoal consist of carbon atoms. Opportunities are provided for unmotivated learners to engage in learning by using CS activities that allow them to discover and reflect on their learning and contribution in class.

The investigation on the impact of computer simulation on the components of engagement in learning and understanding basic concepts of the PT shows that CS had the largest impact (of medium effect) on cognitive engagement while it impacted with small effect on, affective, behaviour and authentic engagement. The post-test results for CS cognitive engagement had the largest value of all constructs, indicating the large cognitive engagement experienced by the participants during the CS intervention.

7.4.4 Answer to research question 4

What are the affordances of context-based inquiry, music and computer simulation engagement strategies in learning pertaining to the Periodic Table?

All three intervention strategies (MU, CB, CS) engaged learners in affective, authentic, behavioural, and cognitive engagement by focusing on the learners and placing them in the centre of the learning environment. The learner-centred approach (in accordance with MIT and CLT) promoted active participation, which then supported their perception of doing well in chemistry.

The study intervention entailed a sequence of activities related to the PT, starting with MU, followed by CB and then CS. The collaborative activities generated songs (music), solution to a daily life problem (context-based inquiry) and models of atoms and molecules (computer simulation) as representations. The results of coordinating the construct variables of these representations afforded mastery learning of the first twenty elements of the PT under multiple intelligence theory and constructive learning theories through increased learning engagement.

Each of the engagement strategies yielded distinctive affordances as discussed 6.5. to 6.5.4. The MU, CB, CS affordances differ for the different intelligence (the eight multiple intelligences) and for the four components of engagement in learning the first twenty elements of the PT. Consequently, the three strategies afforded the following with regard to the components of engagement:

- **Cognitive:** Learning about the first twenty elements with cognitive engagement is evident as a conducive learning environment was afforded with repetitions, reinforcement and mastering of concepts related to the PT. The intervention commenced with repetitive learning of the basic concepts using MU (songs) in the first phase. Progress was made in the CB phase to understanding of more complex concepts such as combustion reactions of elements. Finally, abstract explanations of atoms and molecules building (formation) of atoms and molecules took place in the CS phase to ensure conceptual mastering.
- **Affect:** Learning the first twenty elements of the PT with affective engagement is evident in maintaining affective influences as afforded in a pleasant, friendly working climate, enhancing interest, passion, satisfaction, enjoyment, values and belief in individual ability to learn the PT. The intervention through MU, singing pre-composed PT songs on names and symbols of the elements (MU) aroused interest and enjoyment. The enjoyment activated prior knowledge, which enhanced learning the PT. CB built on the existing knowledge of names and symbols of the elements to understand the compounds formed during the combustion reaction of the elements. CB further provided activities related to real-world scenario which included context-based projects afforded values, belief and ability to complete the CB project and solve the context-based inquiry problem creating satisfaction and a sense of positive emotion. Lastly, CS was used to simulate stable atoms and molecules by visualising these abstract concepts made learning the PT easy and interested and hence affords a sense of satisfaction and enjoyment. Therefore, MU, CB and CS afforded fun and memorable experiences. The affordance of affective engagement creates and develop passion for chemistry.
- **Behaviour:** Learning the first twenty elements of the PT with behaviour engagement is evident as active participation, concentration, active contribution, counted on to do own work,

complete task, problem solving, working harmoniously, and teamwork. Firstly, intervention provided pre-composed PT video songs, which were watched attentively with concentration on the content enhance understanding of basic concepts of PT. After that composing their own songs in groups afforded active contribution to teamwork. Secondly, CB project activities brought together teams who worked harmoniously to complete the CB project afforded active participation and collaboration. Thirdly, CS afforded the ability to apply acquired knowledge from MU and CB to answer questions related to the atoms and molecules. CS affords the ability to draw conclusions from the PhET simulation activities and debriefing sessions. The results and discussions revealed that behavioural engagement affordances allow learners to pay attention, ask and answer questions and maintain active involvement.

- AGAU (agentic/authentic): Learning the first twenty elements of the PT with AGAU engagement is evident as application of real-world scenario affords variety of resources, curiosity, understanding of difficult concepts. Starting with MU to select own PT content (elements) for the lyrics and rhythm from resources in a real music world increases learning engagement. CB activities related and matched real-world tasks in applying combustion reaction through collaboration. CB activities were followed by CS, interaction and manipulating the simulated variables to build the atoms and molecules including molecules formed (CO_2 , H_2O , SO_2) from combustion reaction using CB afforded understanding of most difficult concepts. Authentic engagement ultimately afforded learning and understanding scientific concepts that can bring about conceptual change in accordance with the constructivist theory.

The combination of engagement strategies (MUCBCS) enhanced learning as they drew on specific affordances of the strategies. In this way, different learning styles were accommodated (in accordance with MIT) and the appropriate strategy could be applied to relevant subject content, learning environment, learners' background, etc. (in accordance with CLT). The affordances of the combination of strategies (MUCBCS) to learning pertaining to the Periodic Table, deduced from the results of the study, are summarized as follows:

- The combined MUCBCS strategy affords learning and teaching as it facilitates merging social and educational contexts. During teamwork learners' interactions with their peers and other learners help them construct scientific knowledge themselves under a changing social environment. Social constructivism emphasizes social interactions as the source of knowledge. Within the educational context, teaching and learning focus on the learner and learning through increasing cognitive, affective, behaviour and AGAU engagement. MUCBCS afforded the application of problem solving, active participation, learner involvement, passion

to learn new scientific concepts of the PT and mastering scientific skills and knowledge, leading to conceptual change and finally, academic achievement in chemistry.

- MUCBCS afforded the use of familiar resources (music videos, carbon, charcoal/coal, cell phones) and application of real-life scenarios increased AGAU engagement. The use of everyday resources reduces intimidation of unfamiliar resources and equipment. It also eliminated the need to learn how to use new equipment first before focusing on the science concept.
- MUCBCS afforded access to a variety of resources and activities associated with composing and singing songs, performing experiments, manipulating variables, building atoms and molecules, communicating with others in their learning related to the first twenty elements of the PT.
- MUCBCS afforded consideration and development of learners' different intelligence of different strengths to maximise learning opportunities for each learner in accordance with MIT. Based on the CLT, learners' experiential knowledge was connected to and elaborated on in the MUCBCS sequence, which afforded conceptual learning with understanding.
- MUCBCS afford active participation, curiosity, work harmoniously and complete task in teamwork (interpersonal). Affordance to actively participate and contribute to a lesson provided opportunity to engage in cognitive, affective, behavioural, and AGAU engagement.

7.4.5 Answer to research question 5

What set of guidelines is relevant for the application of engagement strategies in the South African school chemistry curriculum?

The following guidelines follow from the empirical study conducted with South African science teachers:

- Use a variation of teaching strategies to accomplish different components of engagement. Different strategies enhance the different component of engagement successfully with varying degrees. With learners of different intelligences and learning styles and abilities varying strategies provide opportunity for the different learners to engage in the classroom.
- When choosing your teaching strategy for a lesson, take relevant factors into account such as the topic, time available, acquaintance and knowledge of the strategy, background and personality of learners, and the learning environment that will engage and enhance learning (Djan & Lemmer, 2021).

- To create a classroom environment that promotes engagement, inform your learners that disengagement is not allowed in this class. We suggest that the teacher must be a facilitator, a leader with a sense of humour, friendly and helpful to foster engagement in the class. Thus, by creating a passionate, caring, and conducive class atmosphere, engagement is enhanced.
- To develop AGAU, affective, cognitive, and behavioural engagement and to assist learners to use CB, CS and MU effectively in the South African school chemistry curriculum, learners must be first be taught how to use the equipment (PhET simulation, computers, and any other digital item, even the cell phone) as well as laboratory equipment (Bunsen burners, , before introducing the content on the PT.
- Involve learners by asking what activities can help them achieve the selected engagement you as a teacher want to develop among the learners towards achieving specific learning goal(s) of a chemistry topic or unit.
- Use kinaesthetics, play song or video related to the chemistry topic to wake up sleepy, bored learners in your class because they are not engaging in the lesson and learning. Be observant and talk privately to learner who look bored, disengaged, sleepy in your class.
- Provide a variety of resources by giving learners alternative places to engage with the lesson or content. For example, give an online link, send them the PowerPoint or voice lessons via WhatsApp, give references to find in the library, books to read or a video to watch. Thus, help them to engage with learning material at any time, especially when the learner happens to disengage in class at a particular time.
- The teacher must develop enthusiasm and a positive relationship with the learners to increase their interest in class activities and influence emotional and behavioural engagement. Be enthusiastic enough to bring new technology and real-world issues related to the PT and chemistry around them into the class in order to engage them in authentically.
- Take learners' background knowledge and skills into account for constructivist learning. In addition, the study emphasized that learners' intelligences also need to be determined and teaching should take place accordingly.
- MUCBCS has evidently shown that it is learner centred, caters for the seven out of the eight MIT multiple learning styles identified by Gardner. Therefore, MUCBCS as learning strategy can be a model of teaching and learning for the diversity of learners' knowledge, skills, intelligence and learning abilities to overcome the difficulty of how to teach and engage a diverse group of learners for any teacher. Table 7.1 below is a learner MI profile adopted from

Currie (2003) that can be used by teachers in schools as a guide to identify learners' intelligence. This should also guide the choice of learning engagement strategy to use MU, CB, CS, or a combination of two or all three to enhance their strengths, learning, intelligence, and academic achievement. This table can also be used by learners under guidance of the teacher to achieve the same results for themselves.

