THE INFLUENCE OF INDIGENOUS KNOWLEDGE ON CHEMISTRY METACOGNITION: A FOCUS ON PRE-SERVICE SCIENCE TEACHERS IN ZIMBABWE

BY

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I declare that the above thesis is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

(The thesis will not be examined unless this statement has been submitted.)

23 November 2020

SIGNATURE DATE

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ABSTRACT

The teaching and learning of Chemistry concepts are detached from the socio-economic daily life experiences of pre-service science teachers. Pre-service science teachers find Chemistry difficult and challenging as they struggle with the Chemistry concepts resulting in poor academic performance in Chemistry at the teachers' college. Most of the pre-service science teachers in Zimbabwean teachers' colleges also find Chemistry to be a difficult and challenging subject. The aim of this research was to explore the use of culturally contextualised indigenous Chemistry knowledge by pre-service science teachers in Chemistry metacognition. The study was guided by the following questions: (i) What is the indigenous Chemistry knowledge possessed by pre-service science teachers? (ii) How relevant is the indigenous knowledge to chemistry metacognition? (iii) How effective is the indigenous Chemistry knowledge in Chemistry metacognition? (iv) What are the attitudes of pre-service science teachers towards the use the use of indigenous Chemistry knowledge in Chemistry metacognition. The embedded mixed methods case study was underpinned by the social constructivist theoretical framework which was used to collect and analyse the data. Social constructivist theory assumes that knowledge, reality and learning are cognitive functions which are social processes acquired through interaction with other individuals and the environment. Twenty-nine post ordinary level pre-service science teachers in their first year at college were purposively sampled. Their metacognition awareness was determined through focus group interviews which are triangulated with a test. The indigenous Chemistry knowledge possessed by the pre-service science teachers was collected using focus group interviews which was then used in the intervention stage for Chemistry metacognition. The findings of the study suggested that; (i) pre-service science teachers possessed a vast amount of indigenous Chemistry knowledge, (ii) there was a relevance of indigenous Chemistry knowledge to Chemistry metacognition, (iii) indigenous Chemistry knowledge was quite effective in improving metacognition awareness, (iv) indigenous Chemistry knowledge improved the performance of pre-service science teachers in Chemistry after the intervention and (v) there was a positive attitude towards the use of indigenous Chemistry knowledge in Chemistry metacognition by pre-service science teachers. These findings suggested that indigenous knowledge influences Chemistry metacognition in a positive way. The positive interaction of indigenous Chemistry knowledge and Chemistry metacognition has been shown by this study. Further research is required on the relationship between indigenous Chemistry knowledge and Chemistry metacognition. It was recommended that the indigenous Chemistry knowledge of Chemistry learners should be identified and applied in the Chemistry curriculum at teachers' colleges. It was further recommended that Chemistry educators be capacitated with skills for identifying indigenous Chemistry knowledge that is relevant to Chemistry metacognition.

KEY TERMS:

Academic performance; African philosophical orientation; Chemistry metacognition; cultural relevance; indigenous Chemistry knowledge.

LIST OF ACRONYMS AND ABBREVIATIONS

BACEIS	Behaviour Affect Cognition Environment-Interacting Systems.
ECD	Early Childhood Development
GMB	Grain Marketing Board
IQ	Intelligent Quotient
LASSI	Learning and Study Strategies Inventory
MAI	Metacognition Awareness Inventory
MHTESTD	Ministry of Higher and Tertiary Education, Science and Technology Development
MKO	More Knowledgeable Other
MoPSE	Ministry of Primary and Secondary Education
MSLQ	Motivated Strategies for Learning Questionnaire
PST	Pre-service Science Teacher
RC	Regulatory Checklist
SEM	Strategy Evaluation Matrix
SSAAS	Senate Sub-Committee on Associate and Affiliate Status
STEM	Science Technology Engineering and Mathematics
TRA	Theory of Reasoned Action
VSPD	Virus Complex Disease
ZIMSEC	Zimbabwe School Examinations Council

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CHAPTER 1
INTRODUCTION AND BACKGROUND TO THE STUDY

1.1. INTRODUCTION

The background of the study is introduced in this chapter. It gives direction to the research title, problem statement and research question for a better understanding of the research focus and Chemistry challenges held by pre-service science teachers. Also, the rationale, aim, objectives, the delimitation and limitations of the study are discussed in this chapter. Finally, the thesis chapter layout is provided at the end of this chapter.

1.2. BACKGROUND TO THE STUDY

Two ministries make up the bulk of the education system in Zimbabwe which are; The Ministry of Primary and Secondary Education (MoPSE) and the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD)(Ndakala, et al 2019). Other ministries which contribute are the Ministry of Health and Child Care, Ministry of Youth, Sport and Arts and Recreation as well as the Ministry of Lands, Agriculture and Water that are responsible to a small extent for the training of some practical skills. There are three major levels of education in Zimbabwe which are primary, secondary and tertiary level. The MoPSE is responsible for primary and secondary education while the MHTESTD is responsible for tertiary education.

At secondary school, there is junior high school which begins at form 1 and ends with an external public examination at form 4 called ordinary level examination. A full certificate at ordinary level must have five subjects passed including English language, Mathematics and Combined Science (formally Integrated Science) (Tsiko,2018). Senior high school (advanced level) is two years (form 5 and 6) and is done after having passed five ordinary level subjects.

Advanced level external public examinations are written in the second year (form 6) of senior high school. A complete certificate at advanced level consists of two subjects passed. At ordinary level, a pass begins at the grade C up to grade A. At advanced level, a pass grade starts at E going to A. An examining body called the Zimbabwe School Examinations Council (ZIMSEC) is responsible for all external public examinations at primary and secondary level. The grading system of ordinary level and advanced level are shown below in table 1.1

Table 1.1: ZIMSEC ordinary level and advanced level grading system (Adapted from Tsiko, 2018)

Level	Grade	Points	Interpretation
Ordinary	A	1	Very good
	B	2	Good
	C	3	Average
	D	4	Weak
	E	5	Very week
	U		Ungraded
Advanced	A	5	Very good
	B	4	Good
	C	3	Average
	D	2	Pass
	E	1	Pass
	O	0	Ordinary
	F	0	Fail

The perception held by many learners and teachers is that Chemistry is a difficult and challenging subject (Uzezi, Ezekiel and Auwal, 2017; Mahdi, 2014; Gafoor and Shilna, 2013). In Matabeleland North and other provinces, the Biology, Chemistry and Physics subjects are believed to be extremely difficult by both learners and teachers (Regional Centre for Social Responsibility, 2012; Ogunkola and Samuel, 2011). A recent study by, Gadzirayi, Bongo, Ruyimbe, Bhukuvhani and Mucheri (2016) in Zimbabwe showed that science education suffers because of a negative attitude from learners. This has led to many learners not opting to partake in the sciences as shown by the table 1.2 below.

Table 1.2 ZIMSEC 2015 total number of school candidates who wrote examinations by subject. (Adapted from Nhandara, 2016)

Subject	Candidates who wrote examination	Candidates who got Grade C or better
Biology	20 634	11 054
Chemistry	5 175	3 500
Commerce	93 029	35 981
English Language	164 867	44 829
Geography	130 759	50 885
Integrated Science	77 265	49 145
Mathematics	114 236	29 891
Ndebele	22 970	13 251
Physical Science	7 261	5 197
Physics	5 191	4 450
Principles of Accounts	32 295	18 233
Shona	118 583	48 081

The table shows that Chemistry, Physical science and Physics were written by very few candidates when compared to the other Science Technology Engineering and Mathematics (STEM) subjects as well as other subjects. Table 1.2 also shows that Chemistry had the least number of learners doing well when compared to the other STEM subjects. In Matabeleland North, very few candidates take up the

Biology, Chemistry, Physical science and Physics subjects when compared to other Zimbabwean provinces (Nhandara ,2016).

To promote STEM education, the Zimbabwean government sponsored all learners studying STEM subjects at advanced level who had passed the STEM subjects at ordinary level. According to Tshili (2016), Matabeleland North province contributed the lowest number of learners to taking pure science subjects in the Zimbabwean government-sponsored STEM programme at advanced level. This was confirmed by Katongomara (2016) who discovered that whilst contributions by numbers from other provinces were; Harare 798 students, Midlands 573 students, Manicaland 559 students, Mashonaland East 487 students, Masvingo 410 students and Matabeleland South 225 students respectively, Matabeleland North contributed the lowest number of only 130 students to the government sponsored STEM programme.

The perception of Chemistry being exceedingly difficult is even stronger in rural secondary day-schools. Rural secondary schools are government-owned schools in rural areas which are normally poorly resourced in terms of both human and material resources that negatively affects the teaching and learning process. Due to this perception, Chemistry is viewed as a subject for very intelligent or gifted learners only (Cardellini, 2017; Fu et al, 2015). As a result, very few learners take up Chemistry as a subject in their studies. For the few who take it up, their performance is usually poor when compared to other STEM subjects like Physical science and Physics (Thondhlana,2020). Dube (2016) points out that there are concerns in Tsholotsho North in Matabeleland North about the poor performance by learners in pure sciences at ordinary level. Table 1.3 shows the generally poor performance of learners in Chemistry when compared to Physical science and Physics.

Table1.3 ZIMSEC 2015 National Pass Rate (%) by Province. (Adapted from Nhandara, 2016)

Province	Chemistry	Physical science	Physics
Bulawayo	48.5	59.4	69.4
Harare	57.4	62.6	80.1
Manicaland	79.9	74.9	91.7
Mashonaland Central	73.8	80.7	93.9
Mashonaland East	67.5	80.6	92.8
Mashonaland West	68.1	69.0	82.9
Masvingo	62.1	70.7	88.0
Matabeleland North	65.8	69.3	84.6
Matabeleland South	70.1	57.2	82.4
Midlands	75.7	75.8	86.5

In contrast to what was stated above, the table gives the impression that Matabeleland North and Matabeleland South had higher pass rates of 65.8 and 70.1% respectively than the other provinces in Chemistry. The actual number of learners who wrote the subject in the two Matabeleland provinces are lower when compared to other provinces as shown by table 1.4. Chemistry as a subject is usually taken only by a few selected learners in Matabeleland North and Matabeleland South. These learners are chosen on condition of good performance in Chemistry, hence the apparent higher pass rates in the Matabeleland provinces.

In Zimbabwe, the minimum number of subjects for one to be considered to have a full certificate at ordinary level is five as asserted by the Zimbabwe National Statistics Agency (2018). Matabeleland North generally records the least number of learners who attain this required minimum number of five subjects. (Nembaware, 2019). Table 1.4 shows the ZIMSEC 2018 provincial pass rates of school candidates.

Table 1.4 ZIMSEC 2015 Provincial Pass Rates (%) of school candidates. (Adapted from Nhandara, 2016)

Province	Number of candidates who sat for five or more subjects	Number of candidates who passed five or more subjects with Grade C or better	Provincial Pass Rate
Bulawayo	8 658	2 173	25.10
Harare	17 328	4 984	28.76
Manicaland	24 939	7 548	30.27
Mashonaland Central	12 130	2 949	24.31
Mashonaland East	25 956	5 662	21.81
Mashonaland West	17 522	4 142	23.64
Masvingo	21 473	6 437	30.00
Matabeleland North	7 921	1 852	23.38
Matabeleland South	7 803	1 941	24.87
Midlands	17 646	5 215	29.55

There is poor academic performance in sciences, especially in Chemistry (Uchegbu, Oguoma, Elenwoke and Ogbuagu,2016; Hassan, Ali, Salum, Kassim, Elmoge and Amour, 2015; Anditi, Okere and Muchiri, 2013; Ezeudi and Obi, 2013). In the 2015 Zimbabwe School Examinations Council (ZIMSEC) results analysis, mathematics was passed by 29 891 students, integrated science by 49 145 students, biology by 11 054 students, physical science by 5 197 students and chemistry had the least of 3 500 students nationally noted Nhandara (2016).

The above is although the Zimbabwean government has been making efforts to promote Science, Technology, Engineering and Mathematics (STEM) subjects at advanced and tertiary education levels. The government has attempted to do so by paying full school fees and boarding expenses for learners who take up STEM subjects at an advanced level of education. The STEM sponsorship was for the purposes of industrialisation and technological development. The STEM initiative was put in place after realising that there was a general low uptake of Mathematics, Physics, Chemistry and Biology at an advanced level nationally, and more particularly in Matabeleland North. (Chikiwa,2018; Nkala, 2018).

The researchers' observation during the August Vacation School teaching of 2016 and 2017 in Tsholotsho and of pre-service science teachers at the teachers' college was that there was indeed poor performance by learners in Chemistry. The poor performance in chemistry was despite the fact they were exposed and practised some of the chemistry in their daily lives in agriculture, environmental conservation, food processing, food preservation and health (Mapara's, 2009) The majority of the pre-service science teachers at the teachers' college come from Matabeleland province schools which have low pass rates and have learners who find Chemistry challenging. (Chikiwa, 2018; Nkala, 2018). Pre-service science teachers' poor academic performance in chemistry might might changed to high academic performance through metacognition. Metacognition increases the academic performance of learners in various ways such as the application of attentional resources in a better way, application of existing strategies in a better way and a higher awareness of breakdowns in comprehension (Schraw,1998).

1.3. RESEARCH PROBLEM STATEMENT

Pre-service science teachers find Chemistry difficult and challenging as they struggle with the Chemistry knowledge, skills and attitudes, thus resulting in poor academic performance in Chemistry at the teachers' college (Mudzakir,2017; Wheeldon,2017; Cam, Topcu and Sulun 2015). Misconceptions or alternative conceptions, insufficient content knowledge, skills and attitudes contribute significantly to the pre-service science teachers' ability to adequately learn Chemistry resulting in difficulties and challenges in the chemistry learning process. Pre-service teachers were found to have electroChemistry misconceptions and inadequate content knowledge by Yilmaz and Bayrakceken (2015). Pre-service chemistry teachers lacked knowledge on the identity and functions of laboratory equipment necessary for the subject according to Bektas, Tuysuz, Kirbulut and Cetin-Dindar (2011).

The teaching and learning of Chemistry concepts are detached from the socio- economic daily life experiences of pre-service science teachers (Ugwu and Diovu, 2016). The teaching and learning at teachers' colleges is conceptualised from the western and eastern philosophical orientations that are based on a universal approach towards knowledge generation and dissemination (Shumba, 2014).

The ideal Chemistry teaching and learning should be done from the African philosophical orientation that is locally contextualised and culturally relevant in terms of knowledge generation and dissemination that meets the needs and provides practical solutions to the everyday life chemical challenges and problems of the community. (Rahmawati and Ridwan ,2017; Ugwu and Diovu, 2016; Hogan, 2008)

1.4. THE RESEARCH QUESTION.

1.4.1. Main research question

The following research question guided the study:

- How does indigenous Chemistry knowledge influence Chemistry metacognition?

1.4.2. Sub-questions

The following sub-questions helped unpack the main research question:

1. How much indigenous Chemistry knowledge is possessed by pre-service science teachers?
2. How relevant is indigenous Chemistry knowledge to Chemistry metacognition?
3. How effective is indigenous Chemistry knowledge in Chemistry metacognition?
4. What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition?

1.5. RATIONALE

The purpose of this study is to simplify and contextualise the teaching and learning of Chemistry concepts for life-long survival and problem-solving skills. The contribution of Zimbabwean culture to Chemistry literacy has not been analysed to date. Most studies that have been done in teachers' colleges focus mainly on the causes of poor academic achievement in science such as inadequate or lack of resources as well as qualified science lecturers. Aina (2014) identified lack of science teaching equipment, lack of visionary leaders, lack of committed lecturers, poor professional development and bad admission policy as factors affecting the quality of pre-service science teachers in colleges of education in his study.

Inadequate resources for science teaching, inadequate higher education institutions, implementing conflicting educational policies and the use of English for science instruction which is a second language for most of the learners are factors that negatively affect the quality of pre-service science teachers at teachers' colleges, asserts Ogunniyi and Rollnick (2015). The study also intends to explore the influence of indigenous knowledge on Chemistry metacognition by pre-service science teachers in Zimbabwe.

1.6. AIM AND OBJECTIVES OF THE STUDY

The aim of this research was to explore the influence of indigenous Chemistry knowledge by pre-service science teachers in Chemistry metacognition.
The following research objectives led to the attainment of the aim:

i. Identify the cultural indigenous Chemistry knowledge possessed by pre-service science teachers.
ii. Analyse the relevance of the cultural indigenous Chemistry knowledge with respect to Chemistry metacognition.
iii. Evaluate the effectiveness of cultural indigenous Chemistry knowledge in Chemistry metacognition.
iv. Identify the attitudes of pre-service science teachers on the use of cultural indigenous Chemistry knowledge in Chemistry metacognition.

1.7. DELIMITATION OF THE STUDY

The focus of the study was on post-ordinary level pre-service science teachers in secondary school teachers' colleges in the Bulawayo Metropolitan Province who perceived and found Chemistry to be difficult as well as challenging in their studies. The focus on pre-service science teachers from Bulawayo Metropolitan Province was because most of them come from and end up in Matabeleland North and Matabeleland South as science teachers. Matabeleland North and Matabeleland South provinces generally record low uptake and pass rates in Chemistry and other STEM subjects when compared to the other eight provinces of Zimbabwe. Only Indigenous knowledge, skills and attitudes held by pre-service science teachers that conformed to or fitted with Physical Science or the physical world were utilised in this study. This was accomplished by only using indigenous knowledge which was socio-cultural, that was, based on science.

One limitation of indigenous knowledge, skills and attitudes possessed by the pre-service science teachers is that it is not restricted to the physical world as some of it is spiritual. Another limitation of indigenous knowledge, skills and attitudes possessed by the pre-service science teachers is that these are not uniform or common since the pre-service science teachers come from different cultures (multi-cultural).

1.8. STUDY ORGANISATION

An outline of the study's chapters in terms of organisation is provided in this section.

Chapter 1. Introduction and background to the study

An outline of the background context of the study and the research questions as well as the sub-questions the study sought to answer are presented in this chapter.

Chapter 2. Metacognition and science education

This chapter consists of the literature review, the purpose of which is to situate the study as well in strengthening the discussions and arguments in the study.

Chapter 3. Theoretical framework

In this chapter, the social constructivist theoretical framework, which is a model of the constructivist theoretical framework is discussed as the theoretical basis of this research.

Chapter 4: Research Methodology

The research methodology which involves the mixed methods approach, the embedded mixed methods case study design and the interpretive paradigm is discussed in this chapter. The research instruments, rigour as well as research ethics are also discussed.

Chapter 5: Results and Discussion

Results from data analysis and discussion of the study are the focus of this chapter. Tables, pie charts and graphs are the forms some of the results are presented in.

Chapter 6: Conclusions, Recommendations and Limitations of the study

This chapter presents the conclusions, recommendations and limitations which were drawn from the findings of the study.

1.9. SUMMARY

The background of the study, the research problem statement, research question, research sub-questions, rationale, aim and objectives of the study are looked at in this chapter. The delimitation and limitations of the study are also looked at with the layout of the thesis in terms of structure coming at the end. The chapter that follows deals with the literature review of the study.

CHAPTER 2
METACOGNITION AND SCIENCE EDUCATION

2.1. INTRODUCTION

A review of appropriate empirical research as well as their description and plans of action are done in this chapter to scholarly position this study. The chapter discusses the relationship between metacognition and academic achievement. The relationship between science and culture as well as the relationship between Indigenous Chemistry knowledge and Western Chemistry knowledge are also discussed. The purpose of discussing these relationships is to place metacognition into the Zimbabwean context. Methods of metacognitive instruction are discussed. A model of improving Chemistry academic performance is suggested towards the end of the chapter. The education system in Zimbabwe is described in this chapter as well.

2.2. RESEARCH ON METACOGNITION AND ACADEMIC ACHIEVEMENT

Internationally and regionally, research has shown that the acquisition and use of metacognition improves academic achievement and motivation of learners including, those who are intellectually limited, education resource disadvantaged, prior knowledge limited as well as culturally disadvantaged.

Rahman, Jumani, Chaudry, Chitsti and Abbasi (2010) studied how the performance of secondary school students in Chemistry was impacted by metacognition awareness in the Asian country of Pakistan. Their objectives were to ;(i) ascertain the metacognition measurement of science students and (ii) determine how student's performance was impacted by metacognitive awareness. Their findings were that ;(i) metacognition is important in student's academic achievement and, (ii) students with high metacognitive skills performed better than those of low metacognitive skills. In this study only the metacognitive inventory was used instead of multiple methods that avoid similar sources of errors as stated by Noushad (2008).

Aurah, Koloi-Keaikitse, Isaacs and Finch (2011) studied the function of metacognition among primary school learners in the African country of Kenya in everyday problem solving. The focus of the research was; (i) investigating metacognition's role in problem solving ability and, (ii) investigating if the level of metacognition was affected by the age or grade level of primary school learners. The findings of their study were; (i) learners who were better problem solvers were those with higher metacognition level than learners who had low levels of metacognition and, (ii) high grade level learners were better in terms metacognition and the ability to perform problem-solving. The assessment of metacognition levels was conducted using Metacognition Awareness Inventory (MAI) questionnaire which does not capture the actual metacognition processes in the learners' mind. Noushad (2008) suggests that if no multiple methods were used to assess metacognition, it results in having the same source of errors which results in a less dependable picture of the phenomenon being investigated in metacognition assessment.

Van Aswegen (2015) researched the metacognitive awareness development of intermediate phase young learners using stories for facilitation in South Africa. The finding of the research implied that the development of metacognitive awareness using story-based interventions yielded positive results. The questionnaire used in the research did not measure the metacognitive awareness as the tasks were being performed but rather afterwards which is not as accurate as online methods.

Most of the research that have been done has focused on the relationship between metacognition and academic achievement. However, there is a gap in knowledge on the contribution of indigenous Chemistry knowledge (pre-service science teachers' prior knowledge and beliefs) to Chemistry metacognition in the Zimbabwean teachers' college context. This research seeks to fill that gap in knowledge.

2.3. CULTURE AND SCIENCE.

Serrat (2008) defines culture as the distinctive beliefs, knowledge, values and ideas which are shared by a society in their totality. Culture is a society's way of life that includes that society's folkways such as language, knowledge, ideas, customs, dressing as well as the symbols and artefacts, which are developed by the people (Lawson and Garrod, 2003). Culture is defined by Colbert (2010) as the collaboration of common beliefs or shared meanings with members of an organisation. According to Kiyici and Kiyici (2007), science is the study of the natural phenomena that happens in settings that are natural or experimental. Wilson (2009) defined science as the describing, identifying, observing, explaining theoretical and investigating experimentally of phenomena that is natural. Science is whereby evidence is used in the construction of testable predictions and explanations of natural phenomena including knowledge that is produced by means of this process (National Academy of Sciences, 2008). Science is a section of culture and culture affects how science is done asserts as asserted by Iaccarino (2003). Cultural values have been strongly influenced by science whilst culture has also strongly influenced science opines Iaccarino (2003).

Science is a cultural enterprise that is social (Yuenyong and Yuenyong, 2012). Knowledge that is scientific is shared by the scientific community by processes of journals, conferences and peers, thus creating and criticising scientific knowledge. The scientific community (culture of science) has a characteristic that includes working as research groups that link to a bigger network which shares similar interests in enquiry areas (Yuenyong and Yuenyong, 2012). The definition of science as a systematic way of knowing about nature through investigation that results in reliable knowledge was given by Schafersman (1994). Reliable knowledge is knowledge whose probability of being true is high, whose veracity was proven by a method that is reliable (Schafersman ,1994).

The scientific method involves the use of scientific and critical thinking which are based on empirical evidence, logical reasoning practice and sceptical attitude possession (Iaccarino, 2003). Scientists as a community (culture of science) have methods of assessing the reliability of scientific knowledge through the scientific method. Knowledge that is scientific gradually changes with time, which makes scientific ideas tentative (Yuenyong and Yuenyong, 2012). Scientific knowledge must be understood in the context of data that was generated (collected, validated and interpreted) through the social process of negotiation in the scientific community guided by the culture of science (scientific method) as suggested by Yuenyong and Yuenyong (2012)

According to Iaccarino (2003), the aim of science is to describe the causes and effects of events that occur in nature using a philosophy that is based on European cultures. Western culture and concepts-based science education is taught in non-western countries by teachers who apply foreign approaches in teacing, leading to indigenous science learners denying the authority and validity of indigenous knowledge (Iaccarino, 2003). Lee, (2011) points out that effective science teaching and learning begins with the fact that science learners bring to formal science learning and teaching institutions constructed and culturally bound prior knowledge, skills and attitudes. Effective science teaching and learning occurs when the learners' cultural experiences are connected to formal institutional science practices, opines Lee (2011).

Although science learning is challenging, non-western learners have extra challenges as their culturally-based prior knowledge, beliefs, language and experiences (intellectual resources) are usually ignored or marginalised when it comes to science learning in formal science learning and teaching institutions (Lee, 2011; Quigley, 2009). Mhakure and Mushaikwa (2014) assert that African science learners in Sub-Saharan Africa experience many challenges in science education associated with the clashes between western science which is Eurocentric, and African indigenous knowledge due to the two knowledge systems' social and cultural differences.

According to Lee and Buxton (2010), high academic achievements in science occur for non-western science learners when learning opportunities in science that are equitable are provided. Equitable science learning occurs at formal learning institutions for non-western learners when their community and home experiences are valued and respected, suggests Lee and Buxton (2010). Lee and Buxton (2010) go further by pointing out that equitable science learning occurs when the non-western science learners' indigenous knowledge, skills and attitudes are well articulated with science knowledge.

Culturally relevant pedagogy and andragogy results in intellectual, emotional, political and social empowerment of learners using referents of culture for the acquisition of knowledge, attitudes and skills as asserted by Ladson-Billings (1994). According to Gay (2000), culturally relevant andragogy and pedagogy make use of the non-western learners' prior experiences and cultural knowledge to provide effective and relevant learning experiences for learners. The focus of culturally relevant andragogy and pedagogy is on; academic excellence without basing it on teaching and learning institutions failure models, which are deficit of cultural context, competence in culture that identifies excellence in the context of the learners' cultural identity and community as well as challenging structures in society, teaching and learning institutions through critical consciousness, suggests Ladson-Billings (2002).

Boutte, Kelly-Jackson and Johnson (2010) see culturally relevant science teaching and learning as that which values non-western learners' indigenous knowledge, skills, and attitudes as well as worldview. According to Ladson-Billings (2002), conventional teaching and learning, when compared to culturally relevant teaching and learning, privileges culture that is Eurocentric as well as epistemologies that are positivist such as the “Scientific method’’, a framework which has steps to be followed that are “linear’’ when the natural world is to be investigated. Aspects of culture of non-western science learners such as indigenous knowledge (traditional and empirical knowledge), ways of knowing as well as indigenous world views should be seen and incorporated as science learning foundations asserts Quigley (2009).

2.4. LEARNER’S CULTURE EFFECTS ON CHEMISTRY EDUCATION

Chemistry learners are exposed to the cultural beliefs and indigenous knowledge from their culture. All leaning occurs through culture in the social context states Aikenhead and Jegede (1999). Le Grange (2007) states that in Southern Africa, learning and achievement in school are heavily affected by culture and an understanding of the learning process of non-western learners leads to a science education that is more effective. Chemistry learners who have other languages which are not English as their home language struggle to understand Chemistry concepts and the learners would struggle less if they were taught in their mother tongue, according to Barker & Taylor (1995). The linguistic background of the learner is related to the learners’ construction of meaning in Chemistry.

The cultural prior knowledge from the learners’ culture has a significant impact on the learning of formal (school) Chemistry concepts and this cultural prior knowledge determines the learners’ preferred learning style, asserts Baker and Taylor (1995). This is supported by Solomon (1987), who asserts that social influences strongly affect formal school Chemistry development particularly when learners have socially determined preferences and preconceptions. This results in two Chemistry knowledge perspectives (worldviews), indigenous cultural Chemistry knowledge and western cultural Chemistry knowledge which differ only on cultural perspective/ views. Cobern and Aikenhead (1997), state that Chemistry is a sub-culture of Western culture. Barnhardt and Kawagley (2005) and The Alaska Native Science Commission (2003) made some comparisons between indigenous Chemistry knowledge and western Chemistry knowledge as shown in table 2.1.

Table 2.1: Comparison between indigenous and western chemistry knowledge.

Indigenous Chemistry knowledge	**Western Chemistry knowledge**
Integrated, based on a whole system	Analytical, based on subsets of the whole

Sacred and secular	Secular only
Assumed to be the truth	Assumed to be a best approximation
Learning by doing and experiencing	Learning by formal education
Oral or visual	Written
Holistic	Reductionist
Teaching through story telling	Didactic
Experiential	Positivist
Intuitive	Model or hypothesis based
Subjective	Objective
Long-term wisdom	Short-term prediction
Lengthy acquisition	Rapid acquisition
Weak in predictive principles in distant areas	Weak in local areas of knowledge
Powerful prediction in local areas	Powerful predictability in natural principles
Explanations based on examples, parables, anecdote	Explanations based on hypothesis, laws, theories.
Models based on cycles	Linear modelling as first approximation
Classification: • a mix of ecological and use non-hierarchical differentiation • Includes everything natural and supernatural	Classification: • based on phylogeny relationships with hierarchical differentiation • excludes the supernatural

According to Lynch, Chipman and Pachaury (1985), non-western learners are at a disadvantage culturally when it comes to studying western Chemistry curricula. The learners' cultural background significantly affects the learning of Chemistry and their ways of acquiring knowledge. Indigenous knowledge is practical as it is meant for survival purposes and was acquired through the observation of natural processes whilst western knowledge is abstract and its acquisition is normally academic (Ugwu and Diovu, 2016). Although Chemistry is an experimental subject, it is abstract to both the learners and the teachers due to the way Chemistry is learnt and taught which are not related to the everyday life experiences of the learner (Ugwu and Diovu, 2016).

Indigenous Chemistry knowledge and practices are isolated from the teaching and learning of Chemistry in the classroom declares, Ugwu and Diovu (2016).

Traditional explanations also affect Chemistry education in countries that are not from the West, states Baker and Taylor (1995). They go further and point out that Chemistry education presentation without carefully considering the traditional values and views of non-western learners when interpreting natural phenomena is educationally unsound. Chemistry education in non-western countries is affected by the cultural gap of the interpretation of reality that is between non-western Chemistry and western Chemistry learners. Aikenhead (2005) and Aikenhead and Jegede (1999) posits that learners' construction of meaning is done through indigenous Chemistry knowledge (prior Chemistry knowledge).

When the leaner's indigenous Chemistry knowledge agrees with, compatible with (harmony) and supported by (cognitive harmony) by western Chemistry knowledge, there is mental equilibrium and the western Chemistry concept being learnt is easily understood, thus in-depth understanding occurs in the Chemistry class. This represents a smooth movement between the world views and it is called enculturation. If the learners' indigenous Chemistry knowledge is not in agreement, or compatible (harmony) with western Chemistry knowledge, disruption of learners' indigenous Chemistry knowledge worldview occurs (cognitive conflict). The learner might be forced to do away with their indigenous Chemistry world view or devalue it as the new Western chemistry knowledge replaces the indigenous Chemistry knowledge in a process called assimilation. This affects the learner negatively as suggested by Aikenhead and Jegede (1999).

Assimilation results in non-western learners moving (cognitively) away from western Chemistry knowledge in terms of in-depth understanding (evaluation, application and synthesis skills and intrinsic motivation) as learners design innovative methods (Chemistry school games) of achieving good passes in western Chemistry with no meaningful or in-depth learning of western Chemistry knowledge and skills taking place, as asserted by Aikenhead and Jegede (1999). According to Aikenhead and Jegede (1999), this scenario where learners acquire skills of knowing how to do well in western Chemistry knowledge at school without in-depth understanding through rote learning (memorisation) of main points and without putting a lot of effort and time in is called "Fatimas' Rules". The learners construct separate compartments in their minds where they store the western Chemistry knowledge and skills separately from their everyday life indigenous Chemistry knowledge and skills to prevent disruption to their indigenous Chemistry knowledge, values, norms and beliefs by the western Chemistry knowledge and skills, only to retrieve it when they want to use it.

2.5. HARMONISATION OF INDIGENOUS KNOWLEDGE WITH WESTERN KNOWLEDGE.

Indigenous knowledge consists of traditional knowledge and empirical knowledge with traditional knowledge being knowledge that is generationally passed on along with indigenous technologies, beliefs and values, where elders in the community are the custodians of this traditional knowledge, states Quigley (2009). Empirical knowledge in indigenous knowledge is acquired by carefully observing whole ecosystems that extends around a lot of people over a long duration, which is refined or replaced through the acquisition of new information just like in western knowledge, opines Quigley (2009).

African societal expectations, traditional indigenous worldview, authoritarianism, sacredness of indigenous Chemistry knowledge and supernatural forces in natural phenomena were identified by Jegede (1995) as inhibitions from the African culture for western Chemistry learning. These inhibitions, according to Cobern and Aikenhead (1997), result in African learners who have learnt western Chemistry knowledge and skills having difficulties with moving from their indigenous Chemistry knowledge concepts to accepting the western Chemistry knowledge and skills which are rational, reductionist and mechanistic. However, Tsuji and Ho (2002) stress the importance and benefits of identifying similarities between indigenous Chemistry and western Chemistry ways of knowledge construction and transmission of knowledge so as to create an understanding of the natural world which is more encompassing.

Whilst western Chemistry knowledge and skills are mechanistic, reductionist, materialistic, de-contextualised, idealised mathematically and elitist and indigenous Chemistry knowledge and skills are holistic, contextualised, communal, personal, empirical, survival oriented, spiritual and inclusive, there are some common characteristics between the two such as being rational, ideological, communal and empirical as declared by Aikenhead (1997). These similarities were confirmed by Baker, Rayner and Wolowic (2011), who saw indigenous Chemistry knowledge and western Chemistry knowledge as both having characteristics such as; being able to give explanations of complex systems, basing on observations, verifying through repetition, seeking the understanding of the physical world and changing of the body of knowledge over time.

This allows indigenous Chemistry knowledge and western Chemistry knowledge to complement each other in terms of Chemistry knowledge and skills construction and transmission. Erinosho (2013) asserts that formal (western) science knowledge can be made to connect with indigenous science knowledge that exists in the learners' locality through a pedagogical and andragogical approach that is called contextualisation. According to Erinosho (2013), indigenous knowledge which is the learners' experiential knowledge, provides a strong foundation for the building upon and learning of new concepts. This sets a situation where the indigenous Chemistry and skills might be used as the prior knowledge and the western Chemistry knowledge being used in the explanation of the indigenous Chemistry knowledge in the worldview of the African Chemistry learner to promote in-depth and lifelong Chemistry learning.

Banner (2016) says it is crucial to have a blending of indigenous Chemistry knowledge and western knowledge learning, which leads to an environment of shared learning whereby indigenous Chemistry knowledge is not assimilated by the dominant western Chemistry knowledge, but is thoroughly articulated and clearly heard, resulting in learning being reciprocal and making Chemistry learning meaningful to local Chemistry learners.

2.6. RESEARCH ON CURRENT INDIGENOUS CHEMISTRY PRACTICES IN ZIMBABWE.

In a study by Mutandwa and Gadzirayi (2007) on the comparative assessment of indigenous methods of sweet potatoes preservation among smallholder farmers, a case study of grass, ash and soil-based methods in Zimbabwe, the objective was to assess the effectiveness of the three methods in terms of tubers' loss of water rate, discolouration rate, change in weight as well as identifying change in weight. They used the storability of the variety Mozambican White sweet potatoes, using the turgidity and colour as parameters at room temperature to store the sweet potato variety. This showed the food preservation method contribution by indigenous Chemistry knowledge. Current sweet potato preservation is based on indigenous Chemistry knowledge in use.

Sweet potato is an orphan crop as it is not part of a formal agricultural policy program of support to increase productivity in (marginal) areas even though it is heavily utilised as a food source. Sweet potato virus complex disease (VSPD) and nematodes reduce sweet potato production. When using soil, pits are dug on a slope that promotes drainage of water which results in a moisture-removing (dehydrating- a chemical process) effect preventing germination or the rotting of tubers and there by preserving the sweet potatoes. The use of ash as a sweet potato preservation method involves mixing the sweet potatoes with the ash, which acts as a water absorbent which is alkaline. Alkaline conditions do not favour disease outbreaks as viruses require an acidic environment to infect a cell, that is it needs mild acidity for maximum activity, asserts Sircus (2014).

Sweet potato preservation using dry grass results in cool and dry conditions being created by the dry grass in areas of storage. The sweet potatoes should be bruise-free for infection prevention to avoid rotting. Mutandwa and Gadzirayi's (2007) findings were that if Mozambican White sweet potato's weight and colour are to be included in the Mozambican White sweet potato preservation, the soil is the best method of preservation. They also discovered that the soil, ash and grass all did well in maintaining the weight of the Mozambican White sweet potato. Mutandwa and Gadzirayi's research suffers from using one type of sweet potato. Use of other types of sweet potato could be done to find out if the results still hold true.

Matsa and Mukoni (2013) researched on traditional science techniques of seed and crop yield preservation and exploring the contributions of women to indigenous knowledge systems in Zimbabwe. The traditional indigenous selection of seed and their preservation are suitable to agro-economic conditions of Zimbabwe and prevent the loss of traditional indigenous varieties of seed. The purpose of the study was to identify traditional indigenous methods of processing, storage and preserving of seeds and crops in Matabeleland South marginal area of Zimbabwe, which is arid and semi-arid, in order to improve food security. Mixtures of Venda, Kalanga, Sotho and Ndebele cultures are found in that area.

According to the research by Matsa and Mukoni (2013), pumpkin and melon seeds are left in the sun (irradiated), air dried (dehydration) and stored in closed granaries using closed pots to prevent moisture (conditions necessary for seed germination) and pests from affecting the seeds. The fresh pumpkins are left in the fields to dry after which they are crushed to make calabashes (containers) for herbal medicine, water, milk and seed storage. Using of this type of storage, pests do not attack seeds for up to 12 months. Groundnuts and peas which have outer covers last from one to two years, with storage in sacks, calabashes, closed granaries and clay pots which exclude moisture (unfavourable conditions for germination). Half baking (heating to dehydrate) is also used and done by skilled people to preserve bean seeds even though it results in germination rates being low.

According to Matsa and Mukoni (2013), tussles of sorghum, millet and cane (sweet reeds), after cutting and drying (dehydration), are smoked by kitchen smoke (chemical treatment) until the following season, making the seeds bitter so that pests will not want to eat the seeds. Preservation of pumpkin and melon is done by placing the produce in granaries, shade and grain barns. Matsa and Mukoni (2013), state that this method can allow the vegetables to last for up to a year. Rapoko, sorghum and millet in Esigodini, Matopo, Filabusi and Kezi shells need to be winnowed (separation techniques). Seeds for planting are selected using a classification process which uses size of the seed, pest and disease resistance, texture and colour of seeds as required characteristics by elderly woman who are skilled indigenous Chemistry knowledge custodians (indigenous Chemistry repository).

This is supported by the Alaska Native Science Commission (2003), who infer that an indigenous Chemistry knowledge library burns when an elder dies. According to the findings of Matsa and Mukoni (2013) in Matabeleland South, wood ash and manure mixture (chemical mixture) was used to preserve rapoko, maize, millet and sorghum. In Plumtree, a mixture of gum trees, manure, thorn tree and maize cobs (dry) are burnt to ashes that can be used to treat and preserve the rapoko, maize, millet and sorghum grains which makes them bitter and alkaline to pests and viruses. Storage in the form of granaries are built about a half metre from the ground (avoiding ground water or moisture) and roofed for protection from weather elements. This is similar to current methods used by the Grain Marketing Board (GMB) of Zimbabwe.

A mixture of ash, cow dung and mud are used to treat the granary chemically before storing the grain. Granaries protect crops from harsh weather conditions, rodents, pests, animals and thieves as declared by Matsa and Mukoni (2013). Varying concentrations (stoichiometry) of ash, cow dung and mud mixtures are used that give different dates of expiry in terms of grain storage up to the following year’s planting season. Two to three cups of the ash mixture are used per sack. An increase in concentration (stoichiometry) of the ash mixture increases the expiry date. Storage of sorghum is up to 3 years’ maximum.

Characterisation of yeasts isolated from traditional opaque beer beverages brewed in Zimbabwean households was researched by Misihairabgwi, Kock, Pretorious, Pohl and Zvauya (2015). The purpose of the study was to determine the diversity and characteristics of the yeast predominant in a number of traditional indigenous opaque beers from different households in Zimbabwe. Zimbabwean indigenous culture involves the production and sale of traditional indigenous opaque beer for social cultural consumption (nutritional value) that uses spontaneous (Gibbs free energy concept) fermentation (alcoholic fermentation) processes in which fermentation is brought about by bacteria and yeast, which is an uncontrolled process.

Ingredients include finger millet, bulrush millet malts, sprouted maize and sometimes sorghum. The production process of traditional indigenous opaque beer involves a cereal meal being cooked, made sour, mashed, strained and seven days of alcoholic fermentation posits Misihairabgwi et al (2015). These are all indigenous Chemistry knowledge and skills being used which are the same as the commercial production of opaque beer and carbon dioxide. Consumption of traditional indigenous opaque beer is done whilst the fermentation process is active, resulting in the concentration of alcohol, flavour, and taste being uncontrolled as well as having a short shelf life, states Misihairabgwi et al (2015). Bacteria and yeasts that are varied are used.

The process involves controlled activation and deactivation of yeast and bacteria for glucose fermentation and fermentation through different temperature ranges. There is use of starter yeasts and bacteria to initiate the fermentation process of the traditional indigenous opaque beer. Misihairabgwi et al (2015) findings were that traditional indigenous opaque beer had 14 different yeasts types which are also found in most commercial cereal-based beers in Europe. The yeast was capable of growing in temperature ranges from 25^0C to 37^0C, which are normal daylight temperatures in Zimbabwe, making it very suitable for the production of traditional indigenous opaque beer. The yeasts used glucose sugar as a source of carbon.

Nyanga, Nout, Gadaga, Boeknau and Zwietering (2008) performed research on the traditional processing of the fruit Ziziphus Mauritiana (Shona: masau) in Zimbabwe. Their aim was the documentation of masau fruit traditional processing techniques and studying the masau fruit properties, the pulp fermentation and the distillate. The fruit grows in the semi-arid and arid regions of Zimbabwe such as Muzarabani, Mudzi and Mount Darwin, and is used by the rural population as organic manure, herbs, firewood and consumption as a fruit as well as being used for the production of a potent alcoholic spirit called Kachasu through masaus' spontaneous fermentation and distillation (separation process using different boiling points).Traditional indigenous medicines are also extracted from the masau fruit, its seeds, bark, roots and leaves that treat skin diseases, fever, insomnia and inflammatory conditions, declares Nyanga et al (2008).

The alcoholic fermentation process of the masau fruit to produce the potent alcoholic spirit Kachasu involves the dried pulp being mixed with water in the ratio 1:10 pulp to water approximately, which is then transferred into a 120-litre drum filled with water. The drum is covered with a sheet of plastic and fermented for six to seven days at 25^0C. Pipes are connected at the top of the drum and the fermented contents boiled six to seven hours to produce the potent Kachasu alcoholic spirit. Nyanga and et al (2008) identified sugars (glucose and fructose), organic acids (citric, tartaric, malic, succinic, acetic, oxalic) and a pH ranging from 5.6 to 6.6 in the potent alcoholic Kachasu spirit. The surplus Masau fruits are dried in the sun and processed into other products such as traditional indigenous cake, porridge, instant powder drink and traditional beverage called mahewu.

2.7. SCIENTIFIC LITERACY AND CHEMISTRY LITERACY

Scientific culture is the expression of all the modes through which individuals and society appropriate science (Godin and Gingras, 2000). The culture of science, like any other culture has permissible behaviour, knowledge and values. Expectations of the science community are that all ideas must be subjected to rigorous scrutiny. Scientific literacy, according to Holbrook and Rannikmae (2009), is the development of the ability to creatively use science knowledge which is sound in daily life or at work in decision-making and problem-solving, resulting in the improvement of quality of life. Dragos and Mih (2015) see scientific literacy as the capability of a person to understand and interpret scientific theories; laws and phenomena to practically make decisions in ones' life that are informed in relation to science knowledge.

A theoretical scale of scientific literacy was proposed by Bybee (1997), which is comprehensive and appropriate for scientific literacy assessment of school science studies and consists of five dimensions. These dimensions are scientific illiteracy, nominal scientific literacy, conceptual scientific literacy, functional scientific literacy and multidimensional scientific literacy. Scientific illiteracy is where learners are not able to respond or relate to questions about science that should be reasonably expected. Nominal scientific literacy is where learners can recognize a science-related concept but with misconceptions in their level of understanding.

Functional scientific literacy is where learners can correctly describe a concept, but their understanding is limited. Conceptual scientific literacy means learners have developed a major conceptual understanding of the disciplines' major conceptual schemes and those schemes can be related to their general understanding of science. Conceptual scientific literacy also involves scientific inquiries, understanding and procedural abilities as well as technological designs. Multi-dimensional scientific literacy is where there is incorporation of scientific disciplines' concepts and scientific investigation procedures such as social, historical and philosophical science and technology dimensions. The understanding and appreciation by learners of science and technology in relation to the daily lives of learners develops. A person can have several degrees of scientific literacy at the same time (Bybee,1997).

Chemical literacy is a part of scientific literacy. Shwartz, Ben-Zvi and Hofstein (2006) define chemical literacy as the understanding of important chemical ideas, essential skills in Chemistry and contexts in Chemistry. Barnea, Dori and Hofstein (2010) define chemical literacy as the understanding of chemical reactions, the particulate nature of matter, theories and laws in Chemistry and Chemistry applications common in our everyday life. Since it is part of scientific literacy, Chemistry literacy also has the five dimensions as in scientific literacy. Chemistry illiteracy is where learners are not able to respond or relate to questions about Chemistry that can be reasonably expected of their level. Nominal Chemistry literacy is where learners are able to recognise a chemistry related concept, however with misconceptions being shown in their level of understanding.

Functional Chemistry literacy means learners are able to correctly describe a concept, however their understanding is limited. Conceptual Chemistry literacy means learners have developed a major conceptual understanding of the disciplines' major conceptual schemes that can be related to their general understanding of chemistry. Conceptual Chemistry literacy also involves chemical inquiries' understanding and procedural abilities as well as technological designs. Multi-dimensional chemistry literacy is where there is incorporation of the

Chemistry disciplines' concepts and Chemistry investigation procedures such as the social, historical and philosophical Chemistry and technology dimensions. There is understanding and appreciation by learners of Chemistry and technology in relation to the daily lives of learners develops.

2.8. SELF-REGULATION IN CHEMISTRY EDUCATION

The ability by a learner to control the learning environment and understand is called self-regulated learning, suggests Schraw, Crippen and Hartley (2006). For self-regulated learning, goals are set, strategies selected for the attainment of the goals, strategies implemented and the progress to the goals monitored, states Schunk (1996). For Pintrich (2000), self-regulation skills usually lead to the learner using less effort to learn more and learners' academic satisfaction is at higher levels. According to Schraw et al (2006), self-regulated learning is made up of three major components which are motivation, cognition and metacognition. Motivation involves attitudes and beliefs that influence the application of cognitive and metacognitive skills. Epistemology and self-efficacy are sub-components of motivation.

Encoding, memorising and information recalling are necessary skills involved in cognition. Cognition has the sub-components of simple strategies, problem-solving and critical thinking. To Schraw et al (2006), critical thinking includes a number of skills such as the learners' ability to identify (i) the source of the information, (ii) analyse the credibility of the information and (iii) reflection on the information consistent with the learners' prior knowledge and drawing conclusions through critical thinking. Metacognition involves the skills which allow the learner to comprehend and monitor their processes in terms of cognition. Knowledge of cognition and regulation of cognition are sub-components of metacognition.

For self-regulation, motivation, cognition and metacognition as individual components are necessary for Chemistry learning that is skilled, yet it is inadequate, points out Schraw et al (2006). Learners who have cognitive skills but without the motivation to apply them do not perform at the same level as learners who have the cognitive skills and the motivation to apply them as asserted by Zimmerman (2000). Zimmerman (2000) goes on to say that learners who have the motivation to learn but do not have the required cognitive and metacognitive skills usually fail to attain self-regulation at high levels. According to Duggan and Gott

(2002), a section of science educators is of the opinion that there should be a reduction of the quantity of time for teaching allocated to conceptual understanding whilst the time allocated to procedural understanding should be increased.

In science education at higher levels, procedural competences such as specialised problem-solving and critical thinking increasingly become more important, which is the rationale for the suggested increment in time allocated for procedural understanding in science education at higher levels. Garner (1987) saw cognitive skills as being required for the purpose of performing tasks whilst metacognitive skills are required for the purposes of understanding how those particular tasks were performed. For learners to become self-regulated, the distinction between metacognition and cognition must be understood as opined a Schunk (1989). Learners in most cases have strategies and knowledge which are relevant to a task but never apply them due to failing engagement and persistence in a task that is challenging or failure by the learners to identify their successfulness with the application of self-regulation and strategies, states Schraw (1998).

At times, learners may not put in the required effort to succeed in a task as they believe that lack of intellectual ability makes putting in extra effort useless. For Schraw (1998), when learners focus on improving their current performance levels, they are rewarded for the increased persistence, strategy use and effort, creating an environment for mastery which results in more acquisition of metacognitive knowledge and strategy regulation use. According to Schraw(1998), critical thinking and scientific reasoning skills, which are of huge benefit to learners, can be taught and these can be improved in learners; (i) if learners spend enough time in using the skills in a context that is meaningful, (ii) if learners have a chance to see skilled experts applying the skills (iii) if learners are given access to the reflection of an expert on what is being done and how well that that it is done (which is crucial for metacognitive development).

2.9. METACOGNITION AND CHEMISTRY EDUCATION

Metacognition is the advanced deliberate manipulation of mental or emotional effects of perception and reasoning directed towards a particular goal such as improving learning, which is the acquisition of knowledge, skills and affective states. Flavell (1979) defined metacognition as when a person has the ability to monitor their own understanding and awareness of one’s cognitive processes as well as having the ability to control them. Taylor (1999) describes metacognition as recognising the value of prior knowledge with an accurate assessment of the demands of a challenging learning activity or goal and what understanding and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic knowledge in a specific situation reliably and efficiently. Chemistry metacognition is the recognition of the value of indigenous Chemistry knowledge (prior-knowledge) with an accurate assessment of the demands of a western Chemistry challenging learning activity and what understanding and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic indigenous Chemistry knowledge in a specific situation reliably and efficiently.

For Papaleontiou-Louca (2008), metacognition is thinking about one's thoughts, knowing about one's knowledge and the processes involved, and the affective and cognitive states as well as the ability to consciously monitor and control the knowledge and the processes involved, including the affective and cognitive states. The awareness of learning capabilities and the ability to make adjustments in order to improve learning by learners is metacognition. According to Dawson (2008), metacognition represents a number of inter-related abilities involved in learning and thinking such as self-regulation, critical thinking, problem-solving, active learning, decision-making and reflective judgement.

The Teaching Excellence in Adult Literacy (2010) sees metacognition knowledge as consisting of what a person knows about their cognitive processing power, about several approaches that are useful in learning and solving a problem as well as the requirements to effectively accomplish the learning task. The definition of metacognition and its components depend on the researchers' context and theoretical tradition such as educational psychology, cognitive science, cognitive behavioural, cognitive developmental, socio-cultural and social learning, asserts McCormick, Dimmitt and Sullivan (2012). The socio-cultural theoretical definition and context of metacognition is employed in this study. According to Cherry (2018), the socio-cultural theory focuses on the impact of culture (beliefs, attitudes etc) on teaching and learning as well as how peers and adults influence the learning (development) of an individual, making human learning largely a social process.

The several different definitions of metacognition have the following in common; knowledge of one's knowledge, the monitoring and regulation of one's knowledge consciously as well as the cognitive and affective states of being (McCormick et al, 2013; du Toit and Kotze 2009). Schraw (2000), identified John H Flavell's model and Anne Brown's model as the two most common models of metacognition. These are theoretically distinct but compatible theories of metacognition, presenting a problem in terms of the agreed metacognition terminology and metacognitive processes. There are two major components of metacognition which are further divided into other subcomponents. Metacognitive knowledge (cognitive knowledge) and metacognitive regulation (cognitive regulation) make up metacognition (Nazarieh, 2016; Lai,2011 and Noushad, 2008)

Three aspects of knowledge comprise metacognition, that is procedural knowledge and conditional knowledge which are closely related (Mahdavi, 2014; Schraw, 2000) as well as declarative knowledge, which refers to knowing in terms of knowledge, strategies and skills which is important for completing a learning task successfully under different conditions. This is knowledge about the task at hand in terms of prior knowledge, which is useful in the given scenario. Declarative knowledge is divided into person, task and strategies (actions) variables as declared by Flavell (1979). Person variables involve recognition of one's strengths and weaknesses in the learning process, including information processing. Task variables refer to what an individual knows or might find out in terms of the nature and mental (intellectual) requirements (demands) to accomplish the learning task points out Papaleontiou-Louca (2008).

Strategy variables refer to the plans in ones' mind which can be applied flexibly to positively accomplish the learning task as pointed out by Isaacson and Fujita (2006). Mahdavi (2014) sees procedural knowledge as knowledge of how to put into use procedures such as learning strategies or actions using declarative knowledge to achieve goals and conditional knowledge as knowledge about why and when to make use of various skills, procedures and strategies or cognitive actions. That is to say one has knowledge about when and why to make use of declarative and procedural knowledge. According to Mahdavi (2014), metacognitive knowledge can be changed through adding, removing or revising metacognitive experiences and metacognitive knowledge can be inaccurate, fail in terms of being activated, or may fail to have much or any influence.

Metacognitive control / regulation of cognition or executive control are sequences of activities that assist learners to control their own learning or thinking suggests Nazarieh (2016). Schraw and Dennison (1994) saw metacognitive control as having three components or skills which are planning, monitoring and evaluation. Planning includes the choosing of befitting strategies and provisions that are effective in terms of performance or goal attainment. Monitoring is the judgement of the progress of one's current thinking and task performance. Evaluation refers to assessing or examining the completed task or goal which can demand more planning, monitoring and evaluating depending on the outcome.

According to Schraw et al (2006), planning, monitoring and evaluation as self-regulating processes in most learning situations are not explicit or conscious, as they are automated to a large extent and might develop with reflection being unconscious as well as not having a language for communication between teachers/ instructors and learners in this area. Research shows that metacognition can be taught to any individual irrespective of age, grade (level) or subject specialisation (Dawson, 2008 Louca, 2003; Flavell, 1985). According to Schraw et al (2006), adult learners usually have more knowledge of cognition and are better able to describe it in a coherent fashion way when compared to adolescents and children.

Schraw et al (2006) further states that the learners' knowledge of cognition is explicit and develops late in terms of age. Metacognitive skills and their use without assistance develop over time and the experiences of the learner out of the classroom should be taken into consideration because they are significant in the development of metacognitive skills, suggests Noushad (2008). For Schraw (1998), knowledge of cognition and regulation of cognition are related to each other as an improvement in declarative knowledge of cognition makes regulation of cognition easier.

2.10. BENEFITS OF METACOGNITION IN CHEMISTRY EDUCATION.

Georghiades (2004) states that metacognition has a positive impact in general on learner outcomes in terms of thinking and learning, particularly for learners with disabilities. Metacognition promotes independent Chemistry knowledge, knowledge that is more permanent, motivates learners and improves educational achievement across different ages, intellectual abilities and subject areas (Smith, Black and Hooper, 2017; Somerville, 2017; Philly-Cormick. and Garrison, 2007; Louca, 2003). Hartman (2001a) reiterates that learners with high academic achievement have more metacognitive awareness and partake in a lot of self-regulation compared to lower academic achieving learners. Improved learners' metacognitive skills might compensate for cognitive limitations in Chemistry by learners (Somerville, 2017; Noushad, 2008; Veenman, Wilhelm and Beishuizen, 2004).