Table 7-1: An example of learner MI profile

Student Number	Linguistic	Mathematical / Logical	Visual / Spatial	Bodily - Kinesthetic	Musical	Inter - personal	Intra - personal	Naturalistic	Grand Total
1	5	1	3	1	10	4	2	2	
2									
Total number of points									
Summary per learner	Highest personal score + well developed areas		Average scores within each student's range		Less-developed areas				
Key	Well developed Intelligence		Average Intelligence		Under-developed Intelligence				

7.5 CONCLUSION

Based on the findings above, it is evident that active participation in activities using the three different strategies (music, context-based inquiry, and computer simulation) engaged learners in meaningful learning for mastering scientific concepts (cognitive); development of skills and participation (behaviour); aroused interest and passion (affective); and related chemistry learning to real world practices (AGAU (agentic/authentic)).

The present study clearly shows that MIT and CLT were considered in developing the intervention. Each strategy used in the intervention included the development of one or more of the eight intelligences and the type of constructive learning. For example, the MU use of song included identifying and understanding of the number of electrons, protons, and neutrons per element and used atomic number to differentiate the elements. Communication, simulating variables to build stable atoms of PT to discussion to select content for lyrics, solving the context-based inquiry problem and debriefing by the learner shows evidence of active construction of knowledge in the intervention activities.

A uniform, general strategy cannot serve to enhance and assess student learning (Lane, 2000; Gardner & Hatch, 1998). This implies that providing diverse opportunities such as music, context-based inquiry and computer simulation activities for learners to be assessed caters for the different ways learners learn.

In conclusion, music, context-based inquiry, and computer simulation activities afford active participation and learners' contribution in generating their own knowledge towards increasing

learner engagement within the classroom to improve academic progress and performance on the Periodic Table.

However, some factors were identified to limit the generalization of the study to all South African schools. These factors are listed in section 7.6.

7.6 LIMITATIONS OF THE STUDY

One limitation of the study is time constraint due to the COVID-19 pandemic which limited the numbers of participants and case studies.

The use of more learner participants could have yielded a better view of their perceptions and the impact of the strategies in the South African classroom.

7.7 ENGAGEMENT STRATEGIES IN CHEMISTRY WITH FOCUS ON THE PERIODIC TABLE

Application of the engagement strategies in “chemistry with focus on the periodic table” presented in the flow chart (Figure 7.4) starts with the use of MU followed by CB and finally CS. This affords learning and understanding scientific concepts that can bring about conceptual change in accordance with constructivist theory.

MU, singing pre-composed PT songs arouse interest and enjoyment. The enjoyment activates prior knowledge, which enhanced learning. CB build on the existing knowledge. CB further provide activities related to real-world scenario which include context-based projects. Lastly, CS is used to simulate and visualise abstract concepts.

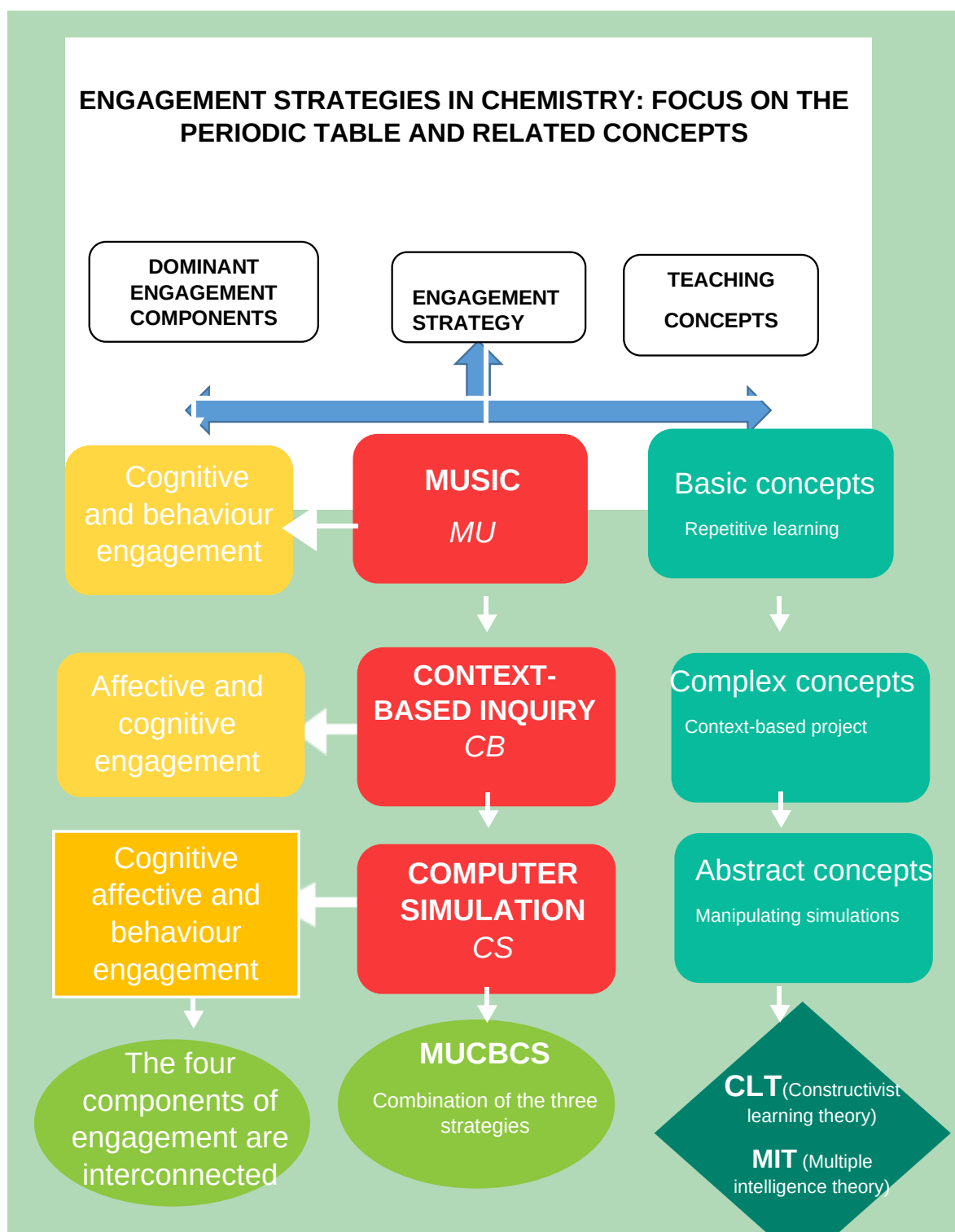


Figure 7-4: Engagement strategies in chemistry with focus on the periodic table
(Image by author)

The repetitive learning of the basic concepts using MU enhance reinforcement and mastering of concepts. Progressing with the use of CB (indicated in Figure 7.7) to understand more complex concepts is followed by abstract explanations using CS to interact and manipulate the simulated

variables ensuring conceptual mastering. CS affords the ability to apply acquired knowledge from MU and CB to ask and answer questions and maintain active involvement.

7.8 RECOMMENDATIONS FOR POLICY, PRACTICE AND FURTHER RESEARCH

The following recommendations are based on the findings of the study.

7.8.1 Recommendation for Policy

Compulsory training workshop on the use of technology and learning strategies for all newly appointed science teachers

Creating effective learning environments with the technology remains a challenge for teachers as well as technology-based learning activities (Harris *et al.*, 2009; Groff & Mouza, 2008). Harris *et al.* (2009) argued that integrating technology in technology-based learning may lack emphasis on content and pedagogy. Therefore, the search for strategies to assist the teacher and enhance learning continues to be necessary in our present technological and digital world (Harris *et al.*, 2009; Groff & Mouza, 2008).

Teachers may struggle to use the technology involved in the strategies applied in this study and implement the strategy the first time. Therefore, it is recommended that a training workshop be conducted for teachers to equip them with skills to use technology and the engagement strategies introduced in this study. Further research is required to determine how equipping teachers with technology affects the choice of strategy to engage their learners.

Introduction of scientific process skills development in the GET curriculum

Learning to use scientific equipment for investigating context-based inquiry projects can intimidate and disengage learners from the content and knowledge to be learnt. Therefore, it is suggested by the researcher to introduce scientific process skill development in the GET curriculum per term. In the GET Natural sciences, CAPS curriculum scientific process skills are required where the use of the scientific equipment is practically handled and accessed to get the learners equipped to engage effectively in science investigations.

Teacher training and teacher workshops to include beliefs and values

Beliefs and values are essential components that influence teaching and learning, and as such, must be included in teacher training and teacher workshops. Teachers should be provided with the opportunity to reflect on how their beliefs affect their teaching strategy and the learning environment they create in their classrooms.

Professional development to empower chemistry teachers

Professional development framework should be structured to empower chemistry teachers to design lessons using music, context-based inquiry, and computer simulation as engagement strategies.

7.8.2 Recommendation for practice

Participants indicated they did not have equipment to organise experiments. Some mentioned chemicals are expired and that the head of the school's science department is not a science teacher and therefore is not bothered to replenish and replace. On the other hand, video clips related to the topic can be downloaded where there is lack of chemicals, material, apparatus, and equipment.

Application of context-based inquiry using science equipment

Science equipment and apparatus are essential for experiment. To avoid overwhelming and disengaging accompanied with first-time users of equipment we suggest that a complete lesson on how to use the equipment should be demonstrated, taught and learners be given the opportunity to practice how to use them at least the beginning of each term.

Use music for introduction and summary of lesson

It may take time to get learners settled after composing and presenting their songs and this may cause disruption and discipline problems. The researcher suggests that a routine and rules of using music should be explained to avoid this. For instance, use music as an introductory lesson for learners to get used to it and form an acceptable behaviour. Additionally, a whole period should be used for learning a concept using music.