Abilities of metacognition assist learners to transfer acquired Chemistry knowledge, skills and affective states to another context or learning task. Smith et al (2017) see learners with inadequate access to educational resources benefitting from metacognition as educational outcomes improve. Pintrich (2004), states that an increase of metacognition leads to increased motivation states. Metacognitive regulation increases academic performance in various ways such as the application of attentional resources in a better way, application of existing strategies in a better way and a higher awareness of breakdowns in comprehension (Schraw,1998). For Cross and Paris (1988), learning is improved significantly when an understanding of how and when to apply the metacognitive skills by learners is achieved.

Schraw (1998) states that a lack of relevant prior knowledge or low academic ability might be compensated for by metacognitive knowledge. Schraw (1998) goes further by saying that there is no strong correlation between metacognitive knowledge and ability. Metacognitive knowledge assists in problem-solving that is successful over and above the assistance of task relevant strategies and intelligent quotient (IQ). For Schraw (1998), metacognition is important to learning that is successful as it allows learners to determine their weaknesses which can be corrected through the construction of new cognitive skills, resulting in learners better managing their cognitive skills.

2.11. TEACHING METACOGNITIVELY AND METACOGNITION IN TEACHING (TUTORING)

All learners, according to Schraw (1998), are capable of metacognition as long as they have the ability to perform a skill. In learners, metacognition is promoted through awareness by learners of the existence of metacognition, which differs from cognition, and thus academic success is increased, suggests Schraw (1998). Metacognition can be promoted through metacognitive-teaching strategies, especially assisting learners to construct knowledge that is explicit regarding when and where to apply these strategies. An interactive approach that mixes teacher and expert modelling, direct instruction, group activities which allow learners to share the knowledge they have on cognition and reflection can be extremely effective. It is possible to improve metacognitive knowledge and metacognitive regulation through instructional practices in the classroom and allowing learners to apply their newly acquired skills to improve their academic performances.

For Hartman (2001b), teaching metacognitively includes teaching with metacognition and teaching for metacognition. Teaching with metacognition is whereby the teacher thinks about his or her own thinking in relation to strategies of teaching, instructional goals, materials, sequence, learners' needs and characteristics as well as other matters regarding the curriculum, assessment and instruction, before, during and after the lesson so as to be effective in the instruction, asserts Hartman (2001b). Hartman(2001b) defines teaching for metacognition as a process in which the teacher is thinking about how the instruction by him /her will lead to the activation and development of learners thinking about their own thinking as individuals who are learning. Hartman (2001b) suggests that in order to maximise the effectiveness of their teaching of learners, self-regulation is needed by teachers in the instruction (teaching) before, during and after performing the lesson.

Consideration of the advantages and disadvantages of other approaches and how they can be applied effectively should be done. Teachers or instructors need successful teaching strategies at their disposal so as to meet the various needs of learners in different times and in different situations or different times suggests Hartman (2001b). Teachers or instructors have a duty in providing effective teaching that emanates from modern research, practice and theory. Hartman (2001b) identified the instructional method or technique choice as depending, to some degree, on the specific subject matter, the goals of teaching and learners' backgrounds.

There is need to know the degree to which a tacit form of knowledge called reflective metacognitive teaching is practised by teachers or instructors. According to Hartman (2001b), the majority of teachers or instructors make the mistake of putting a lot of effort into the presentation of content whilst too little effort is put into whether learners understand the content. Strategies that are used to promote metacognitive development are learner discussions; problem-solving that is explicit, verbalising thinking and modelling. The teachers or instructors' metacognition benefits from knowing the learners' existing metacognition as it gives teachers or instructors information that assists with the planning, monitoring and evaluation of the teaching made to improve learners' metacognition.

Learners' metacognitive knowledge and skills, according to Hartman (2001a), can be taught through the instructional model of tutoring. In metacognition tutoring, there is an emphasis on learner development and metacognition, with learner development insinuating learning how to assist learners to monitor their own progress by tutors as well as confrontation of learners who do not succeed in taking responsibility for learning on their own, opines Hartman (2001b). For Hartman (2001a), most learners experience difficulties academically due to constant focusing on subject matter content retention instead of first learning the intellectual skills required to support the effort. Hartman (2001a) sees intelligent functioning by learners as requiring teachers and tutors to develop metacognitive and cognitive skills which include the positive affect of motivation, attitudes and emotions.

Metacognitive skills can be taught and learned by any individual irrespective of age, grade (level) or subject specialisation (Dawson 2008; Louca, 2003). Frenkel (2014) concurs that metacognitive abilities are learnt and learners should be given a chance to learn them. Alshammari (2015) points out that for any learner to develop metacognitive skills, prior knowledge must be present to facilitate and help in the development of the cognitive skills. Assisting learners in the acquisition of strategic metacognitive knowledge improves the learning and acquisition of executive management skills (metacognitive reading, modelling, graphic organisers, thinking-aloud and self-questioning that are applicable to all content domains) notes Hartman (2001a).

Learners should be assisted in the development and application of metacognitive knowledge and strategies. Strategy is the deliberate and conscious application of a method. Skill refers to a strategy that is refined which is unconsciously, automatically and selectively applied. According to Hartman (2001a), learners who achieve high academic performance have more metacognitive awareness and practice self-regulatory behaviour more than low academic achieving learners. An expert learner possesses metacognition as a characteristic. Metacognition is natural to some learners whilst some learners must be taught. When metacognitive knowledge and strategies are extensively used in different contexts, they can be applied in skilled performance automatically.

For academic success, metacognition alone is inadequate without self-regulation, which is applied when the learner is faced with competing attractions, stressing and fatiguing learning situations asserts Hartman (2001a). Self-regulation is determined by persistence, effort, task choice and self-efficacy, which are motivational issues that are context-dependent. For Hartman (2001a), executive management strategies are one such basic type of metacognition for purposes of planning, monitoring, evaluating and revising as well as processes and products in ones' thinking, whilst strategic knowledge is the second basic type of metacognition, which is the knowledge of what information and skills (strategies) are held by one (declarative), when and why they should be applied (conditional / contextual), and how they should be used (procedural).

According to Wagner and Sternberg (1984), there must be emphasis on metacognitive skills during teaching for the following reasons: Learners have problems in metacognitive performance such as (i) determination of the task as being difficult, (ii) effective comprehension monitoring (learners do not realise / recognise when they do not understand information in textbooks and task directions, (iii) planning in time (what needs to be done and duration of each component), (iv) performance success monitoring or determination of level of mastery of material learnt, (v) usage of all the relevant information, (vi) usage of the step-by step systematic approach, (vii) rushing to conclude, (viii) usage of incorrect or inadequate representations.

Metacognition is not taught even though it is important. Having goal(s) during learning, monitoring performance, progress evaluation in goal attainment and changing or continuing with the approach as required by the task are characteristics of self-regulation. Awareness of factors that affect learners' grades and strategies by learners help self-directed learners to apply the required effort to improve performance. Zohar and Barzilai (2013) emphasise that for metacognition education to be sustainable and effective, lengthy education is required.

2.12. DOMAIN-SPECIFIC AND GENERAL METACOGNITIVE KNOWLEDGE AND SKILLS.

Knowledge of cognition and regulation of cognition as components of metacognition cover a range of subjects making them general domain in nature, suggests Schraw (1998). Initially, metacognitive knowledge is task-specific or domain-specific, but as they acquire more metacognitive knowledge, learners might acquire general metacognitive knowledge and regulation of cognition later that covers all academic domains as explained by Schraw (1998). Metacognition provides extra academic performance improvement that is above and beyond intellectual ability, with metacognitive knowledge appearing as both domain-specific and general in adults as well as in adolescent learners, asserts McCormick et al (2012).

Learners who are older typically acquire general metacognitive skills that cover a large range of tasks points out Schraw (1998). For Schraw (1998), besides acquiring more metacognitive knowledge, learners apply the metacognitive knowledge with greater flexibility especially in areas of learning that are new. Metacognitive knowledge and metacognitive regulation give an impression of being more general and durable than domain-specific cognitive skills, however whilst domain-specific knowledge that is of high level might assist in acquiring and applying metacognition, domain knowledge is not a guarantee for higher metacognition levels, opines Schraw (1998).

College learners can identify the difference between general metacognitive (studying and learning of most learners) and personal metacognitive knowledge (studying and learning themselves). College learners sometimes do not show metacognitive knowledge as well as the use of metacognitive strategies. According to Pintrich (2002), learners that possess metacognitive knowledge and skills are more empowered to use learning strategies that are active in different academic contexts and in learning tasks that are unfamiliar.

2.13. METACOGNITION IN READING

For effective reading in Chemistry, learners should possess a certain minimum degree of understanding the Chemistry text they read as well as comprehension skills which they are assumed to have by the Chemistry instructors or teachers. For McCormick et al (2012), metacognition as a form of self-regulation is influenced by ones' knowledge level in a domain. Expert learners are more likely to engage in activities of metacognition more often and more successfully than learners with less subject content knowledge in that domain in terms of reading. Use of monitoring, active comprehension strategies, prior world knowledge and language are some of the processes employed during reading, whilst the components of metacognition skills such as knowledge of effective reading, identification of reading purpose, knowledge of ensuring understanding as well as remembering what was read are skills that metacognitive readers possess, suggests McCormick et al (2012).

They go further to say that metacognitive readers are aware of when they do not understand the content, pose questions, appropriately modify their strategies and are aware when they need assistance. McKeown and Beck (2009) believe that metacognitive readers summarise, infer and apply to other contexts what they have read. McCormick et al (2012) point out that non-use of metacognitive strategies when reading by learners result in lower chances of understanding what was read, higher chances of misinterpreting the content as well as difficulties in recollecting what was read. According to McCormick et al (2012), college learners in theory are readers who are proficient, who understand and apply ideas in complicated texts with content being context-specific, requiring vocabulary that is specialised and knowledge that is context specific in order to comprehend, but also requires metacognitive reading to better understand what they have read.

Academic performance can be improved through the learning of metacognitive strategies. According to Hartman (2001a), when learners are taught metacognitive strategies such as text processing, the learners might ultimately attain better reading comprehension. Hartman (2001a) goes further by saying that learners who are low academic achievers can be taught how to use strategies of metacognition like text processing which can improve the performance of the learner academically. Activating relevant prior knowledge, skimming, prediction, mental images construction, self-questioning, summarising, monitoring comprehension and connection of prior knowledge with new material (knowledge) are some reading skills that are metacognitive, opines Hartman (2001a).

These skills, according to Hartman (2001a), are usually not taught and their development does not happen independently in the most learners, therefore competence of these skills in learners is not expected before being taught. Continuous and explicit practice, address, internalizing and polishing of these metacognitive reading skills is needed, suggests Hartman (2001a). As academic achievement can be acquired through improvement in metacognitive reading skills, there is a need for teachers or instructors to explain the metacognitive strategies or skills, give examples, model the skills for learners and explain why, how and when the skills should be applied, with emphasis on the importance of being flexible in choosing particular skills that are applicable to that specific context. (Hartman, 2001a).

2.14. METACOGNITION IN WRITING

Writing is a cognitive, textual and social external symbolic representation and translation of thoughts produced for oneself and others under the metacognitive process of monitoring and control, states Hacker, Keaner and Kircher (2009). According to Hacker et al (2009), writing involves idea generation, drafting, editing, revision, translation and word production which are metacognitive control strategies. Problem analysis, composing, writing task, mental representation creation and goal setting are processes involved in writing, opines Bereiter and Scardamalia (1987).

There are two composing strategies which were identified by Bereiter and Scardamalia (1987), namely knowledge telling and knowledge transforming. Knowledge telling is the presentation on paper of what is known on a topic, the knowledge supply is finished (exhausted) and is usually used by writers who are novices. Knowledge transforming involves diagnosis of problems, solution planning and effectiveness of solution monitoring, consciously reworking and texting by the expert writer. Effective writers have a number of metacognitive knowledge and control strategies that assist them.

2.15. CULTURES' INFLUENCES ON METACOGNITION

Learners' self-perceptions are affected by social and cultural influences. Most African Americans and Asian American college learners are ill prepared in terms of competing with affluent and well-educated white learners in the United States of America due to different cultures, as pointed out by Anderson (1988). Most colleges in the United States of America unfortunately react by emphasising the use of counselling and remediation as retention programmes. Anderson (1988) states that the retention programmes' success in the United States of America has not been successful partly due to the ethno-centric assumption of the United States of America of white Americans having a similar cognitive framework as African Americans and Asian Americans.

This assumption, according to Anderson (1988), leads to the use of learning approaches that are based on Anglo-European derived learning theories on learning, cognitive functioning and achievement. The African American and Asian American learners' cognitive assets and learning preferences are rarely attempted in terms of identification by these retention programs. There is an expectation of the African American and Asian American learners to adapt to the program instead of the program of instruction adapting to the African American and Asian American learners' needs. There might be a conflict between the non-western learners' culture with that of the classroom.

Hartman (2001a) states that in college learning environments, there is an emphasis on individual achievement and competition while group achievement and group cooperation are valued by learners from non-western cultures. These non-western cultures are usually taken as deficiencies by the Anglo-European learning approaches used in colleges. Hartman (2001a) suggests that there might be cultural differences in metacognition and the relationship that is between other variables that influence academic achievement and metacognition. For Hartman, Everson, Tobias and Gourgey (1996), there is a relationship between learners' self-concept academically with ethnic groups that are culturally distinct, differing in their interactions and on those measures. Their analysis of variance indicated the presence of notable main differences attributed to ethnicity in learners' metacognition self-reports.

It was noted by Hartman et al (1996) that the most use of metacognition was by African American learners, in the middle were Hispanics followed by Asian Americans. The self-criticism practice by Asian Americans might have been reflected in the Asian Americans' relatively small use of metacognition. For ethnicity and gender, Hartman et al (1996) stated that there were notable interactions in terms of metacognition use. They go on to say there was more use of metacognition by African American female learners when compared to African American male learners and more use of metacognition by Hispanic American and Asian American male learners than females.

The background of the learner and teachers' culture seems to have effects on academic performance as the development of cognition in human beings is a result of society's emphasis or requirements that are described as cultural acquisitions (Hartman, 2001a). For learners who have a mother language which is not English, their academic performance might be affected by the language diversity. Gender and ethnic stereotypes as cultural factors might produce an impact on academic achievement through the quality of teaching by the lowering of expectations or standards by teachers.

According to Treisman (1985), African American learners in the United States of America did not study with their classmates most of the time when compared to Asian American learners, which was contributing to the African Americans' high failure rate in college freshman mathematics calculus. Treisman (1985) attributes this to study groups that were informal and were being used by Asian American learners whilst the African American learners would study alone. The shared purpose through co-operative work by the Asian American learners implied the creation of a rich metacognitive processing environment which resulted in Asian Americans sharing their calculus mathematical approaches, understanding, knowledge and critiquing each other's work.

Social metacognition (metacognition) and content acquisition were facilitated through co-operative learning by Asian Americans as a result. Also noted and specified by Treisman (1985) was that African Americans' worked an average of 8 hours per week on their calculus mathematics whilst Asian American learners worked for about 14 hours. Self-reliance was one of the strongest strengths of African American learners before coming to college to do calculus mathematics and this led to African American learners seeing themselves as self-reliant, a perception that lead to African American learners rarely using the free calculus tutoring which was available on college campus, says Treisman (1985). These findings were used by Treisman to design a workshop programme to academically support the African American learners to collaboratively work on sets of difficult calculus problems for a period of 6 to 8 hours per week.

African American learners who participated in the calculus workshop programme consistently got a grade higher and their retention improved when compared to those African American learners who did not take part in the calculus workshop programme. The persistence rate of African American learners who participated in the calculus workshop programme was 19% higher in two years when compared to those African American learners who did not participate in the calculus workshop programme. The results of this study by Treisman (1985) implied that metacognitive strategies of learners from a background of different culture benefited from sharing ideas with learners of another culturally different background, showing that metacognitive learning is influenced by cultural practices.

2.16. METACOGNITION IN SCIENCE PROBLEM SOLVING

Metacognitive knowledge and skills are employed in effective problem solving, making metacognitive strategies and metacognitive knowledge critical in scientific problem solving as it requires mental representations that are effective which assist in organising and combining information, solution strategies monitoring and enabling generalising to other problems, suggests McCormick et al (2012). The selected solution strategies are then implemented after monitoring and where there are any hindrances, they are recognised and eliminated. McCormick et al (2012) see expert learners allocating more time to the metacognitive processes such as planning, analysing and identifying possible effective strategies and their representations of problems made abstract when compared to novice learners.

For Veenman et al (2006), successful metacognitive instruction is based on three principles which are: (i) ensuring connectivity by having metacognition instruction embedded in science content matter, (ii) making science learners aware of the positive impact of metacognitive processes to spur and motivate them and (iii) continuous metacognitive instruction which is free from problems with continuous application. McCormick et al (2012) emphasise that learners should be instructed in multiple metacognitive strategies for individual use and use with other learners (social metacognition) as well as having a contextual demand awareness of metacognition that suits each particular strategy.

At colleges, according to Isaacson and Fujita (2006), learners are expected to demonstrate and make use of knew knowledge, match demands of the task with learner behaviour and to be independent learners. Those who are successful learners know when they are having challenges, adjust their study behaviour to the level of the learning task and accurately understand when effective learning is happening. Carol (2008) reiterates that learners who apply metacognitive strategies in college are more successful when compared to learners who are gifted but may inaccurately interpret or misjudge learning tasks demands. This is supported by Zimmerman and Moylan (2009), who found that learning and academic achievement is increased by educating learners on metacognition and metacognitive strategies.

2.17. ENVIRONMENTS OF LEARNING THAT PROMOTE METACOGNITION

To promote metacognition awareness: (i) there should be discussion on the importance of metacognition (knowledge and regulation) as well as the special function it has in self-regulated learning by the teacher and, (ii) there should be a planned effort by teachers in terms of modelling their metacognitive knowledge and regulation for their learners. Most often there is modelling of cognition (how the task is performed) by teachers whilst leaving out metacognitive modelling (how the thinking about and monitoring of the performance was done), states Schraw (1998). When facilitators use metacognition to better their facilitation roles, environments that promote the development of metacognition and metacognitive strategies in learners are created, points out McCormick et al (2012).

Hartman and Sternburg (1993) states that in the classroom, metacognition might be increased through improving knowledge of cognition, promoting an awareness that is general of metacognition importance, encouraging environments which promote metacognitive awareness and improving the regulation of cognition. According to Hartman (2001b), metacognitive teaching includes teaching for metacognition and teaching with metacognition. Teaching for metacognition is when teachers actively think about ways of teaching that lead to the activation and development of learners' metacognition. Activities that promote teaching for metacognition are questioning that is reflective, scaffolding, modelling, planning, collaborative learning promotion, peer tutoring and explanation of explicit strategy, asserts Hartman (2001a).

Metacognitive development can be supported through learners being taught strategies of studying, goal setting, work evaluation, analysing errors and organising ideas. Bransford, Brown and Cocking (2000) state that classroom environments which promote metacognition are learner-centred, promote learner engagement in learning as well as increasingly supporting learner self-regulation and self-direction. Learners are challenged by the use of complex activities (tasks) that use prior knowledge and demand active strategic learning, opines Bransford et al (2000). Metacognitive questions, think-aloud techniques used in groups that are cooperative, concept maps, extended wait time and retrospective interviews are some of the techniques in teaching that can be used to promote metacognitive development.

The use of a Strategy Evaluation Matrix (SEM) instructional aid by instructors develops metacognitive knowledge that is related with strategy instruction, asserts Schraw (2001). In SEM, learners list strategies that are accessible to them as well as information as to how these strategies can be used, when the strategies can be used and why the strategies must be used, which leads to the development of strategies on the declarative, procedural and conditional knowledge that is explicit. Learners are asked in the classroom to make a SEM for strategies they are able to enact and make a comparison with their strategies in the matrix with other learners', thus SEM aids in the improvement of metacognitive knowledge, asserts Schraw (2001), as indicated in table 2.2.

Table 2.2: A Strategy Evaluation Matrix (SEM) (adopted from Schraw (1998)

Strategies	How to apply	When to apply	Why apply it
Skimming	Look for words that are highlighted, headings, summaries and previews.	Before text that is extended is read.	Gives an overview conceptually that assists in ones' attention focusing.
Slowing down	Stopping, reading and thinking of the information.	When the information appears especially important.	Improves the focus of an individuals' attention
Prior knowledge that is active	Pausing and thinking about that which is already known. Asking what is not known	Before reading or task that is unfamiliar.	Information that is new made easy. For learning and retaining
Integration mentally	Main ideas related. These are applied for	When information that is complex is being learnt or when	Reduction of memory load. Understanding

	the construction of a conclusion or theme.	understanding that is deeper is required.	at a deeper level is promoted.
Diagrams	Main ideas identified, listed and connected	When plenty of factual information that is related is present.	Assists in main idea identification and arrangement. Reduction of memory load.

In the classroom, according to Schraw (1998), teachers can make use of SEM in a number of ways such as having learners complete every row of SEM individually or in groups over the year. The teacher informs learners that the focus will be on one strategy per month and they need to practice the four strategies that year. Each week, learners individually or in groups reflect on the use of strategies through exchanges regarding when and when to apply a parameter strategy. For Schraw (1998), the strengths of SEM are (i) strategy use promotion such as cognitive skill has a record of improving performance significantly, (ii) metacognitive awareness that is explicit is promoted amongst learners and (iii) learners are encouraged to actively construct knowledge on, where, when and how to apply the strategies.

A Regulatory Checklist (RC) was suggested Schraw (2001) for metacognitive control improvement. RC is a self-questioning framework which is under planning, monitoring and evaluation of metacognitive strategies for which learners must be provided with opportunities to practice and reflect. The RC is an important method because it influences aspects of metacognition as it solves problems through finding practical ways of dealing with problems and learning from experiences from the past, which assists in the regulation of metacognition, asserts Schraw (1998). The regulatory RC checklist makes it possible for novice learners to systematically implement a regulatory sequence which assists the novice learners in controlling their performance and assists learners in being more systematic and strategic when solving problems opines Schraw (1998).

Teaching with metacognition is when a teacher thinks about their own thinking in relation to the teaching strategies, instructional goals, teaching materials, sequence, characteristics of learners, learners' needs as well as other related issues such as the curriculum, teaching and assessments done before lessons, in lessons and after lessons so as to attain maximum teaching effectiveness, suggests Hartman (2001a). All metacognitive knowledge, skills and strategies used by effective learners are also required in teaching by the teacher so that whilst the teacher is practising metacognition, there is simultaneous awareness of ways of supporting metacognitive development in their learners, opines McCormick et al (2012).

2.18. METACOGNITION ASSESSMENT

Metacognition assessment can be difficult as metacognition conceptualisation has no accepted definition, asserts Shodhganga (2007). This is supported by Zohar and Barzilai (2013) who state that the main challenge with research on metacognition is the inconsistence and non-coherence in terms of conceptualisation of metacognition by researchers. Metacognition and the components of metacognition are defined differently by different researchers. According to Schraw (2000), there is no comprehensive and unified theory of metacognition. He further states that John Flavell's model and the Anne Brown's model of metacognition are theoretically distinct but compatible theories, resulting in little agreement on the basic metacognitive terminology and processes even though they are in agreement on regulatory control, performance monitoring and task monitoring with respect to metacognition.

Metacognitive awareness and processes are inert and not overt, making their assessment challenging opines Shodhganga (2007). The learners are not aware most of the time when metacognitive processes are happening, presenting a difficulty in the assessment of metacognition. According to McCormick et al (2012), numerous methods of measuring metacognition have been devised with some metacognition measurements making use of indices that are of the actual performance, such as calibration techniques, in which comparisons of predictions of the learners to actual performance are done. Other methods such as metacognitive questionnaires are measurements in which learners are asked to report their own metacognitive processes (actions) they usually perform, which normally is not in the same context as any real cognitive task, asserts McCormick et al (2012). They also assert that metacognitive measurements can either be done online (presented as the task is done) or offline (presented before or after the task is done)

None-the-less, a number of methods are used for metacognitive assessment such as; interviews, questionnaires, systematic observations, the analysis of thinking aloud protocols, on-line computer log file registration, stimulated recall, reflection when prompted, eye-movement registration and multi-method assessments, according to Shodhganga (2007). These assessment methods have distinct advantages and disadvantages or strengths and weaknesses. Think-aloud and interviews are verbal report methods used for metacognitive knowledge and process externalisation (external expression), opines McCormick et al (2012). McCormick et al (2012) see metacognition and control being verbalised retrospectively through interviews, which are an offline process, whilst cognitive processes and thoughts are verbalised concurrently as tasks are being performed, which are online processes. According to Veenman, van Hout-Wolters and Afflerback (2006), online measurements are seen as giving a better prediction of the actual learning performance when compared to measurements that are offline.

However, information from sources such as metacognitive interviews are not very accurate as they occur at a different time from the real processing, whereas think-aloud occur concurrently as learning is happening. Cognition describing as a process can actually disturb or change the cognitive activity, points out McCormick et al (2012). The inclusion of hypothetical situations with a design to extract responses makes the interview closer to actual processing in the interview protocol, thereby improving its accuracy. Metacognitive interview accuracy can be enhanced through recall stimulation by requesting comments from learners viewing a previous activity of cognition on video.

McCormick et al (2012) state that the combination of metacognition interview and the method of stimulated recall results in a real cognitive activity which is not hypothetical. Even though the interview is distant, there is vividness which is prompted in the memory, thereby potentially leading to recollections of increased accuracy. Interviews and think-aloud methods of verbal reports can be difficult in scoring and administration and normally requires analysis of verbal protocol that is detailed. As a result of different definitions of metacognition, a number of methods of measuring metacognition have been devised. There are metacognition measurements that make use of the actual performance like calibration techniques in which comparisons of predictions of the learners to actual performance is done. Also, metacognitive assessments can be done offline (presented before or after the task is performed) and online (presented as the task is being performed).

Questionnaire administration is easy to apply to large groups, however the scoring rarely corresponds to the real behavioural measurements when the task is being performed. The most used assessment method in educational institutions such as colleges, schools and universities are the Learning and Study Strategies Inventory (LASSI) in questionnaire form that was developed by Weinstein, Zimmerman and Palmer (1988). LASSI has ten individual sub-scales which include motivation, attitude, test strategies, anxiety and self-testing (Noushad, 2008; Schraw, 2000). LASSI diagnoses learners' weaknesses and strengths when compared to other learners on what was covered. LASSI consists of three areas of assessment; skill component, will component and self-regulation.

The skill component measures the learners' processing skills, selection of main ideas and test strategies. The will component measures learners' perception in terms of willingness to listen and to accept new ideas or suggestions. The self-regulation component measures learner's perceptions on their concentration, time management, self-testing and study aids. More accurate measurements of metacognition must make use of Multiple Methods so as to avoid similar sources of error, suggests Noushad (2008). Schraw (2000) asserts that there is a major discrepancy between the theory of metacognition and the practice of measuring metacognition. To make the chasm between measuring practice and metacognitive theory smaller relies on succeeding in having a comprehensive metacognition theory that can be used as a reference point by researchers.

According to Schraw (2000), monitoring strategies differ in various ages and groups, resulting in a type of metacognition model which does not apply to all learners. Also, research on novice and expert monitoring processes can give differing results. Currently, metacognitive measurement is riddled with different important opinions (Schraw, 2000). There is need for an agreement on the definition with sufficient and necessary evidence when assessing metacognitive constructs' validity amid the disagreement on collection of evidence methods. For metacognition measurement, the psychometric properties of the majority of available instruments are unknown. There are two features that are salient for most metacognition measurements; their construction is study specific and the normative information is small or does not exist at all in the population they were designed for, asserts Schraw (2000).

However, there are many instruments that have known psychometric properties. LASSI is one such instrument. Even though LASSI's measure of internal consistency is acceptable for each scale as well as correlating with cognitive performance measurements, there is no clarity on whether metacognition is measured alone or with cognitive skill, which is regulated with assistance from metacognitive knowledge. The Motivated Strategies for Learning Questionnaire (MSLQ) instrument measures both strategy and motivational sub-scales which have known psychometric properties. The Metacognitive Assessment Inventory (MAI) measures regulation of cognition and knowledge of cognition subscales. MAI's reliability is extremely high, points out Schraw (2000). In-depth analysing of metacognitive knowledge cannot be substituted by paper and pencil inventories.

The complex dynamics involved in metacognitive regulation are not captured by inventories on their own. Instruments are required for young learners as LASSI, MSLQ and MAI are designed to be used with adults and adolescents. Domain-generality of metacognition is engrossed in uncertainty (Schraw, 2000). It can be difficult to relate educational practices to metacognitive theory. There are few methods aimed at increasing metacognition in adolescents and children that have been proven to work, according to Schraw (2000). Those metacognitive increment studies resulted in moderate but enduring acquisition of metacognitive skills due to six weeks to six months of intensive instruction, states Schraw (2000). There are inadequate guidelines for standardised assessments when evaluating, particulary learners who are younger, in research or classroom settings.

Schraw (2000) says that for metacognitive assessment to be practical and meaningful, there is need for; a theory of metacognition that is comprehensive with subcomponents that are well specified, agreement on the type of evidence for metacognitive theory validation, construction procedures that are standardised making use of methods that are quantitative and qualitative for metacognitive competencies, assessing, designing as well as intervening for testing to remediate or improve metacognitive competencies that are important and standard proposing for evaluation of the interventions.

2.18.1 Improving chemistry academic performance model

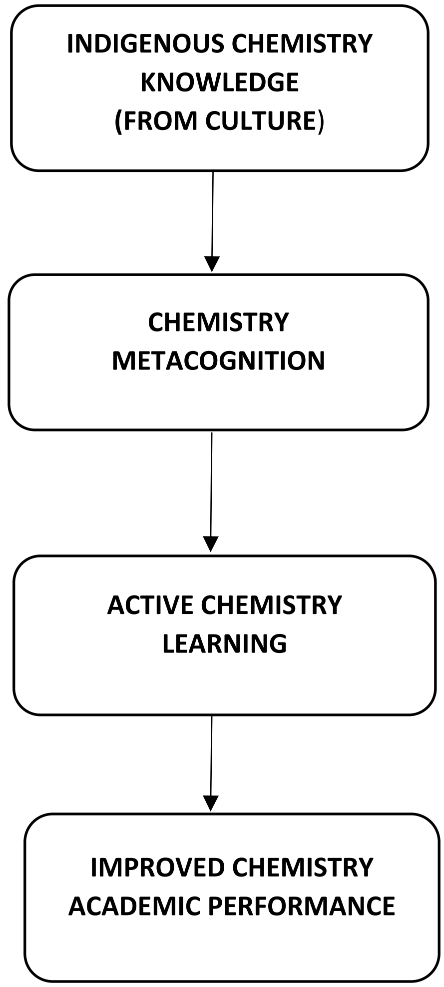

Figure 2.1: Model of improving Chemistry academic performance (Adapted from BACEIS model of thinking)

Teachers or instructors can design lessons or lectures for metacognitive strategies teaching in specific domains. The difficulties such as the covert nature of metacognition, use of alternative teaching methods and application of metacognitive skills should thus be overcome. The learning and application of metacognition are done through daily construction of metacognitive habits, states Lambert (2000).

2.19. BASIC METACOGNITION EDUCATION

Most strategies of metacognition have aspects that are domain-specific such as science, points out Lin (2001). Basic metacognition education assists learners who have little knowledge in a particular domain to recognise relevant prior knowledge, information that is knew (current information) and errors that are common or patterns of errors, asserts Chiu and Kuo (2009). Also, the linking of prior knowledge and new knowledge is learnt by the learners whilst common errors are considered. According to Flavell (1987), a selection of metacognitive strategies, evaluation of the metacognitive strategies and conditions of the metacognitive strategies of their metacognitive strategies applications are done by learners to perform more complex problems provided by the instructors or teachers. This can be done through directing the attention of learners who are facing difficulties to the information that is key, suggestion of partial strategies, work evaluation and asking guiding questions, as they scaffold learners' problem solving.

2.19.1 Basic metacognition education activities model

Basic metacognition education activities

When to apply?

- Pre-service science teachers have little Chemistry knowledge
- Chemistry domain
- Start with tasks that are simple

Methodology

- Whole Chemistry class, focus groups, individuals

Lecturer assists pre-service science teachers

- Identification of relevant indigenous Chemistry prior knowledge and current western Chemistry knowledge
- Common chemistry errors or Chemistry error patterns
- Linking current western Chemistry knowledge with indigenous Chemistry prior knowledge.

Figure 2.2: Basic metacognition education activities. (Based on Chiu and Kuo's (2009) design of metacognition training activities)

2.20. METACOGNITIVE STRATEGIES DEVELOPMENT

A number of techniques can be used to develop the ability to learn by learners as well as the learning of strategies by teachers for metacognitive development in their learners, asserts Hartman (2001a). These techniques include graphic organisers, modelling, self-questioning, assessment, error analysis, inquiry, collaboration, mental models and personal beliefs. A graphic organiser technique assists learners in text analysis and to note its structure. Schemata are brought to the classroom by the learner, leading to expectations that affect interpretations and understanding of that which is being read. If there is no match between the writers and readers' ideas, a breakdown of comprehension can occur.

In Schunk's (1989) view, both metacognitive and cognitive skills must be modelled explicitly by teachers or instructors for their learners. Schunk (1989) further explains that learners are also models for other learners, providing models that are effective and better when compared to those of teachers (instructors). According to Schraw (1998), in most cases when compared to teachers or instructors, learners do a better job in modelling metacognitive and cognitive skills as they give an effective rationale for metacognitive and cognitive skills which are within the learners' Zone of Proximal Development. Schraw (1998) goes on to say that crucial roles are played by extended reflection and practice in metacognitive knowledge and regulatory skills' construction, especially when learners are given periodic chances to reflect on each other's' failures and successes.

According to Hartman (2001a), teachers or instructors provide metacognition models in everyday college or school life for metacognitive knowledge and skills development. To Hartman (2001a), the instructors or teachers externalise their thinking processes by being an "expert model" in order for learners to hear the usage of metacognitive knowledge and skills that are effective. Modelling is normally a scaffolding component, as most learners appreciate when they see higher-level metacognitive strategies models used in everyday life experiences.

Self-directed learners are effectively promoted through self-questioning and questioning in general. Learner-created questions are more effective when compared to questions from the instructor or someone else, states Hartman (2001a). These situations involve instances where the learner ask themselves if they left out any information that is important, thereby noticing the important points that could have been omitted which assists learners to self-direct. According to Hartman (2001a), the performance of the learner is guided before, during and after the task has been performed by self-questioning. This might lead to an improvement in control over thinking and self-awareness, which improves performance.

Retention that is long-term of knowledge and skills can be improved as well as the ability to transfer and apply the knowledge and skills learnt by the learners, opines Hartman (2001a). Hartman (2001a) goes further by stating that the improved performance might lead to an improvement in motivation and attitude. The practice of self-questioning is not enough as explicit instruction is required on why, how and when to make use of self-questioning. The effective procedures and rationale of self-questioning must be understood by the learners for them to recognise the contexts that are appropriate for its usage.

Written and oral feedback from instructors or teachers is a valuable resource. Future performance of learners can be improved by considering feedback received and how best to interpret the feedback Hartman (2001a) asserts. According to Hartman (2001a), the inclusion of self-evaluation and self-monitoring in assessment makes the assessment more effective.

Metacognitive knowledge on error analysis has:

(1) **Declarative knowledge:** Declarative knowledge as stated in section 2.9 refers to knowing in terms of knowledge, strategies and skills which is important for completing a learning task successfully under different conditions. This is knowledge about the task at hand in terms of prior knowledge, which is useful in the given scenario Declarative knowledge according to Flavell (1979) is divided into person, task and strategies (actions) variables. The improvement of an individuals' future performance through a systematic approach of using metacognitive feedback is called error analysis. Error analysis involves creating metacognitive knowledge that is strategic to ones' mistakes and then recycling that particular knowledge for improving oneself.

(2) **Contextual / conditional knowledge:** There are quite a number of potential benefits of error analysis: (i) There is an opportunity for mastery of important materials by learners. (ii)There is development of both executive management and strategic knowledge of metacognition by learners in their test performance evaluation, identification of errors and error patterns that are possible and in planning for the future. For instance, it might assist learners in anticipating the likelihood of errors and self-correct these errors before writing an examination or test. (iii) It assists learners to internalise attributions in order for them to see that their own educational grades or outcomes are a consequence of their individual strategies, actions and effort, which are factors they control, instead

of attributing their ability to perform to factors that are external and outside the learners' control such as bad luck or the instructor (teacher). The learners' self-efficacy feelings and a particular subject area academic self-concept transfer.

(3) **Procedural knowledge:** The requirements of error analysis are the identification of what approach, answer or information is correct and identification of omissions, errors that were made, determination of why they happened and planning their prevention in future. In error analysis, identification of what the wrong answer is and the correct answer is (declarative knowledge), specific determination of why the answer was wrong (contextual knowledge) and action plan formulation of how they learned and understood the given material and how remembering of the information will be done is needed. When the learners' error analysis is analysed, there is a suggestion that declarative knowledge is manageable for learners to produce, contextual knowledge is moderately difficult and procedural knowledge is the most difficult for learners to generate.

Metacognitive knowledge and strategies are developed through the technique of thinking-aloud, suggests Hartman (2001a). Hartman (2001a) goes further by saying learners are provided with strategic metacognitive knowledge on think-aloud techniques for them to make use of situations that are appropriate using proper procedures. Hartman (2001a) notes that think-aloud techniques involve the externalising of the thought processes by an individual as they are performing task where thinking is required. What is being thought or felt is said aloud during the task performed such as question answering, problem-solving, reading in a lecture or textbook notes as well as during the conduction of experiments by the thinker. The instructor or teacher, two learners working together or even a learner working alone can use this method.

It was pointed out by Hartman (2001a) that think-aloud techniques have several challenges associated with them when they are used and an awareness by the thinker of the several challenges associated with the use of think-aloud technique assists in successfully avoiding or dealing with these challenges. According to Hartman (2001a), learners have challenges due to: thinking that rote learning is approved, academic content being unfamiliar, academic skills execution inadequacy, skills and knowledge inadequacy by both or either the listener and thinker, the thinker's use of the technique requires a lot of practice, the background in terms of the learners' culture leading to reluctance by some learners to expose their private thoughts as well as the listener may be at a faster pace than the speaker.

Possession of metacognitive knowledge that is strategic on the technique of think-aloud leads learners to having a higher probability of applying it due to understanding the context and conditions of its application, making it meaningful due to the possession of procedural knowledge which can be applied and transferred when its application is required in situations that are diverse. For Schraw et al (2006), inquiry, collaboration, mental models and personal beliefs are instructional strategies that increase metacognition. In inquiry, planning, monitoring and evaluation that are explicit are improved. In collaboration, self-reflection is modelled. In mental models, reflection and evaluation that are explicit are promoted. In personal beliefs, conceptual change and reflection are promoted.

The four principles, construction principle, assimilation principle, accommodation principle and individuality principle in cognitive science provide a metacognitive framework that assists science teachers in planning, monitoring and evaluating their teaching, learning assessments and classroom activities in order to maximise the understanding of science by learners, states Hartman (2001c). The construction principle is the first principle that says learners organise their experiences and knowledge into mental models and that learners should construct their own models. The assimilation principle is the second principle that says incorporation of new experiences and new knowledge in the learners' mind are controlled by mental models.

Accommodation principle as the third principle, places emphasis on the changing of existing mental models by learners in order for learning to happen. The individuality principle is the fourth principle and states that there are individual differences in learners' mental models due to the learners' personal constructions. For Hartman (2001c), scaffolding (comprehension teaching) includes the provision of temporary support to learners up to where they are able to carry out the tasks by themselves, and for the effective use of scaffolding, metacognition is required. For learners of lower socio-economic status, ability and with lower academic achievement, activity-based teachings such as scaffolding are more beneficial.

Strategic metacognitive knowledge (both pedagogical information and subject are knowledge) is extensive knowledge that is required for effective science teaching, says Hartman (2001c). Pair problem-solving involves teaching a strategy that gives strategic metacognitive knowledge besides self-questioning and think-aloud strategies. Self-monitoring and self-evaluation are promoted in learners by the pair problem-solving strategy. Reflection skills on thoughts from beginning to end after thoughts are encouraged.

2.20.1 Strategies of representation in Chemistry learning.

Information for learning or applying can be mental representations which are valuable determinants of how and whether learning will take place, suggests Hartman (2001c). These representations might be external such as tables and charts or internal such as mental images aiding metacognition. Learning how to learn in human beings is assisted by vee diagrams and concept maps, opines Hartman (2001c). Vee diagrams and concept maps assist learners be empowered, as rote learning is reduced and it assists teachers or instructors in meaningful negotiation with learners and thus better instruction is designed. Teacher education makes use of vee diagrams and concept maps. Hartman (2001c) sees vee diagrams and concept maps as promoting the understanding of ordinate and sub-ordinate relationships, learning that is meaningful, peer trust and relationships are improved, the contributions and role of a learner in group assignments is better understood as well as the conflicts which may arise.

Concept maps and vee diagrams as metacognitive tools assist Chemistry learners and teachers in the improvement of learning and teaching. Metacognitive thinking during the conduction of science lessons, in Hartman (2001c) view, usually involves choosing models or representations such as concept maps, vee diagrams, flow charts to be presented during the lesson, the determination of when they should be presented (sequencing instructional order) and decisions on how they should be represented (video, on whiteboard, transparency). Metacognitive thinking also involves self-assessment on how effective the representations that were selected by the teacher were, implementation timing, presentation method and having a plan for improving the effectiveness of the representations, suggests Hartman (2001c).

2.20.2 Chemistry (scientific) texts reading

Learners have difficulties with text sorting to the test structure, categorising in classification, enumeration, comparison and contrast, generalisation and sequencing, declares Hartman (2001c). For Hartman (2001c), the development of learners' metacognition regarding how scientific texts are read might improve the learners' comprehension by assisting them to be focused on information that is relevant and applying it for the creation of internal representations and connections. Hartman (2001c), states that learners tend to rote learn when it comes to facts, details and big words during scientific text reading when they should rather be attempting to understand the concepts.

When learners activate the prior knowledge they have and realise it is inconsistent with the science text meaning, the learners who are conceptual change readers think about the scientific text meaning and correct it through working to refine how they think, opines Hartman (2001c). The conceptual change strategy involves applying some effort in misconception clarification. The learners will then be showing self-regulation and self-awareness, which are important in learning metacognitively. Alternative conceptions or misconceptions are at times contained in scientific textbooks. Effective metacognitive science teaching involves the awareness of the degree to which misconceptions are common in science textbooks and controlling the selection of science textbooks for false statements avoidance.

2.21. MISCONCEPTIONS

Misconceptions, according to Hartman (2001c), are faulty ideas that make use of incomplete or false information, experience that is limited, generalisations which are incorrect or are not in line with the learners' basic understanding. Hartman (2001c) goes on to say some that misconceptions might be a result of discrepant, ambiguous and vague information. Learners bring to the classroom beliefs, prior knowledge, values, experiences and attitudes which affects how and what they think as well as learn. This background knowledge provides a foundation for science learning. Some of the background knowledge can be used as a foundation in science teaching and learning, some parts need revision and others are thrown away. Some of these misconceptions may become barriers to learning.

Information that is out of date scientifically or cultural myths can contribute to misconceptions. Hartman (2001c) points out that metacognitive science teaching involves a teacher or instructor who is alert to the origin and features of learners' misconceptions as well as strategy selection to dismantle the learners' misconceptions and evaluate or monitor the degree to which critical misconceptions have taken hold, including having accurate conceptions taking the place of the misconceptions. Learners' prior knowledge (indigenous knowledge) has an effect on the observations of the learner as it leads the learners to information that is in agreement with the learners' viewpoint, opines Duit (1991).

Learners pay attention to information selectively for confirmation of their ideas, concepts or views. Hartman (2001c) states that the prior knowledge of the learner might be so entrenched to the extent that learners do not believe their scientific observations. Hartman (2001c) asserts that the development of plans for the identification of misconception types of the learners and the development or selection of procedures for overcoming the learners' misconceptions by instructors or teachers is the application of metacognitive teaching.

2.22. SOCIAL METACOGNITION

Social metacognition, according to Chiu (2008) is whereby members of a group monitor and control each other's' actions, emotions and knowledge. In social metacognition, there is a distribution of the demands of metacognition between group members, increased visibility of each other's metacognition and individual cognition is improved, leading to greater motivation as well as reciprocal scaffolding declares, Chiu and Kuo (2009). The benefits of social metacognition, as seen by Chiu and Kuo (2009), are direct interactions with each other and sharing metacognitive responsibilities besides the reduction of cognitive demands for group members in group collaborations. Specific roles might be assigned to each individual group member when the situation is more structured.

For Chiu and Kuo (2009), explicit communication through the use of facial expressions, actions and words results in group members expressing their metacognitive and cognitive processing visibly as they express their ideas and share thoughts of their own during collaboration. Chiu and Kuo (2009) state there is an improvement of individual cognition and increased metacognitive process visibility as a result of distributed responsibility as well as metacognitive evaluation which identifies ideas that are correct and detects flaws, which is facilitated by greater visibility of metacognitive and cognitive processes. To Chiu and Kuo (2009), there is a reduction in metacognitive demand on individual group members as a result of distributed metacognition that enables more focused specialisation and attention in terms of individual strengths.

This reduces mistakes and distractions as the individual group members' elaborations, repetitions and questions (reciprocal scaffolding) thereby assist the individual learners to expand understanding, build on shared knowledge and identify their limitations explains Chiu and Kuo (2009). Social metacognition through its distribution of responsibilities, enhances greater motivation due to emotional support assistance and distribution of risk. Motivation is increased as a result of the reduced cost of failure and personal risk. Scaffolding difficulties in social metacognition might be faced due to the choosing of strategies that are inappropriate, time being mis-scheduled and resources (physical, cognitive or social) being mis-scheduled which ends up in mismatches in scaffolding for other group members suggests, Salonen, Vauras and Efklides (2005).

Social; metacognition may be hindered by participation which is distorted as well as distorted evaluations due to status differences in the group (Chiu and Kuo (2009). According to Chiu and Kuo (2009), group members whose contribution is expected to be positive to the outcome that is desired are conferred with a higher status and there is a creation of opportunities that are different in terms of performance as well as in receiving rewards. For Chiu and Khoo (2003), group members might selectively invite opinions of high-status group members while the lower status group members' opinions might be undervalued, discouraged or outright ignored. High status members are expected to dominate in the social metacognition interactions to the lower status members' detriment.

In social metacognition groups, Chiu and Khoo (2003) see misunderstandings that might arise which may lead to social relationships being harmed, participation reduced and communication hindered as a result of poor communication. Communication might be hindered and status effects exacerbated by cultural differences in the social metacognition group, suggest Chiu and Kuo (2009). Chiu and Kuo (2009) also say that communication can also be hindered by differences in experiences and background knowledge. Individual metacognition is facilitated by being exposed to applications of strategies, social feedback and diverse views of social metacognition.

There are socio-cognitive imbalances which are experienced by learners when they are exposed to views that are diverse, which motivates learners to find an acceptable solution through comparisons, evaluations and analysis which is metacognitive suggests Chiu and Kuo (2009). Social metacognition can be learned by the entire class through discussions in small groups by learners' use of prompt cards to ask questions and monitor each other's thinking. Lin (2001) saw that learners might understand each other better, learn from each other's weaknesses and strengths and make up their minds on effective allocation of metacognitive resources when working with group members. Discussions by the class as a whole, assist learners in the communication of their ideas in a respectful and clear manner whilst they work with each other, infers Georghiades (2004).

Through the use of integrated monitoring and communication skills, learners identify the understanding of the group members of the task or problem at hand, apply relevant processes of metacognitive regulation to solve the task or problem of the group and attain their objectives or goals (Georghiades, 2004). There are challenges in teaching learners as they are covert by nature, demand extra cognition and teacher preparation is difficult, points out Chiu and Kuo (2009). Chiu and Kuo (2009) stress that just as functioning with inadequate cognitive resources results in flawed or inadequate thinking, allocation in excess of cognitive resources to the processes of metacognition have a reduced performance on learning. According to Leinonen and Bluemink (2008), the extra demands of metacognitive skills and attitude makes it more difficult to be learnt and applied. Conner and Gunstone (2004) concluded that learners who are used to applying their strategies automatically usually have challenges when it comes to moving to active learning methods which require reflection on actions and knowledge.

Application of metacognitive strategies is reduced by conditions of application usage that are unclear. Learners might not know when to apply metacognitive skills, as they usually do not apply metacognitive skills, except for when specifically told to do so, asserts Garner (1990). Garner (1990) goes further and says learners might perform worse than usual due to metacognitive skills underutilisation. Assessment of learners' metacognitive skills might be hindered by both the covert nature and cognitive extra demands of metacognition, suggests Leinonen and Bluemink (2008). To Leinonen and Bluemink (2008), learners who are not applying metacognitive strategies explicitly are probably not applying it at all and those that do apply it might not show its application, and therefore evaluation of metacognition that is objective requires evidence of its application by learners.

The small number of teachers or instructors who were trained in metacognition might find it difficult to teach or their metacognitive skills may be weak. When the metacognitive skills of teachers or instructors are weak, effective modelling of these metacognitive skills become impossible, says Leinonen and Bluemink (2008). Inadequate metacognitive teaching training by teachers or instructors with strong metacognitive skills might result in these teachers or instructors not knowing how the metacognitive skills should be taught to learners. However, even though there are challenges with metacognition education, metacognition can be learnt by learners from pre-school up to tertiary levels of education.

Most of the research that have been done has focused on the relationship between metacognition and academic achievement. However, there is a gap in knowledge on the contribution of indigenous Chemistry knowledge (pre-service science teachers' prior knowledge and beliefs) to Chemistry metacognition in the Zimbabwean teachers' college context. This research seeks to fill that gap in knowledge.

2.23. SUMMARY

Empirical studies on metacognition and science education were reviewed in this chapter which assisted in directing the study's' focus. Relationships between science and culture as well as the relationship between Indigenous Chemistry knowledge and Western Chemistry knowledge were looked at. The relationship between metacognition and chemistry as well as the benefits of metacognition in chemistry education were discussed. Methods of metacognition instruction were discussed as well as a model for improving Chemistry academic performance of learners being put forward. A discussion of the education system in Zimbabwe was also done Most of the research that have been done have focused on the relationship between metacognition and academic achievement. However, there is a gap in knowledge on the contribution of indigenous Chemistry knowledge (pre-service science teachers' prior knowledge and beliefs) to Chemistry metacognition in the Zimbabwean teachers' college context. This research sought to fill that gap in knowledge. The next chapter looks at the theoretical framework of the research.

CHAPTER 3
THEORETICAL FRAMEWORK

3.1. INTRODUCTION

This chapter discusses the social constructivist theoretical framework that forms the basis of argument in this study. The major focus of the social constructivist theoretical framework is the active cultural and social construction of multiple realities, knowledge and learning. The importance of active experience and application of prior knowledge are discussed. The involvement of assimilation and accommodation in learning are also looked at in this chapter. Finally, the Zone of Proximal Development (ZPD) theory, which assists in identifying the best possible conditions between prior knowledge of the learner and introduction of new knowledge, is discussed.

3.2. CONSTRUCTIVIST THEORETICAL FRAMEWORK

The social constructivist theoretical framework as a model of the constructivist theoretical framework guides this research. According to Gatt and Vella (2003), the socio-cultural theory is one of the many models under the constructivist theoretical framework. Kalpana (2014), states that main differences between these models of constructivist learning theories is the extent to which the learner as an individual is independent, when compared to social connections between a person and society where expertise might be present and which can assist the person in social learning. In constructivist learning theory, learners produce their own knowledge and meaning from contact with the environment, asserts Kalpana (2014). Knowledge and meaning are also produced by contact between their ideas and experiences. Ideas are organised, structured and restructured for the purposes of obtaining meaning from ideas, states Shodhganga (2010).

Constructivist learning theory was defined by Singh and Yaduvansh (2015) as learners' construction of knowledge from experiences that are unique to the learner. Har (2013) sees constructivist learning theory as the development of knowledge directly through experience and reflection on those experiences. Duit (1996) points out that the primary view of constructivist learning theory is conceptualisation of knowledge as learner-centred and generated. That is, knowledge acquisition is personal, with the learner actively constructing the knowledge. The constructivist learning theory is made from numerous learning theories that are conglomerated into one theory. The cognitive learning theory and behaviourist learning theory are assimilated into the constructivist theory of learning, asserts Amineh and Als (2015). Cakir (2008) supports this view by saying the instructional model and epistemological commitment of constructivism has resulted in it being appealing. Its appeal comes from its intuitiveness and broadness by including some Vygotskian, Ausbelian, and Piagetian leaning theory aspects. According to Doolittle (1999), psychology and philosophy are the roots of the constructivist learning theory. It postulates that the learner actively makes their own knowledge and meaning from their own experiences.

Constructivist learning theory has four epistemological tenets: (i) knowledge is due to active cognition by the learner, (ii) in a particular environment, the learners' behaviour is made more viable by the adaptive process of cognition, (iii) a learners' experiences are organised and made sense of by cognition, cognition does not present reality as accurate and (iv) there are cultural, social, biological and neurological roots in knowledge construction (Doolittle;1999). The view of learning held by constructivists is that the prior knowledge of the learner is used to construct new understanding, opines Amineh and Asl (2015). Shodhganga (2010) also notes that the prior knowledge and previous experiences are important when it comes to new knowledge creation by a learner.

Knowledge is constructed through the individual or through a group in a social setting. In learners, knowledge construction is an individual process that is social and lifelong suggests Shodhganga (2010). Liu and Mathews (2005) state that enculturation of the learner into appropriate knowledge and into the learning community uses learners' prior knowledge. This prior knowledge interacts with the learning environment that is current, suggests Liu and Mathews (2005). Constructivist learning is inductive by design as learning comes after action. Experiences and prior knowledge (schema) are used to construct new knowledge using accommodation and assimilation as processes. Independent learning and critical thinking are fostered as well as motivation being created by constructivist teaching Bhattacharjee, 2015).

According to Bhattacharjee (2015), constructivist learning has the following characteristics:

- There is encouragement and representation of multiple representations as well as perspectives of content and concepts,
- Learners derive objectives and goals on their own or negotiate with the system or teacher,

- Facilitating, tutoring, coaching, monitoring and guiding are the roles served by teachers,
- Self-awareness, self-reflection, self-regulation, self-analysis and metacognition are encouraged through providing opportunities, activities, environments and tools that promote them,
- The central function of controlling and mediating the learning is done by the learner,
- Realistic, authentic and relevant representations of the learners' real-life natural world complexities must be mirrored by the skills, tasks, content, environment and learning situations in the classroom,
- Real life natural world complexities and authenticity are ensured by the use of data sources that are primary,
- Knowledge reproduction is discouraged whilst the construction of knowledge is encouraged,
- The construction of knowledge occurs in the context of the individual by experiencing, collaborating and negotiating socially,
- The construction of knowledge process takes into account the learners' prior constructions of knowledge, attitudes and beliefs,
- Emphasis is on in-depth understanding, thinking skills of higher order and problem solving,
- The opportunity to see the learners' prior constructions of knowledge is provided for by the errors made by the learners,
- To encourage learners to pursue their own goals and independently look for knowledge, exploration is the approach that is encouraged,
- Acquisition of knowledge, skills and tasks that are more complex are provided for when learners are given the chance to learn through apprenticeship,
- Interdisciplinary learning and conceptual interrelatedness are emphasised that reflect the complexity of knowledge,
- The learner is exposed to alternative viewpoints to promote co-operative and collaborative learning,
- Facilitation through scaffolding assists learners to just go beyond their usual limits in terms of their ability, and
- The teaching is interwoven with authentic assessment.