Learners may want music everyday if majority of your learners dominantly have musical or kinaesthetics intelligence. Therefore, the day you do not use music, they may not want to listen to you, get bored and find lessons boring, hence disengaging. To avoid this, incorporate a short pre-composed song in every lesson as a summary or introduction of your lesson.

Application of computer simulation in under-resourced schools

The availability of internet and computers in schools for all learners in a class to operate PhET is lacking. However, the Department of Basic Education through science subject specialists have made science (chemistry included) PhET related interactive simulations available on CD's and sent links to schools. However, availability of computers still remain a limitation.

The use of cell phones can be an option. Since not all learners can afford a phone, group work can be done, but COVID-19 regulation restricts sharing and group work at this stage. Another option is for teachers to upload the interactive simulation on screen and buy a cordless mouse for each learner. In class, give each learner the opportunity to engage with the interactive simulation, one at a time, this can be in alphabetical order. It may seem time consuming, but it is like using a questioning method, but this strategy ensures that each child had a turn and is engaged.

7.8.3 Recommendation for future research

Everyday life topics should be taught in chemistry lessons since they show positive affect among learners. However, authentic(AGAU) scored the least in this study implying that participants did not experience MU, CB, and CS highly to engage them to relate the chemistry topic PT to everyday life application. Therefore, there is a need for further studies to engage learners in chemistry lessons that relate to everyday life topic.

Time constraints on school timetables that may impede the use of MUCBCS can be addressed. As explained earlier technology-embedded videos can be selected for use within the available time. It should be investigated to determine the amount of time needed to plan, prepare and apply the MUCBCS strategy for a specific chemistry topic effectively.

This study's demographic and qualitative results indicated that teachers with no further qualification in natural or physical sciences are teaching these subjects or are heads of the science departments at school. We recommend a further study to investigate the performances in natural sciences and physical sciences as well as attitude towards science and science careers of learners from primary school to grade 12 taught by teachers who did not study chemistry, physics, natural or physical science after grade 9. The results can be compared with learners taught by teachers with higher qualifications. This study can be a 10-years longitudinal study tracking the same group of learners from grade 4 through to university.

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APPENDIX A: ETHICAL CLEARANCE CERTIFICATE



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**North-West University Education, Management
and Economic Sciences, Law, Theology,
Engineering and Natural Sciences Research
Ethics Office (NWU-EMELTEN-REC)**

Tel: +2718 299 4707

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16 October 2019

Dear Prof Lemmer

NOTIFICATION: APPROVAL OF YOUR APPLICATION BY THE NWU-EMELTEN-REC

Ethics number: NWU-00532-19-S3

Kindly use the ethics reference number provided above in all correspondence or documents submitted to the NWU-EMELTEN-REC secretariat.

Study title: Affordances of engagement strategies in chemistry: Learning the periodic table.

Study leader/supervisor: Prof M Lemmer

Student: Mrs. G Djan

Application type: Single study

Risk level for adult participants: Minimal

Risk level for learner participants: Greater than minimal risk with the prospect of direct benefit

You are kindly informed that your application was reviewed by the NWU-EMELTEN-REC and approved on 19 September 2019.

The commencement date for this study is 20 September 2019 dependent on fulfilling the conditions indicated below. Continuation of the study is dependent on receipt of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation up to a maximum period of one year when extension will be facilitated during the monitoring process.

After ethical review:

Translation of the informed consent document to the languages applicable to the study participants should be submitted to the NWU-EMELTEN-REC (if applicable).

The NWU-EMELTEN-REC requires immediate reporting of any aspects that warrants a change of ethical approval. Any amendments, extensions or other modifications to the proposal or other associated documentation must be submitted to the NWU-EMELTEN-REC prior to implementing these changes. Any adverse/unexpected/unforeseen events or incidents must be reported on either an adverse event report form or incident report form.

A monitoring report should be submitted within one year of approval of this study (or as otherwise stipulated) and before the year has expired, to ensure timely renewal of the study. A final report must be provided at completion of the study or the NWU-EMELTEN-REC must be notified if the study is temporarily suspended or terminated. The monitoring report template is obtainable from the NWU-EMELTEN-REC Office at Ethics-EMELTEN-mon@nwu.ac.za. Annually a number of studies may be randomly selected for an external audit.

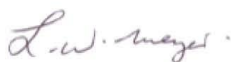
Please note that the NWU-EMELTEN-REC has the prerogative and authority to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.

Please note that for any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the NWU-EMELTEN-REC Office. Ethics approval is required BEFORE approval can be obtained from these authorities.

The NWU-EMELTEN-REC complies with the South African National Health Act 61 (2003), the Regulations on Research with Human Participants (2014), the Ethics in Health Research: Principles, Structures and Processes (2015), the Belmont Report and the Declaration of Helsinki (2013).

We wish you the best as you conduct your research. If you have any questions or need further assistance, please contact the NWU-EMELTEN-REC Office at Ethics-EMELTEN@nwu.ac.za.

Yours sincerely



Prof Lukas Meyer

Chairperson NWU-EMELTEN-REC

Current details: C:\Users\22138630\Google Drive\9. Research and postgrad education\9.1.5 Ethics\NWU-00532-19-S2\Final\9.1.5.4.1_Approval notification

Date: 16 October 2019

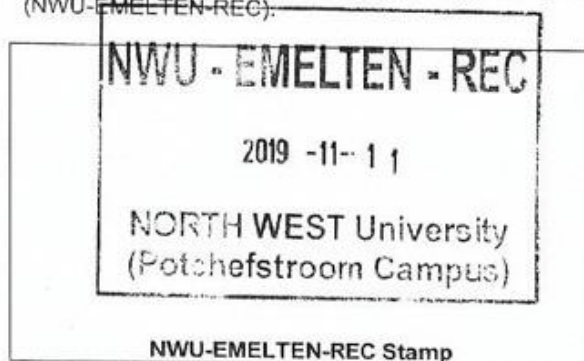
File Reference: 9.1.5.4.1

APPENDIX B: CONSENT FORMS



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Fax: +2718 299-4910
Web: <http://www.nwu.ac.za>

The Faculty of Health Sciences Ethics Office of the North-West University is acknowledged for the use of their document with minor adjustments made by the North-West University Education, Management and Economic Sciences, Law, Theology, Engineering and Natural Sciences Research Ethics Committee (NWU-EMELTEN-REC).



INFORMED CONSENT DOCUMENTATION FOR LEARNER PARTICIPANTS

TITLE OF THE RESEARCH STUDY:

Affordances of engagement strategies in chemistry: Learning the periodic table

ETHICS REFERENCE NUMBERS: NWU-00532-19-S2

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PRINCIPAL INVESTIGATOR:

Prof. M. Lemmer (Supervisor)

ADDRESS:

miriam.lemmer@nuw.ac.za

CONTACT NUMBER:

0182994270

POSTGRADUATE STUDENT:

G. Djan (Researcher)

ADDRESS:

gdjan@hotmail.com

CONTACT NUMBER:

0848931121

CO-SUPERVISOR:

Dr ON Morabe

Address:

nico.morabe@nwu.ac.za

Contact Number:

0790805716

Faculty of Education Research Ethics Committee:

Contact person: Ms Erna Greyling, E-mail: Erna.Greyling@nwu.ac.za. Tel. (018) 299 4656

You are being invited to take part in a **study** that forms part of my/our **research**. Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or person explaining the research to you any questions about any part of this study that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you might be involved. Also, your participation is **entirely voluntary**, and you are free to say no to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part now.

This study has been approved by the **North-West University Education, Management and Economic Sciences, Law, Theology, Engineering and Natural Sciences Research Ethics Committee (NWU-00532-19-S2)** and will be conducted according to the ethical guidelines and principles of **Ethics in Health Research: Principles, Processes and Structures (DoH, 2015)** and other international ethical guidelines applicable to this study. It might be necessary for the research ethics committee members or other relevant people to inspect the research records.

What is this research study all about?

- The primary aim of the study is to investigate and analyse the affordances of the engagement strategies music, context-based inquiry and computer simulation impact on the four components of engagement (behavioural, emotional, cognitive and authentic engagement) in learning the first twenty elements of the Periodic Table?

Why have you been invited to participate?

- You SON/ DAUGHTER have been invited to be part of this research because his/her teacher volunteered to participate in a class visit and observation using affordances of engagement strategies for learning the periodic table towards the improvement of chemistry performance.
- His/her teacher attended series of workshop and learn new skills and learning strategies which she willingly volunteered to apply in teaching the Periodic Table in class to enhance learning and achievement of her/his learners.
- The Periodic Table of element is part of their school curriculum
- Other learners will unfortunately not be able to take part in this research if their teacher did not volunteer to take part in the research or /and if they are in grade 11 or 12.

What will be expected of the learners?

- Watching content-rich music videos
- Learning content-rich lyrics,
- Composing music on the periodic table. Names, symbols, atomic number, mass number.
- Investigation hypothesizing, properties and use of Na, S, Mg, Li, P, C, O, He, in everyday life
- participants use PHET simulation
- Simulation on Building an atom - Na, Cl, O, S, H, C
- Building molecules - NaCl, H₂O, SO₂, CO₂, HCl.
- Pre-test and post-test in the form of questionnaire.
- The pre-test and post- test will in any way affect or be part of their formal assessment or promotional marks. It is also to check the teacher's success of the use of the new strategies to teach the Periodic Table.

Will you gain anything from taking part in this research?

- The gains for you if you take part in this study you will gain knowledge and skills. Expose to variety of learning strategies to enhance your different learning intelligences and interests
- Engaged learners with different intelligences, learning styles given opportunity to use them to effectively learn.
- The other gains of the study are for enhancing the learners' engagement, interest, spark positive attitude and improve performance and achievement.
- The periodic table is fundamental to learning chemistry; therefore, it will enhance the learners understanding of chemistry concepts.

Are there risks involved in you taking part in this research and what will be done to prevent them?

- No risk to participants is foreseen due to the nature of the research study.
- There are more gains for you in joining this study than there are risks
- The results will NOT be part of any formal assessment or term marks
- It will not determine if you pass or fail any subject

How will we protect your confidentiality and who will see your findings?

- No names and identity are required nor will be displayed in any form during and after the study.

- Only the researchers and the University will be able to look at your findings. Findings will be kept safe by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected.
- Audio recording taken will be analysed by researcher and discarded. Only research team will have access to it.
- No photos or videos will be taken of your child.

What will happen with the findings?

- The findings of this study will only be used for this study. Findings are for academic purpose only.
- The results of the pre-test and post-test is for the research only. The results have no effect on your child's class marks, report marks or promotion.

How will you know about the results of this research?

- We will give your child the summary of the important results of this research on request from the researcher.

Will you be paid to take part in this study and are there any costs for you?

There will be no payment to you for participating. There will thus be no costs involved for you, if you do take part in this study. However, NWU sticker will be given to the learners at the end of the class visit and observation by the researcher.

Is there anything else that you should know or do?

- You can contact G. Djan at gdjan@hotmail.com if you have any further questions or have any problems.
- You can also contact the North-West University Education, Management and Economic Sciences, Law, Theology, Engineering and Natural Sciences Research Ethics Committee via Mrs Marlize Bisschoff at 018 299 4707 or marlize.bisschoff@nwu.ac.za if you have any concerns that were not answered about the research or if you have complaints about the research.
- *You will receive a copy of this information and consent form for your own purposes on request.*

Declaration by participant

By signing below, I
agree to allow my child to take part in the research study titled: Affordances of engagement strategies in chemistry: Learning the periodic table.

I declare that:

- I have read this information/it was explained to me by a trusted person in a language with which I am fluent and comfortable.
- The research was clearly explained to me.
- I have had a chance to ask questions and all my questions have been answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be handled in a negative way if I do so.
- I may be asked to leave the study before it has finished, if the researcher feels it is in the best interest, or if I do not follow the study plan, as agreed to.

Signed at (place) on (date) 20....

Signature of parent/guardian

Signature of learner



NWU-EMELTEN-REC

NWU Ethics Number

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The Faculty of Health Sciences Ethics Office of the North-West University is acknowledged for the use of their document with minor adjustments made by the NWU Education, Management and Economic Sciences, Law, Theology, Engineering and Natural Sciences Research Ethics Committee (NWU-EMELTEN-REC).

INDEMNITY FORM (NWU-EMELTEN-REC)

I, the undersigned

.....
Identity number:

hereby indemnify the North-West University ("NWU") and/or any of its office-bearers and staff (temporary or permanent) against any liability in respect of personal losses and/or damages suffered by me or any other person arising from or resulting as a consequence of my participation in the research entitled Affordances of engagement strategies in chemistry: Learning the periodic table (the "Research"), and hereby hold harmless the NWU against above-mentioned liability.

I confirm that I voluntarily consent to participate in the Research, and that I was in no way forced or coerced by the NWU to participate in the Research, and that the waiver and release shall apply to any claims that may arise during and/or after the Research.

I declare that I am aware of the risks involved in the Research, as explained to me, and of the implications of this waiver and release, and agree that this document shall also be binding upon my executor, curator or other assigns.

Signature

Date

APPENDIX C: PERMISSION AND APPROVED LETTERS



Private Bag X6001, Potchefstroom
South Africa 2520
Web: <http://www.nwu.ac.za>

Dr Miriam Lemmer
School for Physical and Chemical Sciences
Tel: 018 299-4270

20 JULY 2019

TO: THE DIRECTOR

NORTH WEST DEPARTMENT OF EDUCATION AND
SPORTS DEVELOPMENT

REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITH EDUCATORS AND LEARNERS FROM SCHOOLS IN DR KENNETH KAUNDA DISTRICT

Mrs Grace Djan, is currently enrolled for the PhD degree in Natural Science Education at the North-West University, Potchefstroom Campus. She conduct her research under my supervision. We hereby wish to apply for permission to conduct a research study with educators and learners from schools in Dr Kenneth Kaunda District in the North West province during the 2019-2020 academic years, using a sample of educators and observing Grade 9 science lessons being taught by these educators.

1. Title of the Research

The title of the research is: Affordances of engagement strategies in chemistry: Learning the periodic table

2. Motivation for the Research

The status of mathematics and science education in South Africa is a great source of concern (Spaull, 2013; Kriek and Grayson, 2009), therefore how we teach mathematics and science is important for future well-being of our nation and people (Glenn, 2000). Hence the standard of engagement in science education is fundamental for the future of science and technology for the ongoing development of our society. Learners are often not actively involved in the learning process (Stolk *et al.*, 2009) and significant emphasis is placed on memorization of facts, theories and rules (Gilbert, 2006; Stolk *et al.*, 2012). These factors have affected the interest, motivation, decline in learner performance and numbers pursuing chemistry courses. Unawareness of how to give meaning to what they learn in class leads to low engagement hence learners lack the ability to retain what they have learnt (Gilbert, 2006). These reasons necessitate a teaching and learning strategy that can enhance engagement and interest, spark positive attitude and improve achievement and performance. The combination of music, computer simulation and context-base chemistry is expected to enhance learners' affect, interest and attitude with consequent improvement in achievement and performance in chemistry.

3. Purpose of the Research

The aim of this study is to investigate the extent to which promoting music, computer simulation and context-based approach affect the teaching and learning of the periodic table of elements. The main instruments to be used to achieve these goals will be surveys (questionnaires), focus group and semi structural interviews.

The proposed research question:

What can music, context-based inquiry and computer simulation activities afford towards increasing learner engagement within the classroom to improve academic progress and performance on the Periodic Table?

4. Procedure of the Research and data collection**Part A**

- A quantitative questionnaire will be used as a pre-test for about 30 Natural Sciences and Physical Sciences teachers to determine their perceptions about the use of music and context in teaching the periodic table as well as their content knowledge on the periodic table, their affect, interest and attitude towards science.
- The participants will receive an introduction on using music, context-based inquiry, computer simulation as a teaching strategy. The strategy will be applied to teaching and learning the elements of the periodic table.
- The intervention is followed by a post-test.
- The intervention with teachers will take place during a workshop on held on three Saturdays.
- Teachers who volunteer to apply the acquired strategies will be observed during a class visit and an interview will be conducted with them.

Part B

- Class visit. A class observation. Educators applying the acquired intervention in their classrooms using their own learners.

4.1 Data Analysis

The analysis of the pre-test and post-test results from the survey will be statistically done by the North West University's Consultation Service. The interview responses will be transcribed and coded by the researcher.

5. Ethical Aspects

Ethical clearance will be obtained from NWU-EMELTEN-RC as it is a requirement of the North West University before the research can proceed.

5.1. Potential Benefits

The proposed research will provide educators with the opportunity to reflect more deeply on their own teaching practices. They may also transfer what they have learned during the intervention to other topics in the GET and FET teaching and improve learners' conceptual development in Natural Sciences and Physical Sciences. Another direct benefit for teachers is their professional development and growth as a schoolteacher.

The periodic table is fundamental to learning chemistry; therefore, it will enhance the learners' understanding of chemistry concepts.

5.2. Potential Risks

The research will not interfere with educators' and learners' school curriculum time. Educators who have attended the afore-mentioned workshop on a Saturday will be invited to participate in the study and observations of science lessons of Grade 9 learners will take place when the periodic table of elements is taught to the learners.

Permission from the participating schools (SGB's & principals), educators, learners and parents of learners will also be obtained.

5.3 Payment

None of the participants will be paid for participating in this study. Tea and coffee will be provided during the workshop.

5.4 Participation and Confidentiality

If permission is granted by the North-West Department of Basic Education, the researcher would ensure that:

- Participants voluntarily participate in the study.
- Participants may withdraw from the study at any time they wish to do so.
- Names of schools and participants will remain anonymous.
- Name of schools and participants will not be used when reporting the results of the study.



education

Lefapha la Thuto la Bokone Bophirima
Noord-Wes Onderwys Departement
North West Education Department
NORTH WEST PROVINCE

Teemane Building, 8 O.R. Tambo Street,
Potchefstroom
Private Bag X1256, Potchefstroom 2520
Tel: (018) 299-8216 / Fax: 294-8234
e-mail: bmonale@nwpg.gov.za
Office Manager: Linda Nelson - Tel: (018) 299-8264
e-mail: Lnelson@nwpg.gov.za

OFFICE OF THE DISTRICT DIRECTOR Dr KENNETH KAUNDA DISTRICT

Enquiry: Max Bolotina: 018 299 8307

Tel: (018) 299 8264 / e-mail : bmonale@nwpg.gov.za

05 December 2019

To: North West University
School for Physical & Chemical Sciences

Attention: Mrs. G. Djan

From: Mr. B. Monale
District Director

PERMISSION TO CONDUCT RESEARCH

Reference is made to your correspondence dated 15 October 2019, being a request for permission to conduct research study with educators and learners from Dr. Kenneth Kaunda District on *affordances of engagement strategies in chemistry for learning for learning the periodic table towards improvement of chemistry performance in schools*.