Shodhganga (2010) sees constructivist theory's expectations as being the construction of concepts, thoughts and ideas from the learners' interaction and negotiation with the environment or in a society(group). The construction of knowledge, according to Shodhganga (2010) can be through a number of processes and performance such as:

(i) Knowledge being physically constructed by learning that is active, (ii) Knowledge being symbolically constructed through actions being made into own representations by the learner, (iii) Knowledge being socially constructed where meaning is made through social settings and (iv) Knowledge being theoretically constructed through the explanation of things and ideas by learners themselves. Constructivism is the construction of knowledge through action and the reflection on that action in a social dimension explicitly(Panasuk and Lewis, 2012; Masciotra, 2005; Gat and Vella, 2003; Cobern,1996). Social constructivists emphasise the importance of contexts and situations. These contexts and situations are in a dimension which is social that affects knowledge construction by learners (Cakir, 2008; Masciotra, 2005)

Constructivism is a theory of knowledge which states that knowledge construction and intelligence development are done by learners(Singh and Yaduvanshi, 2015; Cakir, 2008); Masciotra, 2005). The learners do this due to the learners' actions and the consequences thereof. Learners recognise and understand fully situations that are new. This is done through prior knowledge and modification of prior knowledge for adaptation to a situation that is new(Panasuk and Lewis, 2012; Masciotra, 2005). The adaptation to a situation that is new expands progressively and increases the prior knowledge that is available to the learner. This allows the learner to solve problems which are more complex. Constructivism is sometimes called a theory of active knowing as action brings about development cognitively. In constructivism, knowing is adapting to new situations which results in intellectual action were new situations are concerned. Adaptation is done though actively experiencing the environment.

3.3. THE GREAT VALUE OF ACTIVE EXPERIENCE

Problem-solving in science is learnt in action and in a situation(Blake and Pope, 2008; Masciotra, 2005). whereby learners learn how to apply prior knowledge. The learning act should not be a memorisation act (Lefa, 2014; Masciotra, 2005). Learning knowledge in action results in learning that is meaningful, natural to the learner and a little effort is required to retain it. Constructivism-based pedagogy and andragogy are based on learning knowledge in action were the learners start certain actions being performed. This leads to reflection on those actions as well as their results after which action is returned to once again (Bormanaki and Khoshhal, 2017; Masciotra, 2005). This process, which is dynamic, goes on and on until the grasping of a concept is achieved.

3.4. APPLYING THE PRIOR KNOWLEDGE IS LEARNING

Active knowing includes the activation and application of a learners' prior knowledge(Blake and Pope, 2008; Masciotra, 2005). The construction of new knowledge (western Chemistry knowledge) is based on what the learner already knows in action. Knowledge comes from action and can only be expressed through action. Situations are given meaning not through information processing but through the activation of actual knowledge(Lefa, 2014; Masciotra, 2005). The actual knowledge (prior knowledge) should be close to the situation itself. There are negative consequences when this type of engagement is absent from the situation the learner finds himself or herself in. This results in everything which is included in that situation becoming meaningless to the learner.

The first and foremost entity in learning is prior knowledge. In this study, pre-service science teachers' prior knowledge is their indigenous Chemistry knowledge, skills and attitudes. All learners come to the learning processes, which are formal, with a vast variety of experiences (prior knowledge), suggests Shodhganga (2010). These are the learning prerequisites. The first principle, according to constructivists, is that prior knowledge is the basis of all learning (Bormanaki and Khoshhal, 2017; Masciotra, 2005). For pre-service science teachers in this study, the implication is that they have some form of prior knowledge that should normally facilitate western Chemistry knowledge learning. The second principle, according to constructivists, is that prior knowledge transformation is the basis of all learning(Bormanaki and Khoshhal, 2017; Masciotra, 2005). These two constructivist principles match with the two cognitive functions of Piaget's model of assimilation and accommodation.

3.5. ASSIMILATION AND ACCOMMODATION ARE INVOLVED IN LEARNING

The cognitive functions of assimilation and accommodation are typical in the process of learning (Blake and Pope, 2008; Masciotra, 2005). It is where knowledge grasps the unknown through the known. He goes further to say that learning is an active process. This is because the learning process of new knowledge, in which there is application of prior knowledge (assimilation) is then partly transformed(accommodation).

3.5.1. ASSIMILATION

Initially, learners are only able to assimilate new knowledge through the integration of their existing knowledge conceptually(Bormanaki and Khoshhal, 2017; Blake and Pope, 2008; Masciotra, 2005). The process of assimilation involves making something similar to what is known. Assimilation in cognition is the assimilation of new knowledge, making it similar to prior knowledge(Lefa, 2014; Blake and Pope, 2008; Masciotra, 2005). To some extent, the process involves the new knowledge being transformed into prior knowledge which is already held by the learner. When new knowledge is transformed into prior knowledge, assimilation has taken place. Distortion is to some extent involved in assimilation. Learning process as involving new knowledge that is being transformed and understood in the learners' own terms(Bormanaki and Khoshhal, 2017; Masciotra, 2005).

In constructivists' view, assimilation includes traits of transformation. The new knowledge from the environment is cognitively transformed and later integrated into the learners' cognition. New knowledge can be assimilated exactly as its presentation to learners with no transformation. This results in non-learning of new knowledge as they will have learnt what is already known to them(Lefa, 2014; Masciotra, 2005). Nothing new is learnt through assimilation, which is lateral, as nothing will have been transformed. The perspective of constructivists is that distortion to some extent is involved in pure assimilation as this cannot guide the learner to new knowledge. The learner can only be guided to the new knowledge through transformation of the prior knowledge, which is accommodation.

3.5.2. ACCOMMODATION

Learning in its entirety is a consequence of an equilibrium process that is between accommodation and assimilation(Blake and Pope, 2008; Masciotra, 2005). The process of accommodation occurs when prior knowledge is transformed into new knowledge. Accommodation is when prior knowledge is refined. Accommodation involves differentiating and transforming prior knowledge(Blake and Pope, 2008; Masciotra, 2005). These adjustments occur in each situation and the variation normally induces adjustments that are relatively significant in a learners' knowledge-in-action (Bormanaki and Khoshhal, 2017; Lefa, 2014; Masciotra, 2005). Accommodation is motivated by the environment. From a constructivist perspective, the knowledge is actively transformed.

Chemistry concepts, like any other concepts, are not units that are isolated but are concepts that are interrelated inside the conceptual structure. For instance, it is not possible to know what the element calcium is if there were no other elements to compare it with. The element is the cognitive structure (general knowledge), which enables a learner to distinguish various other elements (specific knowledge). Cognitive structures are organised knowledge whereby the more general or larger bodies of knowledge include and integrate the knowledge which is more specific(Lefa, 2014; Blake and Pope, 2008; Masciotra, 2005). Learners can only obtain meaning from any object or situation of knowledge through assimilation. The assimilation is through a single or through multiple cognitive structures of the learner (Bormanaki and Khoshhal, 2017; Masciotra, 2005).

A situation is given meaning by a learner through assimilation of the situation to the learners' available cognitive structures. The capacity to accommodate by a leaner depends on the range and arrangement of the learners' existing knowledge (prior knowledge) (Blake and Pope, 2008; Masciotra, 2005). The existing knowledge was constructed through accommodations which happened earlier. Assimilation is prior knowledge which is applied within the range of the learners' earlier accommodations. Assimilation is the navigation of a territory that is familiar, however the territory should not be unknown(Bormanaki and Khoshhal, 2017; Masciotra, 2005). With each accommodation that is new, a learner increases the application possibilities of the knowledge. The degree to which the application possibilities of the knowledge increases, relies on whether it includes knowledge that is specific or conceptual knowledge that is structured (Lefa, 2014; Blake and Pope, 2008; Masciotra, 2005). In constructivism, a notion that is key is knowledge organisation. Every new accommodation occurs with differentiation that is more refined.

3.5.3 ASSIMILATION WITH ACCOMMODATION IS ADAPTATION

Every time when a learner is faced with a situation that is new and assimilation does not occur with accommodation, the result is a disequilibrium state(Blake and Pope, 2008; Masciotra, 2005). If the learner succeeds in the accommodation of the situation which is new, there is a re-establishment of said equilibrium that corresponds with the situation that is newly being adapted too. An experience that is active is required for overcoming the disequilibrium in the learner. The re-establishment of equilibrium means that the learners' accommodated thinking has achieved harmony(Bormanaki and Khoshhal, 2017; Masciotra, 2005). There is harmony between the learners' accommodated thinking and the realities of the learners' experience.

The suggestion by Lefa (2014) and Masciotra (2005) is that new knowledge construction and adaptation to the situation means that establishment of equilibrium has occurred between assimilation and accommodation. In constructivism, knowledge comes from action (or from experiences that are active) and from reflecting on the action in the situation(Lefa, 2014; Blake and Pope, 2008; Masciotra, 2005). This is usually not from language, even though language cannot be done away with when it comes to development that is intellectual. New concepts come from experience that is active (meaning coming from action and reflection on the action), with the learner not usually knowing the words that describe them(Bormanaki and Khoshhal, 2017; Lefa, 2014; Masciotra, 2005). The construction of knowledge is done in action and through reflection on the action in the situation. Action and reflection work through assimilation and accommodation which, when in equilibrium makes it possible for adaption to the new situations.

3.6. SOCIAL CONSTRUCTIVIST LEARNING THEORY

Social constructivist learning theory stresses that learning as part of cognitive functions depends on interactions between the learner with the environment and individuals such as parents, peers and teachers. For Kim (2001), social constructivism is rooted on assumptions with regards to reality, knowledge and learning. Knowledge, as an aspect of life, comes from an individual who was created through cultural and social norms and interactions. According to Draper (2013), knowledge in social constructivism is culturally and socially constructed actively, thereby making it a human product. Adaptation of real-life problem-solving is the basis of social constructivist learning which occurs in a social context. This is by sharing experiences as well as discussions which result in prior knowledge matching new ideas with the learner making sense of the world through adaptation (Draper, 2013).

Reality from a social constructivist perspective is constructed by human activity. Each individual learner is complex and unique; this gives rise to the existence of multiple realities. Draper (2013) stresses that the cultural background of the learner is valued in social constructivist learning. Culture affects the learning of an individual as most of the knowledge and cognitive processes are culture specific. Knowledge is a result of social construction and is an active process. Social activity is the centre from which the structure of new learning is based. These are the primary beliefs and understandings of a classroom that is social constructivist, states Shodhganga (2010). Social constructivist learning is based on the ideas of Piaget (cognitive constructivist) and Vygotsky (socio-cultural theory). These ideas emphasise the use of culture, language and social interaction as major contributing factors in learning. Vygotsky, according to Jones and Aranje (2002) is considered the father of the social constructivist learning theory. This is because he focused mainly on the socio-cultural context of learning.

Taylor (2018) asserts that a social constructivist approach promotes the situating of activities designed for learning by contextualising the learners' real (home) life in a way that promotes enhanced Chemistry learning meaningfully. For Vygotsky (1978), the development of cognition happens through:(a) Mind changes that are constant as a result of the interaction which is continuous with the environment. There is influence on the individual by the environment and influence on the environment by the individual. This makes it a process rather than a product, (b) Cognitive development in its entirety is a consequence of social interaction. Social interaction assists in the development of an individuals' mental functions of higher order. There are mental functions of low order and higher order. Low order mental functions are genetically inherent and allow the reaction to the environment by humans. Higher order mental functions are due to social interaction, (c) Language emphasis: signs and language mediation lead into mental functions of a higher order. The tool that is best in social settings for effective interaction, influencing and learning is language. Vygotsky's social development theory of cognitive development is based on the principles of the Zone of Proximal Development (ZPD) and More Knowledgeable Other (MKO).

3.6.1. The Zone of Proximal Development (ZPD) theory

The zone of proximal development is defined by Elliot, Kratochwill, Litlefield and Travers (1996) as the difference in terms of the gap separating the learners' real level of development as established by problem-solving which is independent, and the potential for developing at a higher level as established by problem-solving in collaboration or under the guidance of a more capable individual. The zone of proximal development can be described as the discovering of the best possible conditions between the prior knowledge of the learner and the introduction of new knowledge that maximises the academic growth of the learner in an effective way, suggests the Northwest Evaluation Association (2014).

Howe (1996) and the Northwest Evaluation Association (2014) defined the zone of proximal development as the bridging of the gap between that which a learner knows and that which a learner can know in an effective way. Reciprocal teaching, peer collaboration and apprenticeship programs make up the social interaction principles of the Vygoskyian ZPD perspective. In this study, the zone of proximal development was the gap between the indigenous Chemistry knowledge and the Chemistry metacognition of the pre-service science teachers. ZPD as a cognitive development concept is important in that it assists in identifying or recognising what a learner is capable of independently (Shodhganga, 2010).

According to Shodhganga (2010), the cognitive development should be brought within the range of ZPD. The teacher (instructor or facilitator) benefits by being assisted in deciding the assistance for the learner that is appropriate for reaching the ZPD, asserts Shodhganga (2010). Cognitive development in social constructivism is placed with the intelligence of a learner not being inborn or not changing, but that all learners have the potential to learn. For Shodhganga (2010), learners attain the potential development and the gap is filled through interaction with teachers/instructors, classmates and peers. Scaffolding is advocated for by the ZPD to attain the potential development. In social constructivism, the concept of scaffolding which is key, is associated with the ZPD. Scaffoldings' function is to clearly explain the basic qualities of the improvement of learning.

It also clearly explains systems that support learning which might lead to further improvement of the quality of learning, opines Shodhganga (2010). There is interaction between the facilitator (teacher) and the learner which leads to socially dialogic mediated learning and teaching. The purpose is to give guidance and assistance where it is not possible to attain the goal by not receiving any assistance. There is inspiration and acceleration for the learner by the facilitator through the provision of clues, hints, encouragement and assistance. This is a mechanism of support which assists the learner to develop and grow within the ZPD. For scaffolding to be fruitful, the facilitators and significant others such as parents must increase the extent and teaching as required by the current knowledge (prior knowledge) and ability of the learner, states Shodhganga (2010).

To Shodhganga (2010), for scaffolding to be effective, more assistance is given by the facilitator immediately to struggling learners, which is gradually withdrawn later or less assistance given. This assistance is provided until there is proficient performance by the learner within a systematic and organised educational environment. Scaffolding allows learners to perform tasks they cannot perform on their own. The intention is to have the learner become competent independently which finally allows the learner to do the given task without assistance, opines Shodhganga (2010). In this study, scaffolding was used to assist pre-service science teachers with using their indigenous Chemistry knowledge for Chemistry metacognition.

3.6.2. Criticism of the Zone of Proximal Development theory

The assumption that asymmetric intelligence should be there because of a more knowledgeable individual assisting a less knowledgeable one is not true (Sarker, 2019; Shabani, Khatib and Ebadi, 2010; Cowrie and Van der Aalsvort, 2000). This is because successful and effective learning takes place in collaboration between learners at the same level in terms of ability (Sarker, 2019; Shabani, Khatib and Ebadi, 2010; Cowrie and Van der Aalsvort, 2000)

3.6.3. The More Knowledgeable Other (MKO)

A more knowledgeable other (MKO) refers to individuals or electronic programmes with an ability which is at a higher level than the learner or with an understanding that is better in relation to a certain concept, process or task. The more knowledgeable other might be an older individual, a teacher (instructor or facilitator) or a peer who has more experience or knowledge on a particular concept or topic. There is a relationship between learners' culture and metacognitive processes source, states Vygotsky (1978). Metacognitive skills such as reflective thinking is developed as learners actively contribute in class discussions as well as active listening to other learners. This is a crucial stage in the development of the capability of assessing the feasibility of the learners' prior knowledge and concept development.

Taylor (2018) suggests that social constructivist learning promotes the construction of the ability to justify and explain of learners' reasoning. It also promotes negotiating and learning with the teacher and other learners. For Shodhganga (2010), learners are assisted by prior experiences to learn new ideas. Learners arrive into the classroom learning environment with prior experiences (knowledge, skills and attitudes). Educations' main function is to utilise these prior experiences, which leads to reflection on problems that are authentic. This leads to a form of cognitive disequilibrium which in turn leads the learner to reflection on problems that are authentic. This is done in order to resolve the disequilibrium created by the interaction of the learners' prior experiences and the new experiences leading to the reconstruction of self-concepts and reality (Shodhganga, 2010). The learning cycle becomes a cycle of disequilibrium, exploration of a problem, problem resolution and the reconstruction of self-concepts and reality.

3.6.4. Social constructivist implications for formal science education.

The implications for science education from the social constructivist view as suggest by Shodhganga (2010), are : (i)The ensuring and allowing of ZPD and scaffolding can be done through the creation of challenging tasks, (ii) Competent individuals can assist less competent individuals through the provision of cooperative learning, (iii) Facilitators and competent individuals should act as cognitive models during instruction, and (iv) Environments of the real world should be provided for the purpose of relating learning to situations in real life. Instructional styles and instruction must mirror the content of the learners' culture (Potvin, 2017; Cakir, 2008). In the classroom, there must be an incorporation of cognitive and social constructivist techniques for learning to be effective, infers Powell and Kalina (2009).

3.6.5 Social constructivism application in this study.

To the pre-service science teachers in this study, indigenous Chemistry knowledge is a form of reality (multiple realities) and knowledge which they acquired through the social learning processes of modelling, collaboration, coaching and scaffolding in their everyday lives. In this study the social constructivist theoretical framework is used to;

(i) Determine pre-service science teachers' culturally contextualised indigenous Chemistry knowledge, skills and attitudes. This was done using focus group interview guides designed with the assumptions that the culturally contextualised indigenous Chemistry knowledge, skills and attitudes are forms of reality, knowledge and learning to the pre-service science teachers that originated from social interactions with others and their environment.

(ii) Determine the scientific (chemical) accuracy of the pre-service science teachers' culturally contextualised indigenous Chemistry knowledge, skills and attitudes. A comparison of the culturally contextualised indigenous Chemistry knowledge, skills and attitudes with formal chemistry in terms of Chemistry concepts, efficiency, reliability, benefits and effectiveness is conducted through the design of the indigenous Chemistry knowledge focus interview guides.

(iii) Utilise the pre-service science teachers' culturally contextualised indigenous Chemistry knowledge as prior knowledge, skills and attitudes for Chemistry metacognition learning by the pre-service science teachers. The culturally contextualised indigenous Chemistry knowledge of the pre-service science teachers will be used in Chemistry lectures in explanations and as examples of formal Chemistry concepts and processes.

3.7. SUMMARY

The social constructivist theoretical frameworks' support of the study was discussed in this chapter. The social constructivist theoretical framework highlights the significance of the cultural and social construction of knowledge and reality using prior knowledge. The Zone of Proximal Development also emphasizes the importance of identifying the best possible conditions between prior knowledge of the learner and the introduction of new knowledge. Application of the social constructivist in the context of this study was also done. The next chapter focuses on the research design and data collection.

CHAPTER 4

RESEARCH DESIGN AND DATA COLLECTION

4.1. INTRODUCTION

The purpose of this chapter was to explain the research methods that were used for collecting and analysing data for the attainment of the study's aim. This study examined the influence of indigenous knowledge on Chemistry metacognition. The samples' responses were analysed using the social constructivist theory as the analytical framework. The following is a summary of the procedures which were carried out in collecting and analysing the data:

Table 4.1: Stages of data collection and analysis procedures used in the study

Time frame	Action	Target group
Stage 1. Metacognition awareness	Focus group interviews Pen and paper test	First year post ordinary level 2020 pre-service science teachers
Stage 2. Cultural indigenous Chemistry knowledge identification	Focus group interviews Observations Document analysis	First year post ordinary level 2020 pre-service science teachers
Stage 3. Cultural indigenous Chemistry knowledge metacognitive instruction and learning.	Scaffolding, Modelling Collaboration	First year post ordinary level 2020 pre-service science teachers
Stage 4. Assessing Metacognition awareness.	Focus group interviews Pen and paper test Observations Document analysis	First year post ordinary level 2020 pre-service science teachers
Stage 5. Post-cultural indigenous Chemistry knowledge metacognitive instruction assessment data reduction	Analysis of focus group interviews, observations, document analysis	First year post ordinary level 2020 pre-service science teachers
Stage 6. Cultural indigenous Chemistry knowledge metacognition influence data display		First year post ordinary level 2020 pre-service science teachers
Stage 7. Indigenous Chemistry knowledge metacognitive influence Conclusion drawing.		First year post ordinary level 2020 pre-service science teachers

Stage 1's objective was to obtain information on the Chemistry metacognition awareness proficiency level of the pre-service science teachers before the intervention of the study. The intention was to gather as much information as possible on the pre-service science teachers to establish their Chemistry metacognition training needs. Stage 2's objective was to identify the indigenous Chemistry knowledge practised and known by the pre-service science teachers. The objective of stage 3 was for indigenous Chemistry knowledge metacognition instruction and learning. The objective of stage 4 was to get information on their Chemistry metacognition proficiency level after indigenous Chemistry knowledge metacognitive training and instruction. This led to the establishing of the extent of indigenous Chemistry knowledge's influence on Chemistry metacognition after stages 5 to 7.

4.2. PHILOSOPHICAL TENENTS OF INDIGENOUS CHEMISTRY KNOWLEDGE DATA COLLECTION AND ANALYSIS

Philosophically, indigenous Chemistry knowledge is a form of knowledge that is generated locally which is real and disseminated through learning from social and environmental interactions by pre-service science teachers. Social constructivists view cognitive functions as dependent on social interactions with other individuals and the environment (Masciotra, 2005). Kim (2001) asserts that social constructivists assume that knowledge, reality and learning are cognitive functions that are social processes. Indigenous knowledge Chemistry learning is part of cognitive functions. Learning is situated cognition, implying that thinking is based on physical and social contexts. The learners' prior physical and social experiences influence attention as well as the selection of new learning experiences (Masciotra, 2005).

New Chemistry situations (western Chemistry) are recognised and understood by learners using prior knowledge (indigenous Chemistry knowledge). This results in the prior knowledge (indigenous Chemistry knowledge) being modified in order to adapt to the new Chemistry situation (western Chemistry). The learning of indigenous Chemistry knowledge is dependent critically on the qualities and processes of social collaborative learning. Tutoring, cooperative learning and cognitive apprenticeship are some of the collaborative processes used to teach indigenous Chemistry knowledge. Cognitive apprenticeship includes scaffolding, collaboration, coaching and modelling. Table 4.2 shows the application of the social constructivist theoretical framework in indigenous knowledge Chemistry data collection, analysis and interpretation.

Table 4.2: Philosophical tenents of indigenous chemistry knowledge data collection and analysis.

	Social constructivist premises		
	Reality	**Knowledge**	**Learning**
Indigenous Chemistry knowledge	Indigenous Chemistry knowledge is a result of social consensus (contextual) and cultural practices making reality a product of human beings that is subjective giving multiple realities. Indigenous knowledge is a form of reality which comes from social invention that has solved and continues to solve Chemistry challenges in indigenous society.	Individuals socially and culturally create indigenous Chemistry knowledge through their interactions with other individuals and with their environment. Social interactions and cultural influences result in shared meaning of indigenous Chemistry knowledge making it a human product. Indigenous Chemistry knowledge is an empirical form of knowledge as it has been tested over time and there is physical as well as chemical evidence of it and its uses.	The identification of the significance or meaning of indigenous Chemistry knowledge as a social concept or experience is learning. Learning is a social process which in itself is active knowing that involves the activation and application of prior knowledge. Prior knowledge is the basis for all learning. Indigenous Chemistry knowledge is the prior knowledge which is a basis of learning.

4.3. RESEARCH APPROACH

A mixed methods approach was used in this study. This approach involves the collection and analysis of both qualitative and quantitative data within a primary qualitative approach, leading to integration of the results as well as conclusions from this data into a whole that is cohesive (Leedy and Ormrod; 2015). A mixed methods approach offers data completeness, complementarity, triangulation and resolution of findings that are puzzling (Creswell and Clark, 2018).

The mixed methods approach of this study retained the properties of qualitative research. That is, being a subjective systematic approach, whose function is the description of life situations and experiences with the aim of giving meaning to them, states Dawson (2002). In this study, the pre-service science teachers' indigenous Chemistry knowledge was made up of their life situations and experiences. The study attempted to give meaning to these life situations and experiences in the context of Chemistry metacognition. The focus of this mainly qualitative research was to get locally contextualised understanding and knowledge through the learners' experiences (Mohajan, 2018; Cohen, Manion and Morrison, 2000).

The understanding of an individual's social reality was taken as a form of social action. Qualitative approach stresses the way individuals obtain meaning from their experiences as well as interpret their experiences, explains Draper (2004). This study assisted the pre-service science teachers to obtain meaning from their indigenous Chemistry knowledge experiences in relation to Chemistry metacognition. It also sought to assist the pre-service science teachers to interpret their indigenous Chemistry knowledge in terms of Chemistry metacognition. Due to its nature of inductiveness, the qualitative approach generally leads to exploration. That is the exploration of insights and meanings when a particular situation is presented or presents itself, states Straus et al (2008).

Qualitative research values the accuracy of the phenomenon under study, asserts Cohen et al (2000). A qualitative research approach focuses on peoples' meaning systems, experiences and beliefs from their perspective. Its roots are in the cultural and social anthropology, history, philosophy, sociology and psychology of the individual, suggests Mohajan (2018). Mohajan (2018) also points out that these come from generations of new theories and concepts from the population or individuals' perspectives. How first year post ordinary level 2020 pre-service science teachers' systematic interpretation and describing of phenomena or issues on indigenous Chemistry knowledge were approached was the purpose of the qualitative approach.

Describing and exploring the contributions of culture (indigenous Chemistry knowledge) to Chemistry metacognition and Chemistry literacy by pre-service science teachers was the rationale for utilising a qualitative approach. In this study, the focus was on pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes. Their indigenous Chemistry knowledge meaning systems, experiences and beliefs from the perspectives of pre-service science teachers were also be looked at. These were under natural settings in the Chemistry laboratory for application as prior knowledge, skills and attitudes in Chemistry metacognition. Qualitative research involves detailed examination of a particular case that comes from social life natural flow, opines Neuman (2014).

4.4. RESEARCH DESIGN

A research design is a conceptual structure inside which the research is done, it is a plan by which the data is collected, measured and analysed, asserts Kothari (2004). The embedded mixed methods case design was utilised in this study. Creswell and Clark (2018) describe the embedded mixed methods design as the collecting and analysing both qualitative and quantitative data in a research design that is primarily qualitative or quantitative. The secondary data, according to Creswell and Clark (2018), is collected and analysed before, during or after the data collection and analysis of the primary approach is implemented. In this study, the secondary quantitative data collection and analysis was embedded within the primary qualitative data collection and analysis procedures. The embedded mixed methods case design for this study is shown in figure 4.1.

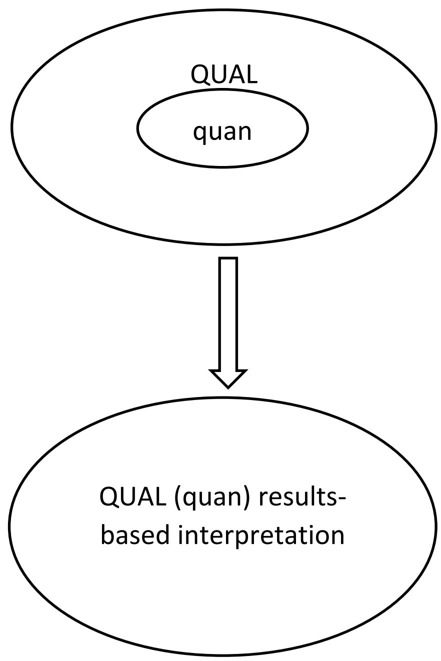

Figure 4.1: Embedded mixed methods case design

The primary qualitative data that was collected and analyzed was the indigenous Chemistry knowledge and the components of metacognition. The secondary quantitative data that was collected and analyzed were the assignment, practical and test scores as well as the Pearson product moment correlation was used to quantify the triangulation between the research instruments. According to Yin (2002), a case is a phenomenon which is contemporary and which is in the context of real life, particularly in which the boundaries are not clear between the phenomenon and context. Yin (2002) further says that the researcher has minimum control of the phenomenon and the context. The indigenous Chemistry knowledge, skills and attitudes are the phenomenon and the pre-service science teachers' culture is the context. Case studies are of three types, which are exploratory, explanatory and descriptive suggests Stjelja (2013).