Accordingly, permission is hereby granted to you to undertake the research study as your request, subject to the following provisions:

- That the onus to contact your target schools and to identify suitable project participants for purposes of the research remains with you.
- That participation in the project will remain voluntary for its entire duration.
- That you take reasonable measures not to compromise Learning and Teaching time in respect of your research participants.
- That the general functionality of schools should not be compromised by this research project, considering that the same will in instances involve teachers.
- That the outcomes of your research will be shared with the NW Department of Education, or its proxy, upon request.
- That the principle of confidentiality will be observed in its strictest terms in relation to information sourced from the project.

With our Best Wishes

Duly Authorised

Mr. B. Monale
District Director:
Dr. Kenneth Kaunda District

Cc: Ms. S. Yssel; :Acting Sub-district Manager J.B. Marks
Ms. N. Seokolo: Acting Sub-district Manager Matlosana



"Towards Excellence in Education and Sport Development"



Education and Sport Development

Department of Education and Sport Development
Departement van Onderwys en Sportontwikkeling
Lefapha la Thuto le Tlhabololo ya Metshameko

NORTH WEST PROVINCE

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e-mail: bmonale@nwpg.gov.za

Office Manager: Linda Nelson - Tel: (018) 299-8264

e-mail: lnelson@nwpg.gov.za

OFFICE OF THE DISTRICT DIRECTOR Dr KENNETH KAUNDA DISTRICT

Enquiry: P Tyatya; 018 299 8264

Tel: (018) 299 8264 / e-mail : ptyatya@nwpg.gov.za

28 May 2019

To: Grace Djan (Ms.) Student No. 17142024
University of the North West
Potchefstroom Campus

From: Mr. B. Monale
District Director

PERMISSION TO CONDUCT RESEARCH WITH EDUCATORS AND LEARNERS FROM SCHOOL IN THE J.B. MARKS SUB-DISTRICT

"Study of Affordances of Engagement Strategies in Chemistry for Learning the Periodic Time-Table Towards the Improvement of Chemistry Performance in Schools"

Reference is made to your e-mailed correspondence dated 10 April 2019 regarding the fore-going matter. The content is noted and accordingly, approval is hereby granted to you to conduct the research work in identified school in J.B. Marks Sub-District, under the above-stated topic.

Please take note that the Research Project undertaken must conform to the following provisions:

- That the onus to contact your target schools/offices, educators and learners about the research and this letter of permission remains with you.
- That participation in the research project will remain voluntary for its entire duration.
- That the general functionality of schools should not be compromised by the research process, considering that interviews will in instances be conducted with Educators & Learners.
- That the findings of your research will be made available to the NW Department of Education & Sports Development, or its proxy, upon request.
- That the principle of confidentiality will be observed in its strictest terms in relation to information sourced from such research.

With our Best Wishes

Mr. B. Monale
District Director:
Dr. Kenneth Kaunda District



"Towards Excellence in Education and Sport Development"

APPENDIX D: RESEARCH QUESTIONNAIRES, INTERVIEW QUESTIONS AND QUALITATIVE RESULTS (SAMPLES)

RESEARCH QUESTIONNAIRE (PRE-TEST)

Initial and code	01
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Researcher: Mrs G Djan

Study leaders: Prof M Lemmer & Dr ON Morabe

PURPOSE OF THE STUDY:

The purpose of this questionnaire is to obtain information that can be used to determine the affordances of the engagement strategies, music, computer simulation and context-based inquiry, towards mastery learning of the periodic table of elements.

CONFIDENTIALITY

Completion of the questionnaire is confidential. The final results of this study will be made available to participants on request.

PARTICIPATION AND WITHDRAWAL

If you volunteer to participate in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

IDENTIFICATION OF RESEARCHERS

If you have any questions or concerns about the research, please feel free to contact Prof Miriam Lemmer (study leader) at 0182994270 or Mrs Grace Djan (researcher) at 0848931121.

RIGHTS OF PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, please ask the researcher or study leader of the study.

INFORMED CONSENT

I understand that participating in this research project is completely voluntary, no pressure is placed on me to participate and I can withdraw at any time. I hereby give permission that this questionnaire may be used for the research purpose.

Signature..... Date

You are requested to spend a few minutes to complete the questionnaire below.

Cross the number in the column to the right of your selected choice. Thank you very much for your time.

SECTION A:

A. DEMOGRAPHIC INFORMATION

1. Age

20 – 29 years	1
30 – 39	2
40 – 49 years	3
50 – 59 years	4
60 or above	5

2. Gender

Male	1
Female	2

3. Educational qualification

Primary Education	1
Secondary education	2
Undergraduate tertiary (diploma/first degree/other)	3
Postgraduate tertiary (Honours, masters, PhD, Doctorate)	4
Professional qualification (PSCE/other)	5
Other. Specify.....	6

4. Major subjects

Chemistry only	1
Physics only	2
Chemistry and physics	3
Natural sciences	4
Never done any form of science after grade 9	5
Other. Specify.....	6

5. Subjects offering at current school (for the educators)

Natural sciences	1
Life Sciences	2
Physical Sciences	3
Agricultural sciences	4
None. I do not teach any of the science related subjects	5

6. Aspects of Natural Sciences I like best

Chemistry (Matter and material) only	1
Physics (Energy and change) only	2
Life Sciences (Life and living)	3
All aspects of Natural sciences	4
Other Specify...	5

SECTION B:

This survey may look lengthy, but the items have been spaced for easy reading to save you time. The typical time to complete this survey is about 15-20 minutes. Varieties of responses have been provided. Kindly make a CROSS the space under the number that applies in the space under your choice. Please TICK WITH A CROSS A BLOCK FOR EACH STATEMENT OR QUESTION.

1=Strongly Disagree. 2=Disagree. 3= Agree. 4= Strongly Agree (Circle OR tick, or darken)

PHASE I

QUESTION 1 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1. Do you think music can aid learning scientific concepts?				
2. Do you think music is useful for learners to understand the relationship between the atomic number and atomic mass of the elements in a group on the Periodic Table?				
3. Do you think that music is useful for learners to understand the relationship between the names and symbols of the elements on the Periodic Table?				
4. Do you expect that using music can give learners opportunity to integrate the theory with practice?				
5. Do you think research on the use of music activities in learning the Periodic Table should be conducted?				

QUESTION 2 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1. Do you think you will be interested in using music to learn about the Periodic Table?				
2. Do you think music will help to improve the class environment by creating a more pleasant working climate?				
3. Do you expect to feel satisfied enough to develop passion for science using music as part of your lessons?				
4. Do you expect to find enjoyment in composing a song using information about the Periodic Table as the lyrics?				
5. Do you think you will be happy if more research is done on the use of music in learning?				

QUESTION 3 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1. Do you believe you can apply what you will learn about the Periodic Table through music in answering questions related to the Periodic Table?				
2. Do you think you can be counted on to concentrate on your work in class even if the beat of the music is your favourite?				
3. Do you think watching content rich music videos in the classroom will enhance your understanding of chemistry?				
4. Do you think using music to learn will help you participate in class?				
5. Do you think composing own songs will help you concentrate on the content?				

QUESTION 4 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1. Do you think using music in learning the Periodic Table in the classroom can help you get through to the most difficult or unmotivated learners?				

2. Do you think using music can give learners an opportunity to make connections between subjects?				
3. Do think composing your own song (music) allow you to be creative				
4. Do you think using music will enable you to express yourself freely and use your talents?				
5. Do you expect the use of music (singing and composing own song) in learning will enable learners to make choices and reflect on their learning both individually and socially?				

PHASE II

QUESTION 1 Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1. Do you think it is important to use context-based inquiry in learning scientific concepts?				
2. Do you expect context-based inquiry to make learning of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen in everyday life easier and interesting?				
3. Do you expect to understand the application of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen to everyday life experience if you are actively involved in constructing the knowledge?				
4. Do you agree that using context-based inquiry will give learners an opportunity to make connections between subjects?				
5. Do you think that context-based inquiry will improve your skills to master the scientific content?				

QUESTION 2 Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1. Do you expect to feel satisfied with a lesson using context-based inquiry because it will become easier to learn the combustion reactions of magnesium, lithium, phosphorous, sulphur, carbon, hydrogen with oxygen?				
2. Do you think context-based inquiry will help create an environment with a more pleasant working climate?				
3. Do you think that context-based inquiry is useful to arouse your interest in learning the properties of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen?				
4. Do you expect to find enjoyment in investigating how combustion of magnesium, lithium, phosphorous, sulphur, carbon and hydrogen is applied in the industry and domestic?				
5. Do you expect context-base inquiry to provide the opportunity to reflect and involve students' beliefs and values?				

QUESTION 3 Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1. Do you think you can work harmoniously in a team to complete a project?				
2. Do you think you can be counted on to concentrate on your work in the teaching and learning process in the classroom even if you work with a group?				
3. Do you expect to identify your own unique tasks and sub-tasks to complete a major task using context-based inquiry?				
4. Do you think participating in an investigation in class will help you and participate actively in class?				
5. Do you think participating in an investigation in class will help you to concentrate on the content?				

QUESTION 4 Context-based inquiry

Item		1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1	Do you think a context-based inquiry task will afford learners the opportunity to examine the problem from a variety of options, rather than allowing a single view that learners must imitate to be successful?				
2	Do you think context-based inquiry activities will match real-world tasks of professionals in practice better than decontextualized or classroom-based tasks				
3	Do you think collaboration (team work) should be integral to the task, both within the class and the real world, rather than achievable by an individual learner?				
4	Do you think inquiry activities will achieve the creation of a whole product rather than an exercise or sub-step in preparation for something else?				
5	Do you expect context-based inquiry to give you an opportunity to use a variety of resources rather than a limited number of preselected references that will require detecting relevant from irrelevant information?				

PHASE III

QUESTION 1 Computer simulations

Item		1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1	Do you think it is important to use computer simulation in teaching scientific concepts?				
2	Do you expect computer simulation to be useful for learners to engage in science problem solving in a meaningful manner that is not possible with a traditional classroom setting.				
3	Do you think computer simulation will be useful for the conceptual understanding of the scientific observation of the Periodic Table?				
4	Do you think using computer simulation will give learners an opportunity to visualize abstract concepts?				
5	Do you expect to master the content of the Periodic Table using simulation computer simulations?				

QUESTION 2 Computer simulations

Item		1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1	Do you expect that using simulation in the learning process will create passion for pursuing chemistry?				
2	Do you think computer simulation will help improve the class environment by creating a friendly working climate?				
3	Do you think you will feel satisfied with the lesson using computer simulation because it makes the abstract concepts easier to learn and understand?				
4	Do you expect to find enjoyment in using simulation of building Na, Cl, O, S, H, C atoms and molecules?				
5	Do you expect to find opportunity to reflect and involve your beliefs and values?				

QUESTION 3 Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 Do you think you can apply what you learn through computer simulations in answering questions and solving problems related to the Periodic Table?				
2 Do you think you can be counted on to do your work in the learning process in the classroom even if you experience the effect of simulation followed by debriefing?				
3 Do you expect that the process of simulation of atomic interaction based on interactive forces will assist the participants to draw conclusions?				
4 Do you expect that simulation of elements of the Periodic Table will help you to actively participate in class?				
5 Do you expect that simulation of elements of the Periodic Table helps to concentrate on the content?				

QUESTION 4 Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
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8

1 Do you think the use of computer simulations in learning the Periodic Table can help learners to understand even the most difficult concept?				
2 Do you think the activities will match as nearly as possible the real-world tasks of professionals in practice rather than decontextualized or classroom-based tasks?				
3 Do you expect that using simulation in the learning process will promote collaboration (team work) within the class?				
4 Do you think assessment of the activities should be integrated with the major task in a manner that reflects real world assessment, rather than separate artificial assessment removed from the nature of the task?				
5 Do you expect computer simulation will give learners an opportunity to use a variety of resources rather than a limited number of preselected references that require detecting relevant from irrelevant information?				

If you would like to provide any feedback about this survey or other information that would help us understand the items asked in this survey, please use the following space

THANK YOU.

Please contact G Djan (0848931121/gdjan@hotmail.com) for any query

RESEARCH QUESTIONNAIRE (PHASE I POST-TEST)

Name and Surname		Code 01
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Researcher: Mrs G Djan

Study leaders: Prof M Lemmer & Dr ON Morabe

PURPOSE OF THE STUDY:

The purpose of this questionnaire is to obtain information that can be used to determine the affordances of the engagement strategies, music, computer simulation and context-based inquiry, towards mastery learning of the periodic table of elements.

CONFIDENTIALITY

Completion of the questionnaire is confidential. The final results of this study will be made available to participants on request.

PARTICIPATION AND WITHDRAWAL

If you volunteer to participate in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any question(s) you don't want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

IDENTIFICATION OF RESEARCHERS

If you have any questions or concerns about the research, please feel free to contact Prof Miriam Lemmer (study leader) at 0182994270 or Mrs Grace Djan (researcher) at 0848931121.

RIGHTS OF PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, please ask the researcher or study leader of the study.

INFORMED CONSENT

I understand that participating in this research project is completely voluntary, no pressure is placed on me to participate and I can withdraw at any time. I hereby give permission that this questionnaire may be used for the research purpose.

Signature.....

Date

SECTION B

You are requested to spend a few minutes to complete the questionnaire below.
Please put a cross in the block that indicates your selected choice. Thank you very much for your time.

PHASE I

This survey may look lengthy, but the items have been spaced for easy reading to save you time. The typical time to complete this survey is about 15-20 minutes. Varieties of responses have been provided. Kindly make a CROSS the space under the number that applies in the space under your choice. Please TICK WITH A CROSS A BLOCK FOR EACH STATEMENT OR QUESTION.

1=Strongly Disagree. 2=Disagree. 3= Agree. 4= Strongly Agree (Tick with a cross)

QUESTION 1 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1. I think music can aid learning scientific concepts.				
2 I think that music is useful for learners to understand the relationship between the names and symbols of the elements on the Periodic Table.				
3 I think music is useful for learners to understand the relationship between the atomic number and atomic mass of the elements in a group on the Periodic Table.				
4 I expect that using music can give learners opportunity to integrate the theory with practice.				
5 I think research on the use of music activities in learning the Periodic Table should be conducted.				

QUESTION 2 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1 I am interested in using music to learn about the Periodic Table.				
2 Music helped improve the class environment by creating a more pleasant working climate.				
3 I feel satisfied enough to develop passion for science using music as part of my lessons.				
4 I found enjoyment in composing a song using information about the Periodic Table as lyrics.				
5 I will be happy if more research is done on the use of music in learning?				

QUESTION 3 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 I can apply what I learnt about the Periodic Table through music in answering questions related to the Periodic Table.				
2 I can be counted on to concentrate on work in class even if the beat of the music is my favourite.				
3 Watching content rich music videos in the classroom enhanced my understanding of chemistry.				
4 Using music to learn the Periodic Table helped me participate in class.				
5 Composing own songs helped me concentrate on the content.				

QUESTION 4 Music

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly Agree
1 Using music in learning the Periodic Table in the classroom will help me get through to the most difficult or unmotivated learners.				
2 Using music can give learners an opportunity to make connections between subjects.				
3 Composing our own song (music) allowed me to be creative.				
4 Using music helped me to express myself freely and use my talents.				
5 The use of music (singing and composing own song) in learning can help learners to make choices and reflect on learning both individually and socially.				

SECTION B

QUESTION 5: The practice of using music in the learning process

Varieties of possible responses have been provided to the following questions. Kindly show your choice with a cross.

1. What resource(s) do you depend on to help you plan your teaching or learning?

Numbering	Resources	1. Never	2. Occasionally	3. Often	4. Always
1	The internet				
2	Textbooks				
3	Teacher's reference books				
4	My experience				
5	Other (Specify)				

2. What do you perceive as the purpose(s) for using music in learning science?

Numbering	Purpose	1. None	2. Some	3. Good	4. Major
1	Consolidate knowledge				
2	Fostering a person ability				
3	Leverage interest				
4	Improve understanding				
5	Promote positive attitude towards science				
6	Enhance performance				
7	Relax for recreation				
8	Fostering engagement				

3. To what extent did you acquire each of the following abilities using music?

Numbering	Ability	1. No/little extent	2. Some extent	3. Large extent	4. Very large extent
1	Cognitive				
2	Affective				
3	Psychomotor				
4	Positive behaviour				
5	Passion				
6	Reliability				

4. What are the impacts or effects of using music?

Numbering	Impact of using music	1.No/little effect	2. Some effect	3. Large effect	4. Very large effect
1	The periodic Table can be studied together with music.				
2	Music can actively process new stimuli and infer the rules of chemistry.				
3	It may code words with heavy emotional and contextual flags.				
4	Evoke a realistic and convincing (cogent) environment.				
5	Enable students to have positive attitude towards chemistry.				
6	Self-perceptions and cultural appreciation is attained.				
7	It can change the artificial classroom environment into a real experience and make new information meaningful.				
8	Bring interest and order to a classroom.				
9	Induce positive effects on science achievement				

5. Which type(s) of music do you prefer?

Numbering	Type of music	1. No	2. Some	3. Generally	4. Very much
1	Producing own song				
2	Downloaded songs				
3	Classical				
4	RNB Rap consideration perusal				
5	Hip pop				
6	Jazz				
7	Other (Specify).....				

SECTION C

Question 6: Content questions on the periodic table of elements- Provide the correct answer

- 6.1 Name TWO noble gases
- 6.2 What is the group name of the elements in group two?
- 6.3 Name the first three elements on the Periodic Table.....
- 6.4 Is sulphur a metal, non-metal or metalloid?
- 6.5 What is the atomic number of Carbon?
- 6.6 What is the name of a horizontal row in the Periodic Table of the elements?
- 6.7 What is the name of a vertical column in the Periodic Table of the elements?

Question 7: Content questions on the periodic table of elements-Multiple choice items

- 7.1. Which of the following elements is a liquid at room temperature?
- A. Hydrogen B. Sulfur C. Bromine D. Tungsten E. Iron
- 7.2. Which of the following statements is incorrect for the elements 'Mg, P and Li'?
- A. Mg is magnesium; P is potassium; Li is lithium
- B. Mg is mercury; P is potassium; Li is lithium
- C. Mg is magnesium; P is phosphorous; Li is nitrogen
- D. Mg is magnesium; P is phosphorous; Li is lithium
- 7.3. Which of these elements is the best conductor of electricity?
- A. 16S B. 15P C. 17Cl D. 35Br E. 6C

If you would like to provide any feedback about this survey or other information that would help us understand the items asked in this survey, please use the following space

THANK YOU.
Please contact G Djan (0848931121/gdjan@hotmail.com) for any query

RESEARCH QUESTIONNAIRE (PHASE II POST-TEST)

Name and surname		Code 001
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Researcher: Mrs G Djan

Study leaders: Prof M Lemmer & Dr ON Morabe

PURPOSE OF THE STUDY:

The purpose of this questionnaire is to obtain information that can be used to determine the affordances of the engagement strategies, music, computer simulation and context-based inquiry, towards mastery learning of the periodic table of elements.