Merriam (1998) states that descriptive case studies describe the phenomenon or intervention and the situation in real life in which it happens in a particularistic and heuristic manner. It gives a rich and thick description of the phenomenon or intervention under study. A descriptive case study design was employed in this research. It is concerned with interpretation and description of situations, circumstances, conditions and events that are contemporary in nature and from a social constructivist perspective (Tobin, 2010; Merriam, 1998). According to Yin (1994), case studies are investigations that are empirical of a phenomenon in the context of its environment where there is no clarity in the environment and phenomenon relationship. In this case study, the focus was on the cultural aspects of Chemistry and their contributions to Chemistry metacognition abilities.

Quantitative data was the first to be collected and analysed through the metacognition awareness scores from focus groups as well as individual pen and paper tests for triangulation purposes. Second to be collected and analysed was qualitative data using indigenous Chemistry knowledge focus groups. Observations and document analysis were used in the third stage of the research to collect qualitative data before the intervention stage (using indigenous Chemistry knowledge) as well as after the intervention stage. The indigenous Chemistry knowledge intervention was the fourth stage which involved the collection and analysis of qualitative data.

In the fifth stage, quantitative data was collected and analysed using metacognition awareness focus groups as well as individual pen and paper tests. Qualitative data was used in data display and conclusion drawing in the sixth and seventh stages respectively. The two quantitative stages played an ancillary role for showing the impact of the qualitative indigenous Chemistry knowledge intervention on the metacognitive awareness levels of the pre-service science teachers. The rationale behind using an embedded mixed method case study was for the quantitative data to show, through quantifying, the impact of the indigenous Chemistry knowledge intervention on Chemistry metacognition awareness as well as on pre-service science teacher's academic performance.

4.5. THE NATURE OF RESEARCH

The interpretive paradigm is employed to study the influence of indigenous Chemistry knowledge on Chemistry metacognition. The interpretive nature of this study came from the desire by the researcher to understand the social reality of indigenous Chemistry knowledge's influence on Chemistry metacognition. The interpretive paradigm is a constructivist paradigm that is humanistic and naturalistic which is used to interpret and understand reality in the human and social context (Shah and Al-Bargi, 2013). This study was based on the subjective indigenous Chemistry knowledge meanings of the pre-service science teachers' understanding and interpretation of the indigenous Chemistry knowledge social and human phenomena. The social constructivist perspective of the constructivist paradigm was used in this study. According to Crotty (2003), the social constructivist paradigm focuses on the culturally obtained and historically placed social life-world interpretations.

In this study, the indigenous Chemistry knowledge was the culturally obtained and historically placed social-life world interpretations. The importance of the learners' social interactions was emphasised in the acquisition of knowledge, skills and attitudes by the social constructivist paradigm, asserts Schunk (2012). The assumptions of the social constructivist paradigm are that individuals look for an understanding of their world. Creswell (2009) opines that the understanding of experiences developed by the individual is subjective, multiple and varied, opines. The multiple realities that exist are mental constructions that are difficult to measure, understand and describe, as pointed out by Guba and Lincoln (1994). Guba and Lincoln (1994) go further by saying that the basis of mental constructions is experience, locality and nature specific that depend on the content and form of the individuals or groups having the mental constructions. Indigenous Chemistry knowledge is pre-service science teachers' cultural mental constructions based on experience, nature and locality.

Reality is socially constructed. To pre-service science teachers in this study, indigenous Chemistry knowledge, skills and attitudes are a socially constructed form of reality built from their social and cultural experiences. Individuals produce their own sense of realities that are social which arise when their consciousness interacts with the environment, argues Shah and Al-Bargi (2013). Language is used to actively shape and mould reality. According to Creswell (2007), interaction between different aspects of the environment and language construct reality, whereas the evidence of realities that are multiple comes from an individuals' actual words.

In this study, indigenous Chemistry knowledge themes in agriculture, environmental conservation, food processing, food preservation and health care were the representations of multiple realities by the pre-service science teachers that were constructed through social interaction with others and their environment. The actual words from indigenous Chemistry knowledge focus group interviews of the pre-service science teachers provided evidence of multiple realities of indigenous Chemistry knowledge held by them. The social meaning of agriculture, environmental conservation, food processing, food preservation and health care are an inter-subjective understanding shared among pre-service science teachers who have common assumptions and interests-based social interactions.

Epistemologies that are transactional and subjective are espoused by an interpretive paradigm, leading to the researcher and respondents being combined into one entity of which particular findings are produced by this interaction, suggest Shah and Al-Bargi (2013). The transactional and subjective nature of indigenous Chemistry knowledge as an epistemology was supported by the interpretive paradigm in this study. This resulted in the pre-service science teachers and the researcher being combined into one entity that produced particular findings of the influence of indigenous Chemistry knowledge on Chemistry metacognition from the interaction. According to Shah and Al-Bargi (2013), subjectivity is the only means by which the construction of reality by the participants are provided under conditions of humans. Guba and Lincoln (1994) state that interactions which are subjective can provide a way to the realities in the minds of the respondents. Subjective interactions were the only means by which the construction of the reality of indigenous Chemistry knowledge in the minds of the pre-service science teachers could be accessed.

The belief held by the interpretive paradigm is that the world is not independent of human knowledge, states Grix (2004). The participation and interpretation of an individual might influence the phenomena being observed. Pre-service science teachers' participation and interpretation in this study could have influenced their indigenous Chemistry knowledge impact on Chemistry metacognition. Interactions that are subjective show how a person or people in groups interpret the phenomenon that is social and how the inquirer construes the establishment of the various theories, concepts, procedures and strategies, opines Cohen, Manion and Morrison (2007). Subjective interactions of the pre-service science teachers showed their interpretation of indigenous Chemistry knowledge as a form of reality, knowledge and learning process. The subjective interactions in the study also showed the researchers' understanding of the establishment of indigenous Chemistry knowledge, Chemistry metacognition, social constructivist theoretical framework and methodology procedures and strategies.

4.6. RESEARCH CONTEXT

The study was conducted at a secondary school teachers' college in Zimbabwe with the respondents being post ordinary level pre-service science teachers. In Zimbabwean teachers' colleges, there is a three year post ordinary level programme and a two year post advanced level programme for science teachers. At the end of their studies, pre-service teachers in both programmes are awarded the same diploma in science education certificate. Zimbabwean pre-service science teachers in teachers' colleges have similar perceptions like other Chemistry students on Chemistry. Students perceive Chemistry as difficult and challenging, states Uzezi, Ezekiel and Auwal (2017). Zimbabwe currently has a serious shortage of science and mathematics teachers at secondary school level. (Chadenga, 2018; Torubanda, 2014; Mawonde; 2013)

Due to this serious shortage of science teachers, the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) now offers secondary science teacher programmes at three primary teachers' colleges, points out Chadenga (2018). Chadenga (2018) further states that a total of 300 pre-service science teachers were enrolled in 2018 at the primary teachers' colleges of Mkoba, Joshua Mqabuko and Masvingo. However, due to the low numbers of secondary school learners who study Science, Technology, Engineering and Mathematics (STEM) subjects, integrated science has been accepted for the post ordinary level science teacher training programme in all teachers' colleges in Zimbabwe.

The normal minimum requirement for science teacher training is five ordinary subjects, including the STEM subjects of Biology, Chemistry, Physics and Mathematics at teachers' colleges in Zimbabwe. The integrated science was not designed for learners to proceed with science education beyond ordinary level studies, but to make the learner appreciate science. According to the Zimbabwe School Examinations Council (2011), integrated science is designed for candidates who do not wish to proceed with science studies beyond ordinary level. This has worsened the problem of Chemistry been seen as difficult by the post ordinary level pre-service science teachers at the teachers' colleges. This research attempted to use indigenous Chemistry knowledge to influence Chemistry metacognition in order to assist the pre-service teachers in learning how to learn for life-long Chemistry learning.

The Chemistry syllabus was designed to be covered over a three-year period, in which in the first and third years, the pre-service science teachers attend lectures at college. In the second year, the pre-service science teachers will be out gaining teaching practice. The programme, a 3-3-3 model, means three terms at college, three terms teaching practice and three terms at college again in the final year. The Chemistry syllabus covers physical Chemistry, inorganic Chemistry and organic Chemistry up to the level of a first-year university Chemistry degree. The Chemistry syllabus is reviewed every five years by the college.

The Chemistry syllabus assessment consists of both continuous and summative assessment. The continuous assessment consisted of the coursework whilst the summative assessment consisted of the final examination. The continuous assessment consisted of five assignments, five in-class tests and five practical assessments which are conducted from the first to the third year. Continuous assessment contributesd 30% to the overall Chemistry mark of the pre-service science teachers. The summative assessment, which was the final examination in the third year, was three hours long and contributed 70% of the overall Chemistry mark. The coursework and examination were set by the teachers’ college Chemistry lecturers with the examination sent to the University of Zimbabwe to be approved, printed and packaged.

The Chemistry coursework and examination were marked and combined by the teachers’ college lecturers. The external examination of the marked and combined Chemistry coursework and examination were done by Chemistry lecturers from other teachers’ colleges as well as universities. These Chemistry lecturers from teachers’ colleges and universities came at the invitation of the University of Zimbabwe’s Department of Teacher Education as external examiners. The externally examined Chemistry coursework and examination that were combined were presented to the University of Zimbabwe’s Senate for awarding of the science education teaching qualification diplomas.

The University of Zimbabwe was responsible for issuing the certificates of the diploma in science education teaching qualification that was offered by the teachers’ colleges. The University of Zimbabwe was the accrediting institution for diplomas in all teachers’ colleges in Zimbabwe. The University of Zimbabwe’s role was one of quality assurance for all teachers’ colleges in Zimbabwe under The Scheme of Association. The coordination of The Scheme of Association was done by the University of Zimbabwe’s Faculty of Education through the Department of Teacher Education. The summary definition of association as written in the Senate Sub-Committee on Associate and Affiliate Status (SSAAS) handbook (2011):

“applies to those institutions which do not seek to participate in the work of the university but which seek to obtain the University’s participation in their work. Such institutions are motivated by a desire to raise their standards and quality and heighten their prestige. In this relationship, the University confines its role in the provision of professional guidance and supervision to Associate Institutions to ensure that they operate at a level appropriate to their own nature and purposes which need not be at University level.”

According to Chivore, Mavundutse, Kuyayama-Tumbare, Gwaunza and Kangai (2015), for an institution to be awarded Associate status, the University of Zimbabwe’s Senate must be satisfied that: (i) the institution’s articles or statutes that govern it are acceptable and the functions and roles of the institution’s Governing Board, Head or Principal, Academic Board are clearly defined, (ii) possession of a minimum academic qualification as an entry qualification by candidates prior to their registration for a particular course which they intend to study that will result in a University award, (iii) the schemes and syllabuses that are used at the institution that intends to submit the candidates have designs that are done according to the broad principles and rules the University of Zimbabwe suggests. The schemes and syllabuses are subject to the approval of the University of Zimbabwe’s Senate and should have content that is appropriate with adequate and sufficient allocation in terms of time, (iv) the course being studied must have a stipulated period of academic years, semesters or terms and (v) the teaching staff must be competent to teach at the specific award level and have relevant qualifications. The numbers of teaching staff must be adequate.

4.7. POPULATION AND SAMPLING

A research population is a collection of individuals who are well defined and have characteristics that are similar and of interest to the research (Kumar, 2011). As the population in this context was pre-service science teachers, purposive sampling was used. Mason (2002), is a set of procedures in a research process in which there is manipulation of data generation, theory, sampling activities and analysis interactively by the researcher. A homogenous sampling strategy was employed as purposive sampling in this study. Homogenous sampling is where individuals are purposefully sampled based on defining characteristics of subgroup membership, states Creswell (2012). The first year post ordinary level pre-service science teachers’ group was the homogenous sample. This is because they had the desired characteristics of finding Chemistry challenging and, had a negative perception and attitude towards Chemistry.

Attitudes are expressed as affective responses (moods, feelings, emotions), cognitive responses (ideas, beliefs, thoughts) and behavioural responses (verbal and non-verbal/overt) towards the attitude object (Jain, 2014). Pre-service teachers expressed their negative attitude by being pessimistic, fearful, and disliking, as well as having unfavourable thoughts and beliefs towards Chemistry as a subject. They thought it was a difficult subject while being unexposed to tertiary level Chemistry and have a full three years to complete college studies. The Theory of Reasoned Action (TRA) shows that an individuals' beliefs or thoughts influences his/her attitudes whilst his/her intentions to act are influenced by his/her attitudes (Fishbein and Ajzen, 1975). Since an individuals' thoughts influences the attitude of an individual, what the individual is thinking will be expressed through affective, behavioural and cognitive components all of which are observable. The pre-service science teachers were 29 in total and their demographic data is shown in appendix 10.

4.8. DATA COLLECTION AND INSTRUMENTATION

Data collection was performed through multiple sources to capture the entirety and complexity of the case which were being studied (Yazan, 2015).

Focus group interviews, observations and document analysis were employed in this research.

4.8.1. Focus group interviews

A focus group interview is when data is collected from a group of individuals. Focus group interviews can be used togather an understanding of a phenomenon that is shared by a group of subjects as well as views from particular individual subjects (Creswell, 2012). The advantage of focus group interviews is that the respondents' interaction produces information that is current and relevant if respondents have the same characteristics and are cooperative amongst themselves. The other advantage is that they are useful if the time for collecting information is limited and respondents are hesitant in terms of information provision. Focus groups interviews provided the experiences, attitudes and perceptions of the pre-service science teachers on the cultural indigenous Chemistry knowledge in relation to Chemistry metacognition.

Kothari (2004), points out that focus group interviews provide information of great depth as well as more information with respect to respondents such as pre-service science teachers on cultural indigenous Chemistry knowledge. However, the interviewers' presence at the scene might affect the validity of the responses as respondents might give subjective information (Hawthorne effect). The pre-service science teachers were in five focus groups that ranged from five to seven members each and the interview was conducted once with each focus group to ascertain the indigenous Chemistry knowledge. These focus group interviews were conducted orally during pre-service science teachers' lecture time using semi-structured questions on indigenous Chemistry knowledge, skills and attitudes. The semi-structured questions were for assessing metacognition proficiency. They were also used to identify the indigenous Chemistry knowledge, skills and attitudes held by the pre-service science teachers. An interview schedule was prepared. The questions and responses were videotaped and interview notes taken during focus group interviews as backup for the video-tape.

4.8.2. Observations

The researcher took up the role of a participant observer in the study. Creswell (2012) defines a participant observer as a researcher who takes part in the research activities which the researcher is observing. Field notes were taken by the participant observer whilst taking part in the lecturing and marking activities of the research in the selected topics of equilibrium, chemical thermodynamics and chemical kinetics. Observation of pre-service science teachers eliminated subjective bias as it was done properly and no willingness on the part of pre-service science teachers was required in terms of obtaining certain information about them. According to Mason (2002), observations provide current information that is occurring at the time, such as the cultural indigenous Chemistry knowledge possessed by the pre-service science teacher.

The observations focused on the application of indigenous Chemistry knowledge as the prior knowledge in the topics: atomic structure, redox reactions, stoichiometry, periodic table and periodicity as well as practical assessments by the pre-service science teachers. The teaching methodologies that were used in in the Chemistry lectures were presentations by pre-service science teachers, discussions, lecture method and demonstrations (modelling) by the lecturer. These observations were conducted in 12 chemistry lectures over eight weeks. However, observations gave limited information with respect attitudes towards cultural indigenous Chemistry knowledge of pre-service science teachers. Observation of pre-service science teachers' practice and application of indigenous Chemistry knowledge, skills and attitudes were done in the Chemistry lectures, presentations and practical assessments.

4.8.3. Document analysis

Use of document analysis allowed the researcher access to information which pre-service science teachers might not have wanted to talk about in regards to indigenous Chemistry knowledge, skills and attitudes. Document analysis gives natural data from the respondents as it eliminates the Hawthorne effect, making document analysis more stable, asserts Bowen (2009). More information on pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes was provided by document analysis as documents can be more detailed. However, pre-service science teachers' documents were not made or done for research purposes, therefore, they might not have provided information which would effectively answer the research questions of the study. Document analysis of pre-service science teachers were Chemistry assignments, tests and practical assessment write-ups. They were analysed for indigenous Chemistry knowledge, skills and attitudes during marking and presentations.

4.9. DATA COLLECTION PROCEDURE

Focus group interviews, observations and document analysis were used to collect data on pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes. Focus group interviews were conducted with pre-service science teachers in the Chemistry laboratory at the teachers' college during Chemistry lecture times. In stage one, the sub-components of knowledge of cognition and regulation of cognition, which themselves are components of metacognition, were focused upon in the focus group interviews. These gave the metacognition knowledge and skills held by pre-service teachers before the intervention These were declarative knowledge, procedural knowledge, conditional knowledge (knowledge of cognition) and planning, information management strategies, comprehension monitoring, debugging strategies and evaluation (regulation of cognition).

In stage two, focus group interviews were used for identifying the cultural indigenous Chemistry knowledge held and practised by pre-service science teachers. Stage three involved the use of collaboration, scaffolding and modelling in indigenous Chemistry knowledge metacognitive instruction and learning. In stage four, focus group interviews were used to assess and find out the extent to which pre-service science teachers have acquired Chemistry metacognition through cultural indigenous Chemistry knowledge. Observations were done with pre-service science teachers in the Chemistry laboratory at the teachers' college during Chemistry lecture times. Focus group interviews were used for identifying the cultural indigenous Chemistry knowledge held and practised by pre-service science teachers in stage two. The function of observations in stage four were to assess and find out the extent to which pre-service science teachers had acquired Chemistry metacognition through the use cultural indigenous Chemistry knowledge in the lectures

Document analysis was done using pre-service science teachers' written tests, assignments and practical write-ups at the teachers' college after marking the pieces of work. These written tests, assignments and practical write-ups were set, administered and marked by the research as the researcher was the pre-service science teachers' chemistry lecturer. Document analysis was used for identifying the cultural indigenous Chemistry knowledge held and practised by pre-service science teachers in stage two. In stage three, indigenous Chemistry knowledge metacognitive instruction and learning was done as the intervention stage by the researcher. For stage four, document analysis was used to assess and find out the extent to which pre-service science teachers have acquired Chemistry metacognition through cultural indigenous Chemistry knowledge. The pieces of work that focused on the topics of atomic structure, redox reactions, stoichiometry, periodic table and periodicity as well as practical assessments were analysed. This was done over a period of eight weeks for the written tests, assignments and practical write-ups as per the college minimum assessment requirements.

4.10. DATA ANALYSIS AND INTERPRETATION

Flick (2013) describes qualitative data analysis as a process whereby material that is visual or linguistic is classified and interpreted to produce statements that are explicit and implicit in dimensions as well as structures for making meaning from the material that it represents. This was done through the components of qualitative data analysis, which are data collection, data reduction, data display and conclusion drawing as well as verification (Miles, Huberman and Saldana, 2014). Data collection involved the use of focus group interviews, observations, document analysis and recordings to ascertain the indigenous Chemistry knowledge held by the pre-service science teachers.

Simplifying, selection, transforming, and focusing the collected indigenous Chemistry knowledge data were performed in data reduction. In data display, tables, graphs and pie charts were used as they were applicable to display the indigenous Chemistry knowledge. Confirmation, verification and giving meaning to the displayed indigenous Chemistry knowledge were done in conclusion drawing. However, the processes of data collection, data reduction, data display and conclusion in data analysis are not linear. This non-linear characteristic of data analysis is shown in the data analysis scheme in fig 4.2

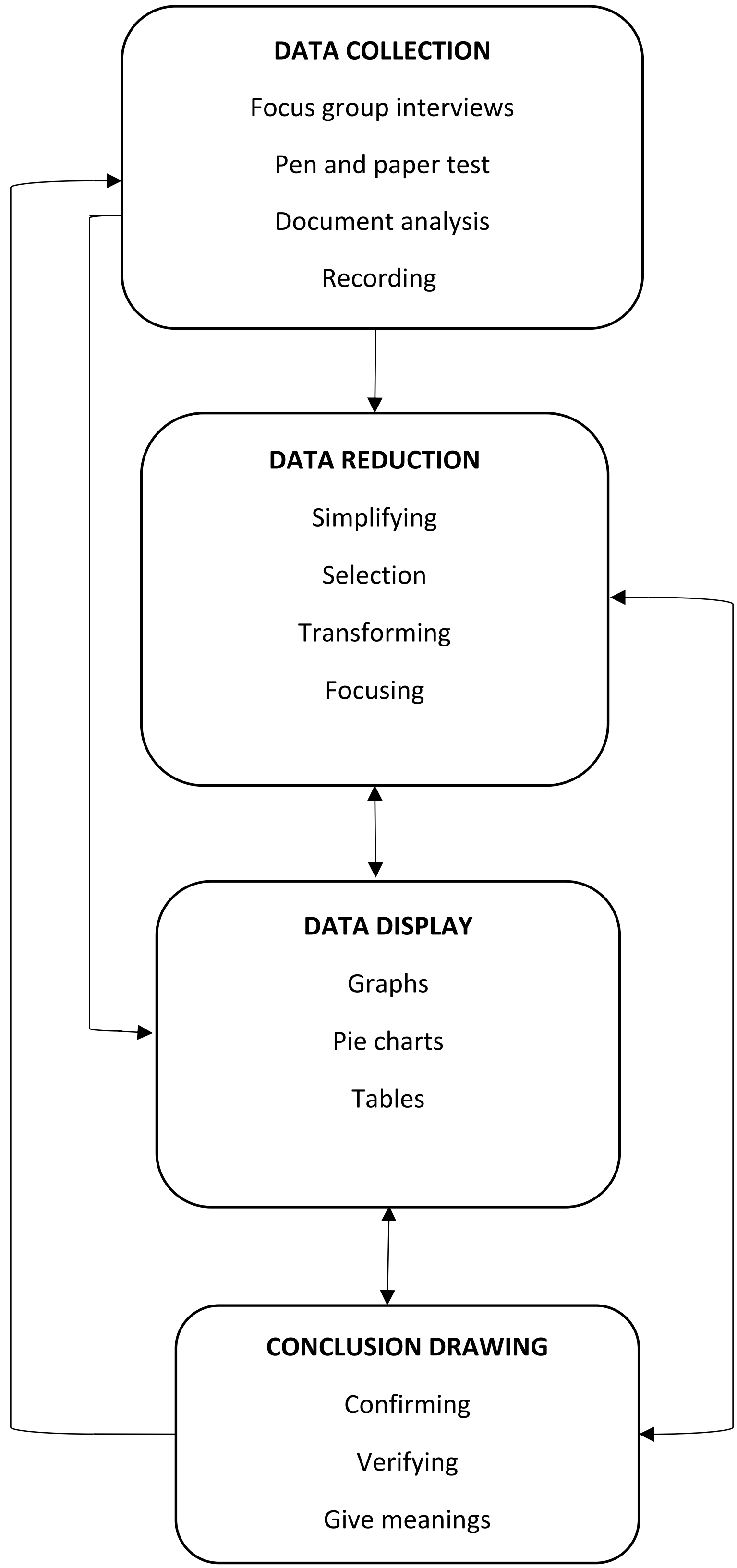

Figure 4.2: Data analysis scheme

The data collected on indigenous Chemistry knowledge held by pre-service science teachers was coded to give agriculture, environmental conservation, food processing, food preservation and health care major sub-categories. The sub-categories lead into emerging themes. The indigenous Chemistry knowledge themes were used in the intervention stage which was done by the reseacher. Scaffolding, modelling and collaboration were used for Chemistry metacognition instruction. A second metacognition proficiency assessment was conducted after the intervention stage to find out if there was a change from the first metacognition proficiency assessment.

4.11. RIGOUR

4.11.1 Trustworthiness

Trustworthiness refers to the extent to which the results of a given work of research are truthful, consistent over time (replicable) and applicable to settings that are similar. This study was made more trustworthy by utilising publicly accessible research methods. This was done through being transparent and methodic as well as by adhering to evidence on the influence of pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes on Chemistry metacognition. According to Yin (2011), trustworthiness can be built through transparency, being methodic and adherence to evidence.

Transparency in this study was achieved through research procedures that were well described and well documented for scrutiny which led to criticism, refinement and support. The findings are supported by evidence. A methodic approach was attained through orderly research procedures that reduced whimsical work but left room for unseen events as well as discovery. Deliberate distortion or unexplained bias was avoided through clear research procedures and data cross-checking. Adherence to evidence was achieved by having the findings and conclusions of the study based on evident data.

4.11.2 Transferability

Transferability refers to the extent of transferability or generalisation of the findings of a qualitative research to other settings or contexts asserts Korstjens and Moser (2018). In this study transferability was achieved through provision of a thick description of the influence of pre-service science teachers' indigenous Chemistry knowledge, skills and attitude on Chemistry metacognition in context, making the behaviour and experiences meaningful to the reader who may be an outsider. The purposeful selection of the first-year pre-service science teachers enhanced transferability of the study as they had the required characteristics that were in line with the study's' limitations and research design.

4.11.3 Credibility

Credibility is the confidence placed in the truthfulness of a qualitative research works' results (Given, 2008). It ascertains whether the study's results agree with respondents' original data and that the respondents' original views were interpreted correctly. Credibility was achieved in this study through prolonged engagement with pre-service science teachers during focus group interviews, observations and lecture time to familiarize with the context and settings, misinformation testing, gaining trust and gaining knowledge on data to ascertain the richness of the data.

4.11.4 Confirmability

Confirmability is the extent to which the outcomes of a study can be shown to be true or correct by different researchers other than the original researcher asserts Given (2008). Confirmability according to Given (2008), accurately verifies if the phenomenon under study was understood from the respondents' perspectives. It also verifies the meanings given to the experiences by the respondents. Confirmability in this study was achieved by clearly describing all stages of the research on the pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes influence on Chemistry metacognition such as data collection, data analysis and having examples of the coding processes in the final document.

4.11.5 Dependability

Dependability is the extent to which a research study can be repeated by a different researcher and the research findings will remain consistent over time, suggests Given (2008). In this study, dependability was achieved through the utilisation of an audit trail that is a detailed and extensive record of all the procedures involved in the determination of the influence of pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes on Chemistry metacognition.

4.11.6 Validity

Validity refers to conclusions of a research study which will be arrived at by using data that is collected and interpreted properly and which accurately reflects and represents the actual world environment that was researched, opines Yin (2011).

Validity of this research study was achieved through an involvement with pre-service science teachers that is long-term and intensive to increase chances of repeating focus group interviews and observations to get an understanding that is deeper and more complete. Receiving pre-service science teachers' feedback to minimize misinterpretations of their views and behaviours which they reported was also important for validity. Identifying negative cases and discrepant evidence of pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes was to test for competing or rival information.

4.11.7 Pilot study

A pilot study is a small-scale feasibility assessment of research done to determine potential problems with respect to sample, research procedures, data collection, data analysis and instruments before the full-scale research is done (Given, 2008). A pilot study was done with pre-service primary school teachers majoring in science from a teachers' college on the other side of town before the full research was conducted with the pre-service science teachers. The pilot study was done to assist the researcher to: (i) develop observing, focus group interviewing and document analysis skills, (ii) develop questioning or wording techniques which give rich data, and (iii) develop clear data collection, data analysis procedures and identify the type and number of documents required which provided chances of examining alternatives and possible adjustments in the research study.

The researcher was surprised at the support he received from the pilot study teachers' college administration, but however hostile treatment was garnered from the science department. The researcher had been referred to the science department by the college's administration. Initially the science department had given the researcher a maximum of twenty-five (25) minutes to conduct the pilot study. The researcher was also told by the science department that the pre-service science teachers had no free periods on their college timetable to participate in the pilot study which became a limitation at that time.