CONFIDENTIALITY

Completion of the questionnaire is confidential. The final results of this study will be made available to participants on request.

PARTICIPATION AND WITHDRAWAL

If you volunteer to participate in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any question (s) you don't want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

IDENTIFICATION OF RESEARCHERS

If you have any questions or concerns about the research, please feel free to contact Prof Miriam Lemmer (study leader) at 0182994270 or Mrs Grace Djan (researcher) at 0848931121.

RIGHTS OF PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, please ask the researcher or study leader of the study.

INFORMED CONSENT

I understand that participating in this research project is completely voluntary, no pressure is placed on me to participate and I can withdraw at any time. I hereby give permission that this questionnaire may be used for the research purpose.

Signature.....

Date

SECTION B

You are requested to spend a few minutes to complete the questionnaire below.

Please put a cross next to your selected choice. Thank you very much for your time.

PHASE II

This survey may look lengthy, but the items have been spaced for easy reading to save you time. The typical time to complete this survey is about 15-20 minutes. Varieties of responses have been provided. Kindly make a CROSS the space under the number that applies) in the space next to your choice. Please TICK WITH A CROSS A BLOCK FOR EACH STATEMENT OR QUESTION.

1=Strongly Disagree. 2=Disagree. 3= Agree. 4= Strongly Agree (Circle OR tick, or darken)

QUESTION 1: Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 I think it is important to use context-based inquiry in learning scientific concepts.				
2 Context-based inquiry made the learning of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen in everyday life easier and interesting.				
3 I understand the application of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen to everyday life experience because I was actively involved in constructing the knowledge.				
4 I agree that using context-based inquiry gave learners an opportunity to make connections between subjects.				
5 Context-based inquiry improved my skills to master the scientific content.				

QUESTION 2: Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
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1 I feel satisfied with the lesson using context-based inquiry because it becomes easier to learn and understand the combustion reactions of magnesium, lithium, phosphorous, sulphur, carbon, hydrogen with oxygen.				
2 Context-based inquiry created an environment with a more pleasant working climate.				
3 Context-based inquiry is useful and aroused my interest in learning the properties of magnesium, lithium, phosphorous, sulphur, carbon, oxygen and hydrogen.				
4 I found enjoyment when I investigated how combustion of magnesium, lithium, phosphorous, sulphur, carbon and hydrogen are applied in the industry and domestic.				
5 Context-base inquiry provided the opportunity to reflect and involved learners' beliefs and values.				

QUESTION 3: Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 I worked harmoniously in a team to complete a project.				
2 I could be counted on to concentrate on my work in the learning process in the classroom even when I worked within a group.				
3 I could identify my own unique tasks and sub-tasks to complete a major task using context-based inquiry.				
4 Participating in the investigation improved				

my active participation in class.				
5 Participating in an investigation in class helped me to concentrate on the content.				

QUESTION 4: Context-based inquiry

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 The task used in context-based inquiry afforded the opportunity to examine the problem from a variety of options, rather than allowing a single view that learners must imitate to be successful.				
2 Context-based inquiry activities matched real-world tasks of professionals in practice better than decontextualized or classroom-based tasks.				
3 Collaboration (teamwork) should be integrated to the task, both within the class and the real world,				
4 The context-based inquiry activities created a whole product rather than an exercise or sub-step in preparation for something else.				
5 Context-based inquiry gave participants an opportunity to use a variety of resources rather than a limited number of preselected references that required detecting relevant from irrelevant information.				

SECTION B

QUESTION 5: The practices of using context-based inquiry in the learning process

Varieties of possible responses have been provided to the following questions. Kindly show your choice with a cross.

1. What resource(s) do you depend on to help you plan your teaching or learning?

Numbering	Resources	1. Never	2. Occasionally	3. Often	4. Always
1	The internet				
2	Textbooks				
3	Teacher's reference books				
4	My experience				
5	Other (Specify)				

2. What do you perceive as the purpose(s) for using context-based inquiry in learning science?

Numbering	Purpose	1. None	2. Some	3. Good	4. Major
1	Consolidate knowledge				
2	Fostering a person ability				
3	Leverage interest				
4	Improve understanding				
5	Promote positive attitude towards science				
6	Enhance performance				
7	Relax for recreation				
8	Fostering engagement				

3. To what extent did you acquire each of the following abilities using context-based inquiry?

Numbering	Ability	1. No/little extent	2. Some extent	3. Large extent	4. Very large extent
1	Cognitive				
2	Affective				
3	Psychomotor				
4	Positive behaviour				
5	Passion				
6	Reliability				

4. What are the impacts or effects of using context-based inquiry?

Numbering	Impact of using context-based inquiry	1.No/little effect	2. Some effect	3. Large effect	4. Very large effect
1	The periodic Table can be studied together with music.				
2	Music can actively process new stimuli and infer the rules of chemistry.				
3	It may code words with heavy emotional and contextual flags.				
4	Evoke a realistic and convincing (cogent) environment.				
5	Enable students to have positive attitude towards chemistry.				
6	Self-perceptions and cultural appreciation is attained.				
7	It can change the artificial classroom environment into a real experience and make new information meaningful.				
8	Bring interest and order to a classroom.				
9	Induce positive effects on science achievement				

SECTION C

Question 6: Content questions on the periodic table of elements- Provide the correct answer

6.1 Determine the location of an element on the Periodic Table, that is used in manufacturing matches.....

6.2 The common compound of sodium is, which is used to de-ice roads in winter.

6.3 How many electrons are found in a neutral oxygen atom? \

Question 7: Content questions on the periodic table of elements-Multiple choice. Circle the CORRECT answer

7.1. Which of the following elements is a solid at room temperature?

A. Hydrogen B. Bromine C. Sodium D. Mercury E. Oxygen

7.2. Which of the following statements is correct for the elements 'O, H and N'?

A. These elements are in the same group of the Periodic Table

B. Their melting and boiling points are very low

C. These elements exist as single atoms in the gas phase at room temperature

D. They are all diatomic molecules under standard conditions

7.3. Which of these elements is the best conductor of electricity?

A. 16S B. 15P C. 17Cl D. 35Br E. 6C

If you would like to provide any feedback about this survey or other information that would help us understand the items asked in this survey, please use the following space

THANK YOU.

Please contact G Djan (0848931121/gdjan@hotmail.com) for any query

RESEARCH QUESTIONNAIRE (PHASE III POST-TEST)

Initial and code		0001
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Researcher: Mrs G Djan

Study leaders: Prof M Lemmer & Dr ON Morabe

PURPOSE OF THE STUDY:

The purpose of this questionnaire is to obtain information that can be used to determine the affordances of the engagement strategies, music, computer simulation and context-based inquiry, towards mastery learning of the periodic table of elements.

CONFIDENTIALITY

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PARTICIPATION AND WITHDRAWAL

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IDENTIFICATION OF RESEARCHERS

If you have any questions or concerns about the research, please feel free to contact Prof Miriam Lemmer (study leader) at 0182994270 or Mrs Grace Djan (researcher) at 0848931121.

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INFORMED CONSENT

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Signature..... Date

SECTION B

You are requested to spend a few minutes to complete the questionnaire below.
Please put a cross in the block that indicates your selected choice. Thank you very much for your time.

PHASE III

This survey may look lengthy, but the items have been spaced for easy reading to save you time. The typical time to complete this survey is about 15-20 minutes. Varieties of responses have been provided. Kindly make a CROSS, TICK or DARKEN the space under the number that applies) in the space next to your choice. Please TICK WITH A CROSS A BLOCK FOR EACH STATEMENT OR QUESTION.

1=Strongly Disagree. 2=Disagree. 3= Agree. 4= Strongly Agree (Circle OR tick, or darken)

QUESTION 1: Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 I think it is important to use computer simulations in teaching scientific concepts.				
2 Computer simulation is useful for learners to engage in science problem solving in a meaningful manner that is not possible with a traditional classroom setting.				
3 Computer simulation is useful for the conceptual understanding of the Periodic Table.				
4 Using computer simulation gave participants an opportunity to visualize abstract concepts.				
5 Using computer simulations assisted in mastering the content of the Periodic Table.				

QUESTION 2: Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 Using simulation in the learning process created passion for pursuing chemistry.				
2 Computer simulation improved the class environment by creating a friendly working climate.				
3 The lessons using computer simulation made me feel satisfied because the abstract concepts became easier to learn and understand.				
4 I found enjoyment in using the simulation of building Na, Cl, O, S, H, C atoms and molecules				
5 I found opportunity to reflect and interact with my beliefs and values.				

QUESTION 3: Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 I can apply what I have learnt through computer simulation to answer questions and solve problems related to the Periodic Table.				
2 I could be counted on to do my work in the learning process in the classroom even if I experienced the effect of simulation followed by debriefing.				
3 The process of simulation of atomic interaction based on the interactive forces assisted the participants to draw conclusions.				
4 The use of computer simulation to learn the elements of the Periodic Table helped me to participate actively in class.				
5 Simulation of elements of the Periodic Table helped me to concentrate on the content.				

QUESTION 4: Computer simulations

Item	1. Strongly disagree	2. Disagree	3. Agree	4. Strongly agree
1 The use of computer simulation in learning the Periodic Table can help learners to understand even the most difficult concept.				
2 The activities matched as nearly as possible the real-world tasks of professionals in practice rather than decontextualized or classroom-based tasks.				
3 Using computer simulation in the learning process promoted collaboration (teamwork) within the class				
4 Assessment of the activities was integrated with the major task in a manner that reflects real world assessment, rather than separate artificial assessment removed from the nature of the task.				
5 Computer simulation gave participants an opportunity to use a variety of resources rather than a limited number of preselected references that require				

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detecting relevant from irrelevant information.				
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SECTION B

QUESTION 5: The practices of using computer simulation in the learning process

Varieties of responses have been provided. Kindly show your choice with a cross.