When the researcher suggested to the science department that the pilot study could be done after hours, the researcher was told that this would not be possible. The issue was that most of the pre-service science teachers were non-resident at college. The non-residents leave immediately after lectures at the end of the day as public transport was expensive and problematic due to the unfavourable economic conditions of the country. It was on the third day of the researcher coming to see the science department of the pilot study teachers' college that more time was given. The researcher was given 3 hours for piloting the research instruments and then asked to leave afterwards as piloting the study was disturbing them.

In the full-scale study, these challenges were overcome by making use of the pre-service science teachers' free periods; (i) in the college timetable, and (ii) created by their lecturer's official examination invigilation timetables and teaching practice observation timetables. This was made possible by the researcher diligently checking the pre-service science teachers' free periods in the timetable and their lecturers' invigilation and final year teaching practice schedules. These timetabled free periods and other free periods were created by their lecturers' absence due to extra official duties at the teachers' college.

These official duties were examination invigilation and final teaching practice assessment. These extra duties of the lecturing staff take them away from their normal official timetabled pre-service science teachers lecturing time. This creates a lot of extra free periods for the pre-service science teachers as they are left unattended by the lecturers. The college administration was very happy to have the pre-service science teachers meaningfully occupied by the researcher conducting the focus group interviews as well as the paper and pen tests.

The pilot study focus group interviews for metacognition awareness and indigenous Chemistry knowledge were conducted. The pilot study for metacognition awareness paper and pen test was also done in the Chemistry laboratory. The time taken to conduct the two focus group interviews and paper and pen test one after the other was 1 hour 48 minutes which is not too dissimilar from respondents' 1 hour 30 minutes long lectures. This meant that respondents were under an environment similar to their lectures during the pilot study. The piloting of these instruments revealed some weaknesses in the design of the instruments as well as in the procedures whilst using them. The researcher had intended to use a voice recorder but due its unavailability had to resort to interview note-taking and video recording using the webcam of a laptop.

The focus group instruments had the challenge of having to read the questions from the instrument and take notes down on a note pad that is separate from the instrument. Note-taking was a challenge as the respondents' rate of speaking was higher than the rate of note-taking by the researcher. According to Creswell (2012), as too much will be happening during focus group interviews, note-taking becomes difficult. Also, it was difficult to concentrate and keep eye contact simultaneously with the respondents between asking questions and note-taking. Dawson (2002) points out that eye contact cannot be maintained all the time during note-taking in focus group interviews.

The challenge with the webcam of the laptop was that it could only record the video and voices of respondents who were near the laptop and in the webcam's view. The researcher overcame these challenges in the actual research by slowly asking questions, repeating the questions and writing the responses verbatim on the focus group instruments to give verisimilitude. The use of the webcam of the laptop for audio and video recording was improved by arranging respondents around and closer to the laptop. The pilot study showed that the use of the research instruments with minor adjustments was feasible for the full-scale study.

4.11.8 Triangulation

Triangulation is the use of three or more sources of data that are of different kinds, suggests Walliman (2011). In this study focus group interviews, observation and document analysis were used to determine pre-service science teachers' indigenous Chemistry knowledge, skills and attitudes influence on Chemistry metacognition. This triangulation improved the research's data completeness and validity.

4.11.9 Member checking

Member checking refers to the chance given to research participants to approve by checking certain interpretations of the information they provided in the research, asserts Carlson (2010). Pre-service science teachers were given the research transcripts from focus group interviews, observations and document analysis so as to clarify, delete, edit and elaborate on their narratives. Member checking increased the validity of this research's findings.

4.11.10 Verisimilitude

Verisimilitude refers to thick, detailed, narrative writing of a qualitative research work that induces feelings or experiences that were felt by the respondents in the real world of the respondents through reading, suggests Creswell (2007). Verisimilitude makes the reader of the qualitative research understand the respondents' emotions felt and decisions made in the study by the respondents (Loh, 2013). Pre-service science teachers' indigenous Chemistry knowledge, skills and attitude influences on Chemistry metacognition was written in a thick description that is contextual, detailed and emotional which induces feelings and experiences that feel like the real and actual live experiences of the pre-service science teachers in the study

4.12. RESEARCH ETHICS

There are ethical principles issues to be considered in scientific research such as voluntary participation, harmlessness, informed consent, anonymity and confidentiality, opines Bhattacherjee (2012). The researcher ensured that respondents participated voluntarily and were free to withdraw without any consequences. It was also ensured that respondents were free from harm through participation or non-participation in the study. The respondents received informed consent forms which they signed. Confidentiality and anonymity of respondents' identities was ensured by not using the real names of respondents as well as the institution where the pre-service science teachers are from. Information about the research was disclosed to respondents before collection of data which assisted them in deciding whether to take part in the research. Negative and unexpected research findings were fully disclosed.

4.13. SUMMARY

This chapter looked at the qualitative approach, descriptive case study, interpretive paradigm, research context, the population and sampling procedure of this study. The research instruments, rigour and finally research ethics were also discussed in this chapter. The next chapter focuses on the study's results and discussion.

CHAPTER 5
RESULTS AND DISCUSSION

5.1. INTRODUCTION

There has been an increase in interest of late on the impact of metacognition on academic achievement in science subjects that are perceived as difficult in terms of teaching and learning, as was discussed earlier in this thesis. Specifically, there is need for research that focuses on the learners' cultural and social background in relation to metacognitive processes. Vygotsky (1978) points out that there is a relationship between metacognitive processes and learners' culture. Indigenous knowledge, skills and attitudes are part of a learners' culture. The learners' prior knowledge (indigenous knowledge) which comes from the cultural and social background of the learner is crucial in concept development during teaching and learning.

This chapter presents the results and discussion on the influence of indigenous knowledge on Chemistry metacognition. First to be presented is the data on the indigenous Chemistry knowledge held by the respondents. The data was analysed using constant comparison analysis to identify the indigenous Chemistry knowledge of the pre-service science that was used in the intervention stage of the research. Second to be presented and analysed is data on: the respondent's metacognitive awareness before intervention, the intervention stage/ process and after intervention. The academic performance of the pre-service science teachers before and after the intervention is through the results of assignments and test scores. (document analysis). An outline of the main research question and the sub-questions that are investigated in this thesis is given in table 5.1.

Table 5.1: Main research question and sub-questions.

Main research question How does indigenous Chemistry knowledge influence Chemistry metacognition?
Sub-questions 1. How much indigenous Chemistry knowledge is possessed by pre-service science teachers? 2. How relevant is indigenous Chemistry knowledge to Chemistry metacognition? 3. How effective is indigenous Chemistry knowledge in Chemistry metacognition? 4. What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition?

To ascertain the indigenous knowledge, skills and attitudes possessed by pre-service science teachers, five focus groups in groups ranging from five to seven respondents were conducted. This was done as the pre-service science teachers were continually being enrolled as few of them had taken up the vacancies.

5.2. RESULTS FOR RESEARCH SUB-QUESTION ONE: 1. How much indigenous Chemistry knowledge is possessed by pre-service science teachers?

To identify the indigenous Chemistry knowledge possessed by pre-service teachers, each focus group question was looked at with corresponding responses from the five focus groups.

5.2.1. The meaning of indigenous, knowledge, skills and attitude.

Pre-service science teachers defined indigenous as local, traditional, home grown things, content and knowledge which belong to a certain place or people. Knowledge was defined as information, ideas or understanding of something that is acquired or passed on to an individual. Pre-service science teachers described a skill as an ability, expertise and knowledge an individual has to do something better or executing an action professionally. Attitude was explained as the way a person acts, views, responds, reacts, feels, behaves or thinks about or towards something that can be positive (good) or negative (bad) by the pre-service science teachers. The meanings of indigenous, knowledge, skills and attitudes according to pre-service science teachers shown in table 5.2

Table 5.2: Meanings of indigenous, knowledge, skills and attitudes.

Indigenous PST22: 'Something that is peculiar to a certain place or people.'
Knowledge PST23: 'Information that one has.' PST26: 'Experience of something.'
Skills PST12: 'Ability to do something.'
Attitudes. PST14: 'How you mentally look towards a task or something.'

Knowledge, skills and attitudes, according to pre-service science teachers, are attained through socialization which includes learning, practical experiences, reading, imitation, rehearsals, interaction with the environment as well as problem-solving (trial and error) amongst others. Pre-service science teachers were also in agreement that knowledge, skills and attitudes are dependent on the locality, place, culture or society as well as being unique to a locality, culture and society. The descriptions of the meanings of the words indigenous, knowledge, skill and attitude by pre-service science teachers implies that they understood or correctly interpreted their meaning before and during the study. They also showed that they knew how knowledge, skills and attitudes are acquired and that they are determined by the society or location concerned.

5.2.2. Agriculture, environmental conservation, food processing, food preservation and health care Indigenous knowledge

Pre-service science teachers exhibited that they are a repository for indigenous Chemistry knowledge and skills. Indigenous Chemistry knowledge and skills possessed by pre-service science teachers cover most survival areas in their lives. Extensive use and effectiveness of indigenous Chemistry knowledge and skills were found in agriculture, environmental conservation, food processing, food preservation and health care. Agriculture indigenous knowledge, skills and attitudes are shown in table 5.3

Table 5.3: Agriculture indigenous knowledge and skills.

Agriculture indigenous knowledge and skills practiced by pre-service science teachers' communities of origin
Use of manure as a fertiliser. Use of ashes as a pest control such as maize stalk borer. Ploughing using cattle. Rearing animals (cattle, sheep, goats, pigs). Crop rotation, paddocking. Nhimbe - other villagers assist in ploughing, planting, cultivation and harvesting. Cultivation using hoes. Mixed farm planting-a variety of crops in the same field. Milking of cattle. Hand picking of locusts. Ox drawn ploughs. Crops, chicken and cattle rearing. Removing weeds using cultivation. Land preparation - cutting down trees. Hunting using catapults and dogs. Using cattle for ploughing. Use ashes to remove aphids from vegetables. *Use of chickens to get rid of locusts (predator method) without harming the plants. Use of ashes as fertiliser. Weeding and ploughing. Growing sorghum and millet. Planting seeds from the previous produce. Organic agriculture. Use aloe vera to control pests on livestock. Subsistence farming. Keeping road runners for commercial use. Fishing using hooks and nets. Farming vegetables, harvesting, hunting wild animals for meat, gathering fruits and edible roots. Planting sorghum or millet. Using plant litter to make compost (recycling). Mulching. Cross breeding. How to plant sweet potatoes. Herding cattle. Fishing using nets, traps, fishing rods and herbs used to kill fish.*

Most of the indigenous agriculture involves some Chemistry concepts such as urea in manure and ashes used as fertilisers, use of ashes' pH for pest control, chemical to kinetic energy, in ox-drawn ploughs, light energy to chemical energy in rearing animals, proteins and calcium in milk during milking and carbohydrates in maize, sorghum, millet and rapoko. Indigenous environmental conservation knowledge, skills and attitudes are an area of specialisation that is held by pre-service science teachers. Most indigenous people in Zimbabwe have totems that are derived from animals and parts of animals. One is told from childhood not to eat an animal which denotes your totem. This attitude that is well engraved in the minds of most Zimbabweans leads to animal conservation.

Also, community chiefs and headman in Zimbabwe are the protectors of the environment as one has ask for permission to cut down trees from them. Most of the pre-service teachers' environmental conservation majored mainly on soil, tree, plant nutrients and animal conservation. These areas are important when environmental Chemistry is being taught in western Chemistry knowledge and skills. The indigenous environmental conservation knowledge and skills practised by pre-service science teachers' communities of origin are shown in table 5.4.

Table 5.4: Indigenous environmental conservation knowledge and skills

Indigenous environmental conservation knowledge and skills practiced by pre-service science teachers' communities of origin
Creating ridges to prevent soil erosion. Planting trees to avoid de-forestation. Crop rotation as different plants use different minerals. Cow dung used as floor polish. Ploughing before rain season to preserve nutrients. Headman prevents villagers from cutting down trees. Tree planting-prevents soil erosion. Fire guards. Plant trees (indigenous). Do not cut trees that are in your homestead (Mukusu) or immediately after the homestead. Afforestation- growing trees were they never existed before. Not eating an animal with the name similar to your totem (For example Mpofu would not eat an eland). Application of rocks on gullies, contour ridges to prevent soil erosion. Use of sticks to prevent gully formation. Use of contour ridges and filling up gullies with sticks.

Quite a variety of indigenous food processing knowledge, and skills are practised by pre-service science teachers. The indigenous food processing knowledge and skills are important as they save food in terms nutritional value and quantity (mass) as they are not lost as quickly. The importance of the indigenous food processing knowledge and skills, besides preserving nutritional value and mass, is ensuring that the food does not become poisonous. The indigenous food processing knowledge and skills that are practised by pre-service science teachers' communities of origin are indicated in table 5.5.

Table 5.5: Indigenous food processing knowledge and skills.

Indigenous food processing knowledge and skills practiced by pre-service science teachers' communities of origin
Boiling and drying, salting. Boiling of milk. Drying vegetables/ meat and drying sweet reeds. Grinding grain using a mortar and pestle. Pounding grain to make mealie meal. Drying mealies. Smoking (meat), Caterpillar (mopani worms) preparation - remove insides, boil, salt and dry. Meat salting. Dehydration of food. Sweet potatoes - pfimbi - kept in a hole and covered with ashes. Use of ashes (soda) to cook okra. Fermenting marula fruit. Maize cooked, dried and put in kitchen so that it is smoked. Making (grinding) peanut butter using a mortar and pestle. Production of peanut butter using stones (mortar and pestle). Brewing of beer and wine. *Making soap. Drying vegetables (ulude). Making biltong. Processing(fermenting) milk into sour milk. Cooking (Idelele) okra. Preparing amangqina (cow hooves). Preparing porridge (nhopi) from pumpkin / melon. Dried meat (biltong). Milking and keeping the milk fresh. Umxhanxa(food)-mixture of melon and dried mealies. Umcaba - amasi mixed with amabele. Salting food (meat, fish). Brewing. Mahewu (indigenous non- alcoholic drink). Winnowing. Brewing tototo, thothotho (an illicit alcoholic brew through fermentation and distilling). Chimodo (homemade bread from wheat and maize-meal). Cooking sadza (thick maize meal). Wine preparation (tototo, marula, opaque beer). Chimodo - home bread - wheat, mealie - meal.*

Preservation of food for later use ensures food security for humans as well as animals for sustenance. Indigenous food preservation knowledge and skills also ensure that food maintains its nutritional value as well as being fit for human consumption. A lot of Chemistry processes are involved in indigenous food preservation knowledge and skills. There is the cooling due to evaporation that occurs when keeping meat fresh in a moist sack. Salting, drying and smoking meat in the kitchen involves dehydration, evaporation and chemical treatment to dry (kill bacteria) and repel insects (flies that lay maggots). Fermentation is involved in converting marula juice to wine and fresh milk to sour milk. The indigenous food preservation knowledge and skills practised by pre-service science teachers' communities of origin are shown in table 5.6.

Table 5.6: Indigenous food preservation knowledge and skills.

Indigenous food preservation knowledge and skills practiced by pre-service science teachers' communities of origin
Place meat in a bowl/tin and place in a sack that is moist. Smoking. Boiling and salting. Boiling. Clay pot placed in sand and water poured to preserve food. Fermenting marula fruit to make wine and fresh milk to sour milk. Maize cooked, dried and put in kitchen so that it is smoked. Smoking meat, drying vegetables and meat. Placing food in a hole in the ground to keep it fresh and cover with soil. Drying and smoking. Sweet reeds are dried; they are sweeter than wet/fresh ones. Building traditional silos. Drying grain, store in silos. Vegetable – preservation - cut it up and dry. Preservation of food by drying (mfushwa - dried vegetables).

The physiological and psychological states of human beings require the use of medicines at some point in periods of ill health. Medicines are based on Chemistry hence the name chemist when referring to pharmacies which deal in medicines to improve peoples' wellness. Indigenous health care knowledge and skills in health care are based on herbs that are usually taken in different forms such as powders and solutions. These are used to treat a variety of illnesses that afflict society. Some of the indigenous health care knowledge and skills practiced by communities that pre-service science teachers originate from are shown in table 5.7.

Table 5.7: Indigenous health care knowledge and skills.

Indigenous health care knowledge and skills practiced by pre-service science' communities of origin
When a cow udder is not releasing milk for the calf, herbs and a chicken feather are used to make the cow udder release milk as the chicken feather is inserted into the cow udder overnight after applying the herbs. Intolwane - Herb for treating excess acid and wind in the stomach. Traditional healers-herbs, isihaqa treats stomach acids. Isihaqa - herb used for treating excess bile. Marula bark-strengthening bone. Guchu-mixture of herbs (msasa, murumanyama) treats sextual infections. Marula bark - used by women who recently gave birth to treat loose vagina so as to tighten the vagina. Use of black jack to treat stomach pains. *For a cough - boil thetshane and drink. Stomach problems – drink aloe vera. Use a hot iron rod on the eye of a cow for a sight problem. Drink unshashanyama / isihaqa for stomach pains or running stomach. Marula/ Nyama bark/charcoal- used to treat running stomach. Using honey to prevent asthma attacks. Use of ashes to heal wounds. Use of marula bark to relieve constipation. Treat infertility in humans using mupapama. Herbs – isihlalutho- used to treat tooth ache, isihaqa-treating stomachache, enhance sexual performance, intolwane - treats stomach as well as excess air or gas in the stomach. Bark of marula tree cures stomach acids. Use of natural herbs-coughs, stomach acids, headaches. Herbs for nose bleeding. Grinding using a mortar and pestle. Survival skills – when you get injured you know which herbs to go for.*

5.2.3. Other indigenous Chemistry knowledge of pre-service science teachers

Besides major areas of agriculture, environmental conservation, food processing, food preservation and health care, pre-service science teachers also have other indigenous Chemistry knowledge in a few areas. Table 5.8.

Table 5.8: Other Indigenous Chemistry knowledge and skills

Indigenous Chemistry knowledge
Brick moulding. Baking. Water harvesting. Sawing. Hunting. Soso - a plant used for shampooing hair. How to preserve the body of the deceased? Rekindle fire through blowing using the mouth. Salt - brushing the teeth. Cow dung – as floor polish. Basket weaving using reeds. Carpentry. Matowe - African chewing gum. Roofing and thatching huts. Pottery. Traditional dyes (for painting clothing materials and other objects).

These indigenous Chemistry knowledges are part of the pre-service teachers' rich Chemistry prior knowledge that comes from their interaction with individuals and the environment. This makes pre-service teachers' Chemistry prior knowledge a product of culture and thus a social construction.

5.3. **RESULTS FOR RESEARCH SUB-QUESTION TWO:** How relevant is indigenous Chemistry knowledge to Chemistry metacognition?

The relevance of indigenous Chemistry knowledge to Chemistry metacognition came from the indigenous Chemistry knowledge focus groups.

5.3.1. Indigenous knowledge and skills that use Chemistry ideas / concepts.

Indigenous knowledge that uses Chemistry ideas or concepts that are known by pre-service science teachers is quite vast. Table 5.9 shows indigenous knowledge and skills that the pre-service science teachers gave as using some Chemistry ideas/ concepts.

Table 5.9: Indigenous knowledge and skills that use Chemistry ideas or concepts.

Indigenous knowledge and skills that use Chemistry ideas/concepts.
Use of ashes to heal wounds. Salting meat. Maize - grind using a mortar and pestle. Animal skins -clothing leather. Pumpkin seeds – processed into cooking oil (roasting, grinding, squeezing of the pumpkin seeds). Cooking sadza. Traditional medicine(herbs). Salting fish- dehydration and pH. Drying of vegetables (irradiation and evaporation). Sour milk production. Boiling water. Mango leaves plus honey and boiling and consuming the syrup (flu and colds). Applying table salt to wounds to stop bleeding. Smoking meat- no flies to the meat after smoking. Salting and drying meat. Sour milk- fresh milk placed in closed contain. Drying meat. Ashes used to kill pests. Fire making- exposure to oxygen to promote combustion. Brewing traditional beer or drink (Mahewu). Ashes as fertiliser. Cow dung fertiliser- too high a dosage kills plants. Boiling - denaturing of cells and enzymes. Application of ashes in fields (neutralisation). Cooking. Fermentation of sour porridge. Mahewu. Harvesting honey from a beehive. *Salting meat. Tototo (illicit brew) brewing - fermentation and fractional distillation, raw material in tototo brewing using rotten sadza/food and rotten fruits. Cooking sadza- endothermic and exothermic reactions. Smoking food - chemical treatment. Fire exothermic and oxidation/reduction reactions. Agriculture - smoking farm produce in the kitchen hut (chemical treatment). Making use of the acidity of intolwane to treat the stomach, using ashes solution (basic/ alkaline properties) in cooking okra instead of soda. Applying wooden ashes to neutralise acidity in soils for farming, applying ashes to vegetables to control aphids, using ashes to treat agricultural produce and to kill chicken mites. Application of animal manure to fields in order to obtain ammonium nitrate. Use of ashes for pest control. Bathing hands using ashes kills bacteria. Ashes removes dirt.*

These Chemistry ideas/concepts are the same ideas/concepts which are found in the western Chemistry knowledge. Indigenous Chemistry knowledge is the Chemistry prior knowledge for western Chemistry knowledge. Metacognition relies heavily on subject prior knowledge for it be learned well (Vygotsky,1978).

5.3.2. Benefits of indigenous Chemistry knowledge and skills.

The continuous use of indigenous Chemistry knowledge and skills suggests that different cultures or communities place a lot of value on them as they are beneficial. Pre-service science teachers gave some benefits associated with indigenous Chemistry knowledge and skills from their experiences in their daily lives. Table 5.10 gives a list of beneficial characteristics of indigenous Chemistry knowledge and skills as given by pre-service science teachers.

Table 5.10: Beneficial characteristics of indigenous Chemistry knowledge and skills

Beneficial characteristics of indigenous Chemistry knowledge and skills
Quite efficient but not 100%. User friendly. Easily accessible. Rarely has side effects. Readily available. Nature derived. Help in understanding Chemistry concepts. Use environmentally friendly methods. Learn as you go. Practised in everyday life. Indigenous medicines are more effective. One type of herb can be used to treat many diseases. No side effects. Environmentally friendly. Cheaper. Affordable. Passed from generation to generation (heritage). Economic. Safe. Always available. Original taste of some food stuffs not lost so much. Get money through selling processed fruits. Store of wealth. Eco-friendly. Most do not have side effects. Herbs have limited side effects. Convenient. Has been practiced for generations

As shown in table 5.10 by pre-service science teachers, indigenous Chemistry knowledge and skills have numerous beneficial characteristics in most aspects of life in general. However, it is their invaluable assistance in understanding Chemistry concepts which was also mentioned among other benefits in terms of Chemistry metacognition. The fact that they are passed from one generation to the next generation ensures continuity of chemistry prior knowledge which is a vital bridge between indigenous chemistry knowledge and western Chemistry knowledge. Pre-service science teachers were also in agreement that the indigenous Chemistry knowledge and skills are very efficient.

5.3.3. Usefulness and reliability of indigenous Chemistry knowledge and skills

Indigenous Chemistry knowledge and skills are seen as useful and reliable by pre-service science teachers to a larger extent. However, the pre-service science teachers identified the aspect of some of the indigenous Chemistry knowledge and skills as being seasonal that can pose challenges on reliability.

5.3.4. Experiences with indigenous Chemistry knowledge and skills.

The experiences of indigenous Chemistry knowledge and skills that have been had by most of the pre-service science teachers are positive. Having positive experiences with indigenous Chemistry knowledge and skills means the pre-service science teachers will less easily forget the acquired indigenous Chemistry knowledge and skills. They went on to say these indigenous Chemistry knowledge and skills are relatively easy to master, though it depends on the complexity of the indigenous Chemistry knowledge and skills to be mastered. This implies that most of pre-service science teachers have acquired some indigenous Chemistry knowledge, skills and attitudes from their everyday cultural experiences.

5.3.5. Common characteristics between indigenous Chemistry knowledge and skills with formal school/college Chemistry.

There are some common characteristics between indigenous Chemistry knowledge and western Chemistry knowledge that were identified by pre-service science teachers. Table 5.11 shows some common characteristics between indigenous Chemistry knowledge and western Chemistry knowledge themes that were identified by pre-service science teachers.

Table 5.11: Common characteristics between indigenous and western Chemistry.

Common characteristics between indigenous Chemistry knowledge and western Chemistry knowledge themes
Precautions. There are stages to be followed when executing. Cure. Processes are the same, for example beer brewing - fermentation and fractional distillation process. College Chemistry depends on indigenous Chemistry (based on), the practical part. Serve the same purpose - processes. College Chemistry is a modification of indigenous Chemistry knowledge. Time periods – set time for the processes. Practical application, practice, the concepts behind, putting theory into practice. Processes, they sometimes serve the same purposes such as healing. There are measurements that are done. Opaque beer fermentation. Yes, there is a relationship. Makes life easier. Indigenous knowledge used as assumed knowledge (indigenous Chemistry knowledge the known and college Chemistry the unknown). School / college – theory. Home-practical. College chemistry relates to indigenous Chemistry knowledge. They depend on nature. Indigenous Chemistry- application (practical) and college Chemistry (theoretical). *College Chemistry and improvement of indigenous Chemistry knowledge. College Chemistry is an advancement of indigenous Chemistry knowledge; indigenous Chemistry knowledge is the backbone of college Chemistry. Practical. Indigenous Chemistry knowledge is prior knowledge to the college Chemistry. Theory and practice with College chemistry being theoretical whilst indigenous Chemistry is practical or hands on. Similar process. Theoretical Chemistry (college) makes learners realise what is done at home is exactly the same. Similar concepts between the two, at times college brings about knowledge from other places (exotic) whilst indigenous Chemistry knowledge is local, relationship mutual but indigenous people won't be knowing that they are applying Chemistry. Share knowledge, serve the same purpose e.g. aloe vera – used as indigenous medicines also formal Chemistry uses it to make pills.*

Pre-service science teachers are aware that there is a relationship between indigenous Chemistry knowledge and formal Chemistry with the indigenous

Chemistry knowledge being the known and college Chemistry the unknown in teaching and learning. A number of common characteristics between indigenous Chemistry knowledge and western Chemistry knowledge were highlighted by the pre-service science teachers such as having the same processes and saving the same purposes. Pre-service science teachers again highlighted that college Chemistry (Western Chemistry knowledge) is based on indigenous Chemistry knowledge with college Chemistry being an improvement of indigenous Chemistry knowledge. Indigenous Chemistry knowledge is the prior knowledge for college Chemistry (Western Chemistry knowledge) in which indigenous Chemistry knowledge emphasises the practical aspect of Chemistry whilst college Chemistry focuses on the theoretical aspect of Chemistry.

5.4. RESULTS FOR RESEARCH SUB-QUESTION THREE: How effective is indigenous Chemistry knowledge in Chemistry metacognition?

In order to ascertain the metacognition awareness of pre-service science teachers before intervention, focus groups interviews were given first and then an individual metacognition awareness pen and paper test given afterwards. The Pearson product moment correlation was used to correlative the focus group interview with the pen and paper test metacognition awareness scores before intervention. Pearson product moment correlation was used because the data on metacognition awareness scores was continuous and had a normal distribution underlying(Jackson, 2009; Peers, 1996). This was for triangulation purposes of the metacognition awareness before intervention. One assignment and one test were given before the intervention. The intervention consisted of using indigenous Chemistry knowledge, skills and attitudes in the Chemistry lectures. The pre-service science teachers' college syllabus assessment requirements are that one assignment, one test and one practical must be done per term.

The metacognition awareness of the pre-service science teachers was ascertained after the intervention with the focus groups being done first and the pen and paper test being done second. Once again, the Pearson product moment correlation was used to correlate the focus group interview with the pen and paper test metacognition awareness scores after the intervention. This was also done for triangulation purposes. One assignment and two tests were given after the intervention in which the indigenous Chemistry knowledge and skills were used in the Chemistry lectures using scaffolding, modelling and collaboration. Also, two Chemistry practical activities were given after the intervention.