1. 1. What resource(s) do you depend on to help you plan your teaching or learning?

Numbering	Resources	1. Never	2. Occasionally	3. Often	4. Always
1	The internet				
2	Textbooks				
3	Teacher's reference books				
4	My experience				
5	Other (Specify)				

2. What do you perceive as the purpose(s) for using computer simulations in learning science?

Numbering	Purpose	1. None	2. Some	3. Good	4. Major
1	Consolidate knowledge				
2	Fostering a person ability				
3	Leverage interest				
4	Improve understanding				
5	Promote positive attitude towards science				
6	Enhance performance				
7	Relax for recreation				
8	Fostering engagement				

3. To what extent did you acquire each of the following abilities using computer stimulations?

Numbering	Ability	1. no/little extent	2. some extent	3. Large extent	4. Very large extent
1	Cognitive				
2	Affective				
3	Psychomotor				
4	Positive behaviour				
5	Passion				
6	Reliability				

4. What are the impacts or effects of computer stimulations?

Numbering	Impact of using computer stimulation	1.No/little effect	2. Some effect	3. Large effect	4. Very large effect
1	Creates a higher interest in science careers.				
2	Context-based inquiry can actively process new stimuli and infer the rules of chemistry.				
3	Induce positive effects on science achievement				
4	Evoke a realistic and convincing (cogent) environment.				

5	Enable students to have positive attitude towards chemistry.				
6	Provide laboratory and science process skills.				
7	It can change the artificial classroom environment into a real experience and make new information meaningful.				
8	Bring interest and order to a classroom.				
9	Induce cognitive development and understanding of science knowledge.				

SECTION C

Question 6: Content questions on the periodic table of elements- Provide the correct answer

- 6.1 Name TWO noble gases
- 6.2 What is the group name of the elements in group two?
- 6.3 Name the first three elements on the Periodic Table.....
- 6.4 Determine the location of an element on the Periodic Table, that is used in manufacturing matches.....
- 6.5 The common compound of sodium is, which is used to de-ice roads in winter.
- 6.6 How many electrons are found in a neutral nitrogen atom?

Question 7: Content questions on the periodic table of elements-Multiple choice

- 7.1. Which of the following elements is a solid at room temperature?
- A. Hydrogen B. Bromine C. Sodium D. Mercury E. Oxygen
- 7.2. Which of the following statements is correct for the elements “O, H and N”?
- A. These elements are in the same group of the Periodic Table
- B. Their melting and boiling points are very low
- C. These elements exist as single atoms in the gas phase at room temperature
- D. They are all diatomic molecules under standard conditions
- 7.3. Which of these elements is the best conductor of electricity?
- A. 16S B. 15P C. 17Cl D. 35Br E. 6C

If you would like to provide any feedback about this survey or other information that would help us understand the items asked in this survey, please use the following space

THANK YOU.
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Individual semi-structured and focus group interview questions

INDIVIDUAL INTERVIEW

The semi-structured interview with the teacher was to determine his experience and the effectiveness of music, context based, computer simulation as an engagement strategy to learn the elements of the Periodic Table, combustion reactions, atoms, and molecules. His success, difficulties, as well as support and guidance needed was discussed.

1. How was your preparation compared with the strategy you have been using?
2. Describe your experience using music, context-based inquiry, and computer simulation.
3. What is the difference between this strategy and your normal traditional method of teaching and learning?
4. How do you view context-based inquiry, i.e. how was your experience implementing it in class?
5. What do you think this strategy can afford (i.e. how it can benefit learners) reflecting on your experience when applying this strategy?
6. Do you prefer a single strategy like just music or all three combined and why?
7. Do you think using music, context based, computer simulation will enhance learning scientific concepts?
8. Do you think using music will enhance mastering knowledge?
9. Do you think using music will enhance active construction of own knowledge/ active participation?
10. In your opinion, what is the difference between doing experiments and context-based inquiry and do you think context-based have more value to learning and improvement of scientific skills /knowledge?
11. With context-based inquiry a project was incorporated to apply knowledge to solve a real life problem. How does this compare with having a project assignment as in our current science curriculum?
12. How does context base affect / impact engagement in your opinion?
13. What, as a teacher, will you emphasise as important factors of engagement to enhance learning the Periodic Table and chemistry in general?
14. How will you prefer to apply these strategies in your classroom?
15. What emphasis regarding engagement will you prefer to share with South African Chemistry teachers?

Other areas to consider

1. How as a teacher will you engage your learners
 - To learn and master concepts?
 - Enjoy learning?
 - Actively participate in class?
 - Apply what is learnt to everyday life?

FOCUS GROUP INTERVIEW

The semi-structured interviews with the teachers were to determine their experience and the effectiveness of music, context-based and computer simulation as an engagement strategy to learn the elements of the Periodic Table, combustion reactions, atoms, and molecules. Their successes, difficulties, as well as the support and guidance needed, were discussed.

1. What guidelines will assist you to implement music, context-based and computer simulation as engagement strategies in your day-to-day teaching or as a teaching/learning strategy?
2. Which aspects and grades will this strategy apply to in the South African school curriculum?
3. What do you think can these strategies afford with regard to learners, teachers, and learning?

I mean:

4. What do think, can music as a learning engagement affect learning?
5. What do you think, can music as a learning engagement affect teaching?
6. What do you think, can music as a learning engagement help learners?
7. What do you think, can context-based inquiry as a learning engagement affect learning?
8. What do you think, can context-based inquiry as a learning engagement affect teaching?
9. What do you think, can context-based inquiry as a learning engagement help learners?
10. What do you think, can computer simulation as a learning engagement affect learning?
11. What do you think, can computer simulation as a learning engagement affect teaching?
12. What do you think, can computer simulation as a learning engagement help learners?

Other questions

1. Do you think these strategies (music, context-based and computer simulation) will work or not in South Africa schools?
2. How can the three strategies improve engagement?

Interviews transcript, before and after worksheet results

Source	Index	Authentic	Behaviour	Affective	Cognitive
Interviewee 1	A grade 10-12 educators	"And that that I think it's very helpful and then you learnt things that you have no idea of."	"by the time you have to split out and go back to where they came from, they are not interested". Instead, they will still talk about "eish did you hear my rap was good, did you hear that, instead of sitting down".	"I really enjoyed the process where we got to use music"	"music help with memorization of facts definition and things like that"
Interviewee 2	A grade 8-10 educators	"It can work in all of them" but the time to create the music will take all your time".	"for example someone knowledge and putting everything together and taking part each of us".	"we got excited and the lesson got excited"	"each one of us was interested in giving input and knowing more".
Interviewee 3	A grade 4-7 educators	"I think for this music it is going to help them". "each on each one do his own thing"	"they get distracted easily with song, there is no such with song everyone is going to participate"	"they don't even listen to you, but you sing to them they listen and everyone take part"	"but for them the music is going to help them to remember by their repeating thing"
Focus group 1	Group of 6 Grade 8-12 educators	And ...eeh other thing we might come across to learners is they will for always want to use music as a lesson in class" "All the topics that will need music" Mmmm!, yes! Hmmm	"even with that it actually make you see that, the very shy person who you thought was not interested in reading or They even have more knowledge than those who actually pass they are just seated there, they just worked".	"once learners like music they will be happy interested, they want things that excite them".	"to find themselves composing bringing music to level of content matter". "how tom put those calculations of their formular in terms of music to have an understanding there?"
Focus group 2	Group of 6 grade 4-10	"music will work best especially for inclusive education"	"as for we (teachers) going to be resistance how come we sing and sing its wasting time". "Wa bo". "when it comes to the younger ones, they will think it's just a song, eh that is why the teacher must guide them"	"at primary school they are still young they gonna enjoy themselves"	"after the whole activities I can now answer with more understanding"
Focus group 3	Group of 6 Grade 4-7 educators	It did	"It did"	"It did"	"It did"
Observation 1	Group 1	Creative	Enthusiastic	Smiling	An application song on no more load shedding, use of copper.
Observation 2	Group 2	Very creative	Very enthusiastic	Interesting. Ended with funny action and laughed.	Song: "two by two" Cl ₂ , H ₂ , Br ₂ (song on diatomic molecules)
Observation 3	Group 3	Not ready to present. Busy in group planning	Engaged as a group to compose song	Serious in their group then joined group 2. Took the lead dancing, singing smiling, enjoying	Song: "two by two" Cl ₂ , H ₂ , Br ₂ (song on diatomic molecules)

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APPENDIX E: CONFIRMATION OF LANGUAGE AND TECHNICAL EDITING



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4 December 2021

TO WHOM IT MAY CONCERN

I hereby declare that the proposal titled:

**Affordances of engagement strategies in chemistry:
Learning the periodic table**

by

**G Djan
17142024**

has been technically edited by myself, which includes all tables and figures as well as the layout of the document's contents.

E Oosthuizen

December 2021



Editing Services

CERTIFICATE OF EDITING

This is to certify that the manuscript listed below was edited for proper English language, grammar, punctuation, spelling, referencing and overall style by a qualified English editor at OU Editing Services.



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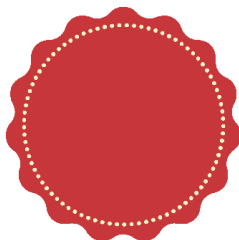
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