5.4.1. Comparison of focus group with pen and paper test metacognition awareness scores before intervention.

The focus group as well as the pen and paper metacognition awareness scores were the average scores for the focus groups and pen and paper test. A comparison of the focus group with pen and paper test metacognition awareness scores before intervention for the pre-service science teachers are shown in Figure 5.1.

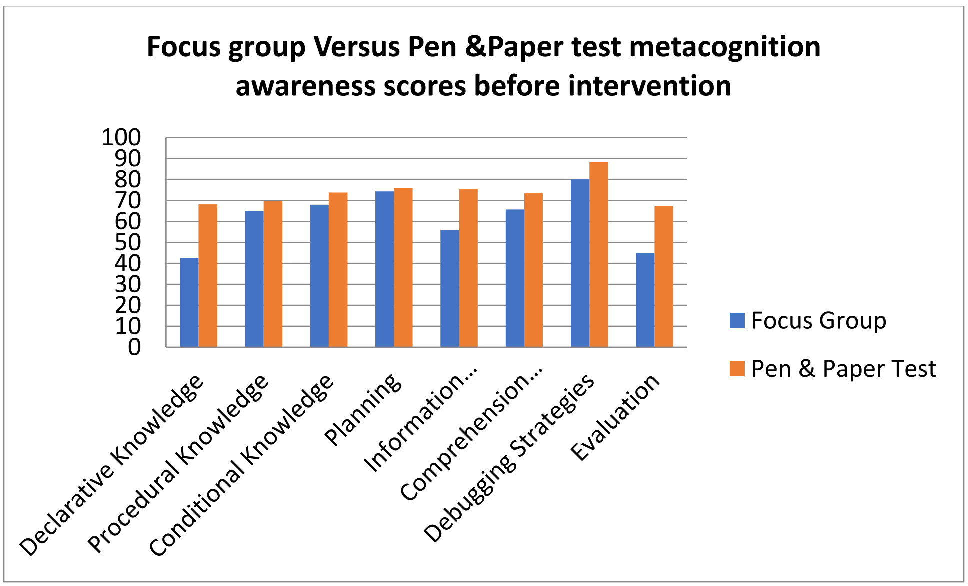

Figure 5.1: Comparison between focus group with pen & paper test

The pen and paper test metacognition awareness scores are higher than for focus group metacognition awareness score before the intervention. The Pearson product moment correlation was used to correlate the focus group metacognition awareness scores with those of the pen and paper test metacognition awareness scores before the indigenous Chemistry knowledge intervention. Pearson product moment correlation was used because the data on metacognition awareness scores was continuous and had a normal distribution underlying(Jackson, 2009; Peers, 1996). The correlation was found to be 0.79 which shows a strong positive correlation between the focus group metacognition awareness scores and pen and paper test metacognition awareness scores before intervention. Appendix 9 shows how 0.79 correlation coefficient was calculated. The variance of the focus group metacognitive awareness scores that is accounted for by the variance in the pen and paper test metacognition awareness scores is 62% before the intervention.

5.4.2. Metacognition awareness mean scores before intervention for focus group as well as for pen and paper test.

The mean scores for focus group metacognition awareness as well as for pen and paper test metacognition awareness before intervention are indicated in figure 5.2.

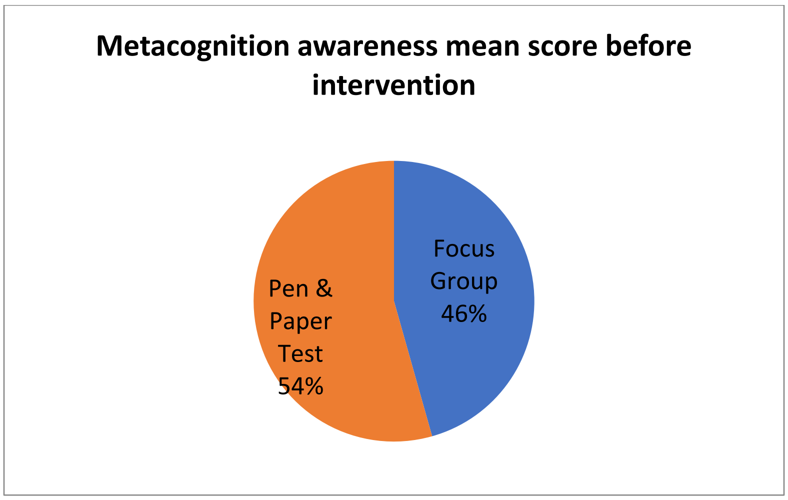

Figure 5.2: Pre-intervention test versus interview metacognition awareness

There is a slight difference in the mean scores implying a slight difference in metacognition awareness between focus group and pen and paper test before intervention. This indicates that the results of the focus group metacognition awareness are confirmed by the paper and pen metacognition awareness test in terms of triangulation.

5.4.3. Comparison of pre-service science teachers' Chemistry assignment one and Chemistry test one before intervention.

The performance of pre-service science teachers in Chemistry assignments and tests before intervention give vital information which give an indication of the effect of an intervention in terms of performance. Appendix 11 shows the academic raw marks of the pre-service science teachers. A line graph comparison of pre-service science teachers' performance in Chemistry assignment one and Chemistry test one before intervention is shown in figure 5.3.

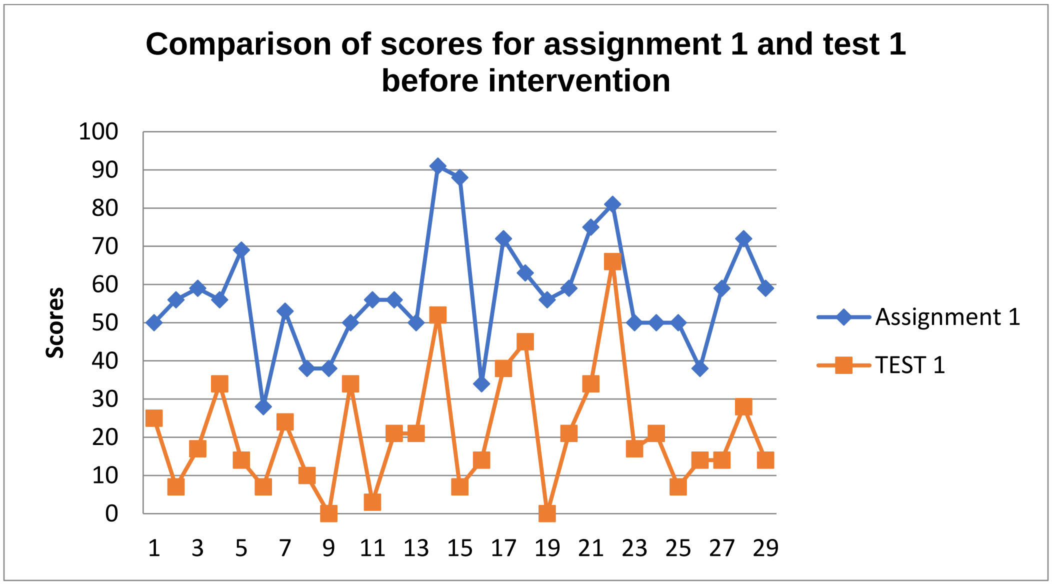

Figure 5.3: Comparison of Chemistry assignment one and Chemistry test one scores.

The line graph shows a positive correlation between the Chemistry assignment one scores before intervention and the Chemistry test one scores before intervention. Most pre-service science teachers who had high scores in the Chemistry assignment one before intervention also had high scores in the Chemistry test one before intervention. The line graph also shows that most of the pre-service science teachers who had lower marks in the Chemistry assignment one before intervention had lower marks in the Chemistry test one before the intervention. The Chemistry assignment one before the intervention was done well by most pre-service science teachers when compared to the Chemistry test one in which most pre-service science teachers performed badly before the intervention.

5.4.4. Correlation of pre-service science teachers' Chemistry assignment one and Chemistry test one before intervention.

The relationship between pre-service science teachers' performance in Chemistry assignment one before intervention and pre-service science teachers' performance in Chemistry test one before intervention can be shown by a scatterplot. Figure 5.4 shows the scatterplot for the relationship between pre-service science teachers’ performance in Chemistry assignment one and the pre-service science teachers’ performance in Chemistry test one before intervention.

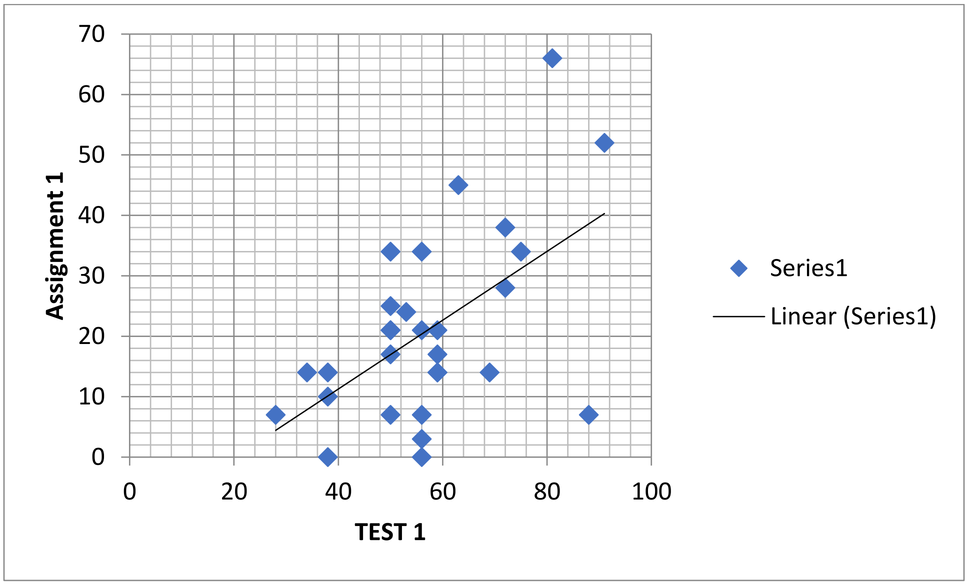

Figure 5.4: Correlation between assignment one and Chemistry test one scores.

The scatterplot shows that there is a strong positive correlation between the pre-service science teachers’ Chemistry assignment one scores before metacognition and the pre-service science teachers’ Chemistry test one scores before intervention.

5.4.5. Observations of application of indigenous Chemistry knowledge in lectures before intervention through participant observation.

Three lectures before the intervention, three intervention lectures in which metacognition instruction was done using indigenous Chemistry knowledge and four lectures after intervention were observed.

The atomic structure which involves the three sub-atomic particles (electron, proton and neutron) was done in this first lecture before intervention. No mention, explanation or application of indigenous Chemistry knowledge ideas or concepts was done by pre-service science teachers in this lecture on the atomic structure. Classical atomic models by Thompson and Rutherford were utilised in second lecture before intervention. In this lecture on the Thompson and Rutherford models before intervention, there was a medium standard in terms of application of indigenous Chemistry knowledge ideas or concepts. This was when PST17 likened the ‘’Plum Pudding’’ model to a positively charged pumpkin which has pumpkin seeds acting as the electrons. This is an indigenous Chemistry knowledge idea or concept was used to describe the ‘’Plum Pudding’’ model by PST17.

Rutherford’s α-scattering experiment was done in the third lecture before intervention. No mention, description or application of indigenous Chemistry knowledge was done by pre-service science teachers on the conclusions made from Rutherford’s α-scattering experiment. Indigenous Chemistry knowledge was not applied by the pre-service science teachers on Rutherford’s α-scattering experiment, resulting in a failure to explain the stability of an atom. No mention, description or application of indigenous Chemistry knowledge on the failure to explain the distribution of electrons and energies of the atom by Rutherford’s atomic model was attempted.

5.4.6. Observations of application of indigenous Chemistry knowledge in lectures during intervention through participant observation.

The first intervention lecture was on electromagnetic radiation. There was a high standard of the application of indigenous Chemistry knowledge ideas or concepts by pre-service science teachers in this lecture. The light, sound, heat and ultraviolet components that were identified by PST13, PST8, PST25, PST1 and PST22 are part of the indigenous Chemistry knowledge (prior knowledge) experiences of the pre-service science teachers. The identification of cooking, drying meat, providing warmth and working on iron by blacksmiths as the uses of heat by PST29, PST5 and PST17 arose from the pre-service science teachers’ indigenous knowledge ideas/concepts. The changing of the colour of iron from dull red to redder and then white hot as a result of more heat being added by a blacksmith was popular with some pre-service science teachers. This example of indigenous Chemistry prior knowledge was used in explaining blackbody radiation.

The second intervention lecture was on the particle nature of electromagnetic radiation. In this intervention lecture, there was a high standard of the application of indigenous Chemistry knowledge by pre-service science teachers. The heating effect, a straight stick appearing bent in water and mirages that were identified by PST5, PST2 and PST22 respectively are indigenous Chemistry knowledge examples that were applied in the lecture from the pre-service science teachers' prior knowledge. The indigenous Chemistry knowledge of absorption and later emission of heat by substances was the prior knowledge possessed by pre-service science teachers. PST8 identified clay pots, PST28 identified water, PST 21 identified brick and clay walls and PST17 identified metallic objects as some of the substances which absorb heat energy and emit it afterwards. The clay pots, water, brick wall, clay wall and metallic objects' property of absorbing heat and later releasing the heat energy through emission should be from the pre-service science teachers' indigenous Chemistry knowledge.

In the third intervention lecture, the Bohr atomic model and dual behaviour of matter was discussed. The application of indigenous Chemistry knowledge in this lecture was of a high degree as was shown by PST14s' application of ripples of water. PST14 described ripples of water as growing bigger from the origin or centre going outwards. Ripples that were stated by PST22 and applied by PST14 are part of pre-service science teachers' indigenous Chemistry knowledge which was used as prior knowledge.

5.4.7. Observations of application of indigenous chemistry knowledge in lectures after intervention through participant observation.

The application of indigenous Chemistry knowledge by pre-service science teachers was high in the first lecture after intervention on the dual behaviour of matter (wave-particle duality). An illustration of the quantisation of energy was given by PST10. In the illustration by PST10, the amount of firewood required to properly cook food depends on the amount of food to be cooked. An example of orbital being like an area in a watermelon where there is a very high chance of finding a seed was also given by PST22 as an example to try and explain the atomic orbital concept.

The Modern Periodic Law was done in the second lecture after intervention. There was a high standard of the application of indigenous Chemistry knowledge by the pre-service science teachers. Examples of classification of soils, animals and crops from PST14, PST18, PST8 and PST15 were based on their indigenous Chemistry knowledge (prior knowledge on classification) The low melting point of copper and higher melting point of iron given by PST21 was from the pre-service science teachers' indigenous Chemistry prior knowledge from blacksmiths. The same goes for the solubility of sodium chloride (common salt) by PST14. These examples are a high standard of the application of indigenous Chemistry knowledge that was done by the pre-service science teachers in the Chemistry lecture.

The mole concept, molar mass, oxidation and reduction, empirical and molecular formulae as well as molar solutions were done in the third lecture after intervention. In this lecture, indigenous Chemistry knowledge ideas or concepts' application was high regarding the concepts of the mole, molar mass, oxidation, reduction, empirical formula, molecular formula as well as molar solutions. Examples of a dozen eggs, a loaf of bread and packed drinks (carton) were given for the mole by PST14 and PST22. A dozen of eggs, a loaf of bread and a carton of drinks were all examples given by PST14 and PST22 as standard quantities used in other areas like the mole in Chemistry, which represented prior knowledge of the pre-service science teachers from their everyday life experiences

Burning of wood in air was identified as an oxidation reaction by PST28 and the browning of some fruits' whitish flesh after having been freshly cut or bitten were also given as oxidation by PST17.The examples of oxidation, such as burning of firewood and of oxidation as the browning of whitish flesh of fruits after being freshly cut or bitten, are indigenous Chemistry knowledge which is the pre-service science teachers' prior Chemistry knowledge on oxidation. In his presentation, PST15 gave an example of molar solutions such as the changes in concentration of sugars in sweet fruits as well as sweet reeds, in which dried sweet fruits and sweet reeds are sweeter than fresh sweet fruits and sweet reeds respectively. The explanation of the dried sweet fruits/sweet reeds being sweeter than fresh sweet fruits/sweet reeds was because the concentration of the sugar (sucrose) will have increased as some of the water dries up is an indigenous Chemistry knowledge concept.

In the fourth lecture after intervention, the preparation and use of sodium carbonate solution as well as the flame test practical were done. The application of indigenous Chemistry knowledge was high but the majority of the application, especially the handling and attitude, was on the negative side of the practical. Most groups such as PST7's group weighed the sodium carbonate without the required precision (it was more of an approximation). Quite a number of groups, which included PST28's group, had measuring and handling skills which were not up to the expected standard. This was shown by their lack of precision where there was more approximation which is common in some indigenous Chemistry knowledge practical when dealing with or using indigenous chemicals or herbs.

Some groups which included PST10's group, when performing their titrations, were first filling the burette up to the 0 cm^3 mark before titrating even though the first run showed that the required titration was less than 20cm^3. Three groups (PST18, PST7 and PST9) could not read the meniscus correctly from the beakers and burettes. In some groups, there were pre-service teachers who seemed to be doing most of the duties like collecting apparatus, measuring the mass of solids, volume of liquids and performing the titration. Others seemed content by taking recordings of measurements whilst others just watched. Most groups were not planning in terms of sharing the duties for its members during the practical. There was lot of spilling of chemicals on the workbench. PST9's group was among the groups whose rough run titration was done drop by drop. Some of the groups, which included PST7's group lacked handling and precision skills by overshooting the end of the titration by more than 1cm^3.

Handling of chemicals and apparatus showed some indigenous Chemistry knowledge skills and attitudes. Pre-service teachers' focus was more of routine and obeying an authoritative figure in the preparation and use of the sodium carbonate solution. Failure to systematically allocate each other duties, taking things for granted as well as expecting someone else to automatically take charge and responsibility in doing the practical are skills and attitudes associated with indigenous Chemistry knowledge, skills and attitudes. Spilling of chemicals is a sign of clumsiness or lack of care and accuracy with what one is doing. Taking things for granted like doing a rough titre drop by drop and overshooting the end point by more than 1 cm^3 is also associated with indigenous Chemistry knowledge, skills and attitudes.

In the flame test practical, pre-service science teachers were again in four groups of six and one group of five. This was due to inadequate chemicals and apparatus. Two groups which PST9 and PST18 were a part of were using burner flames which were luminous orange instead of luminous blue to burn the metal salts. In the flame test practicum, in PST10's group, one individual was doing most of the duties whilst others watched. Also, one or two of the pre-service science teachers would be doing the recording instead of everybody taking their own recordings of the observations.

The use of burner flames that were luminous orange instead of luminous blue was the application of indigenous Chemistry knowledge, skills and attitudes by pre-service science teachers. Most pre-service science teachers are used to using luminous orange flames when using fires from fire wood, charcoal as well as coal at home for heating, burning and lighting purposes in their everyday life experiences. The application of indigenous Chemistry knowledge was high, but the majority of the application especially the handling and attitude, was on the negative side of the practical. These negative indigenous Chemistry handling and attitude included the approximating of quantities when measuring and waiting for an authoritative figure to direct what the group should do.

The application of indigenous Chemistry knowledge in the lectures before the intervention phase was rare except for second lecture where it was medium standard. This was when the ‘’Plum pudding” model of the atom was described using a positively charged pumpkin, which has pumpkin seeds acting as the electrons by PST17. However, after metacognition instruction using indigenous Chemistry knowledge as prior knowledge, there was a high standard of the application of indigenous Chemistry knowledge in Chemistry concepts. Also, in the two Chemistry practical assessments that were done, the application of indigenous Chemistry knowledge was high though most of the time negatively. This suggests that the indigenous Chemistry knowledge intervention was effective as pre-service science’s frequency of using indigenous Chemistry in the Chemistry lectures had improved.

5.4.8. Comparison of focus group metacognition awareness with pen and paper test metacognition awareness after intervention.

The focus group as well as the pen and paper metacognition awareness scores are average scores for the focus groups and pen and paper tests. A comparison of the focus group with pen and paper test metacognition awareness scores after intervention for the pre-service science teachers are shown in figure 5.5

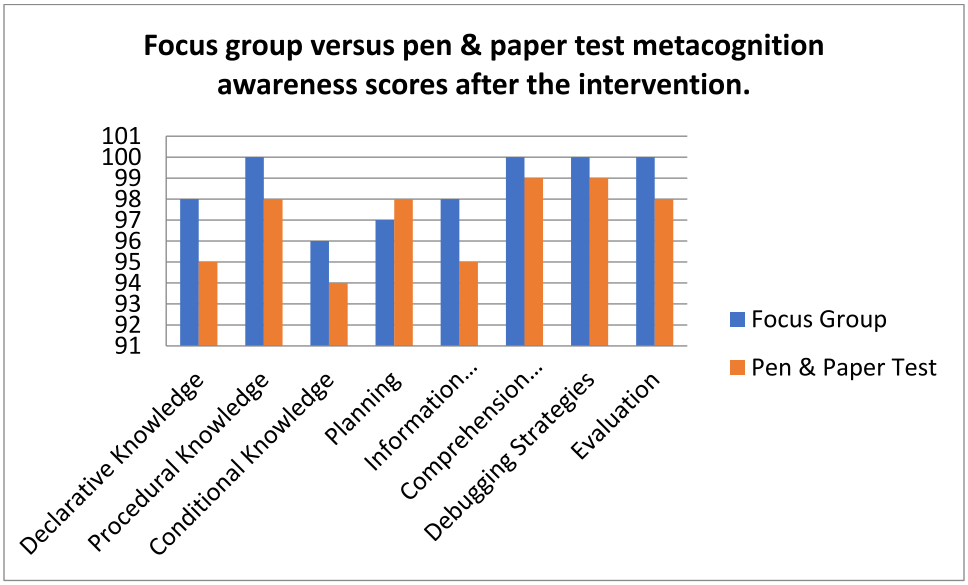

Figure 5.5: Post intervention comparison between interview and test scores

There was a high metacognition awareness for the focus groups when compared to pen and paper test in most of the metacognition components except for planning after the indigenous Chemistry knowledge intervention. This is the opposite for the scores before the indigenous Chemistry knowledge intervention in which the metacognition awareness for focus groups was lower when compared to the pen and paper test. There is no consistency in the increase of the scores.

The Pearson product moment correlation was used to correlate the focus group metacognition awareness scores with the pen and paper test metacognition awareness scores after the indigenous Chemistry knowledge intervention. The correlation was found to be 0.76 which shows a strong positive correlation between the focus group metacognition awareness scores when correlated to the pen and paper test metacognition awareness scores after the intervention. Appendix 9 shows how the 0.76 correlation coefficient was calculated. The variance of the focus group metacognitive awareness scores that is accounted for by the variance in the pen and paper test metacognition awareness scores is 58% after the intervention.

5.4.9. Metacognition awareness mean scores after intervention for focus group as well as for pen and paper test.

The mean score of focus groups when compared to the mean score of the pen and paper tests after the indigenous Chemistry knowledge intervention give the extent to which the two are in agreement. The mean scores for focus group metacognition awareness as well as for pen and paper test metacognition awareness before the indigenous Chemistry knowledge intervention are indicated in figure 5.6.

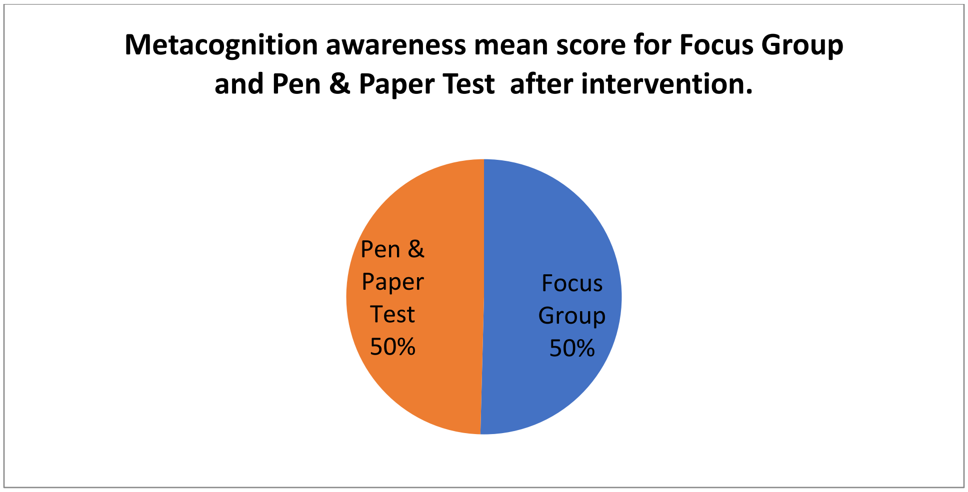

Figure 5.6: Metacognition awareness mean scores after the intervention

There is no difference in the mean scores implying there is no difference in the metacognition awareness after the indigenous Chemistry knowledge intervention of the mean score of the focus groups when compared to the mean score of the pen and paper test after the indigenous Chemistry knowledge intervention. This indicates that the results of the focus group metacognition awareness were confirmed by the paper and pen metacognition awareness test after the indigenous Chemistry knowledge intervention in terms of triangulation.

5.4.10. Comparison of focus group metacognition awareness before and after intervention

The impact of the indigenous Chemistry knowledge intervention on metacognitive awareness can be ascertained by comparing the focus group scores after the indigenous Chemistry knowledge intervention to those before the indigenous Chemistry knowledge intervention. A comparison of the scores after the indigenous Chemistry knowledge intervention and before the indigenous Chemistry knowledge intervention are shown in figure 5.7.

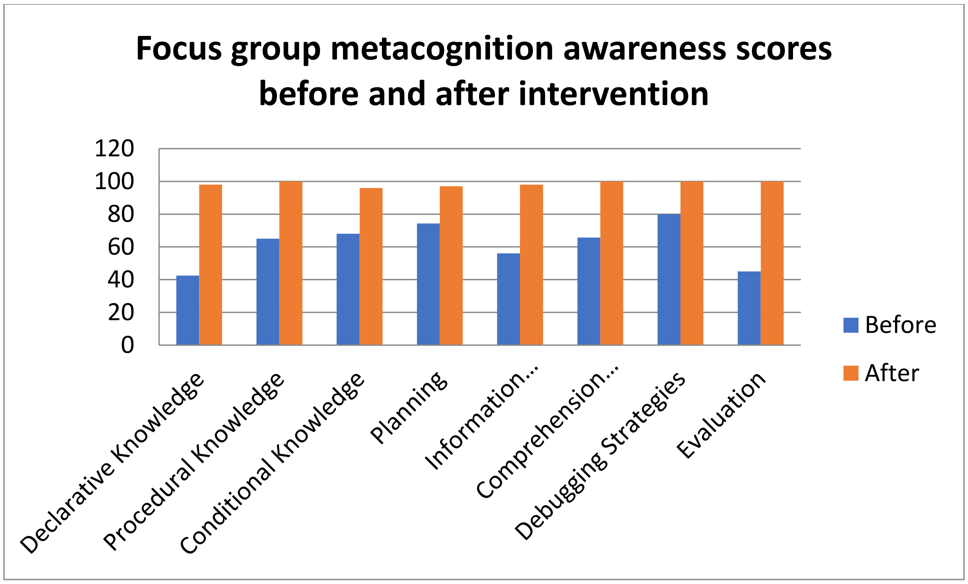

Figure 5.7: Comparison of focus group scores before and after Intervention

The metacognition awareness scores are higher after the indigenous Chemistry knowledge intervention when compared to the metacognition awareness before the indigenous Chemistry knowledge intervention. The indigenous Chemistry knowledge intervention had an effect in the positive direction on the metacognition awareness. The indigenous Chemistry knowledge intervention had an effect of improving the metacognition awareness of the pre-service science teachers.

5.4.11. Metacognition awareness mean scores for focus group before and after intervention

Comparing the means scores of the focus group before and after the indigenous Chemistry knowledge intervention gives an idea of the degree of change after the indigenous Chemistry knowledge intervention. Figure 5.8 shows this comparison.

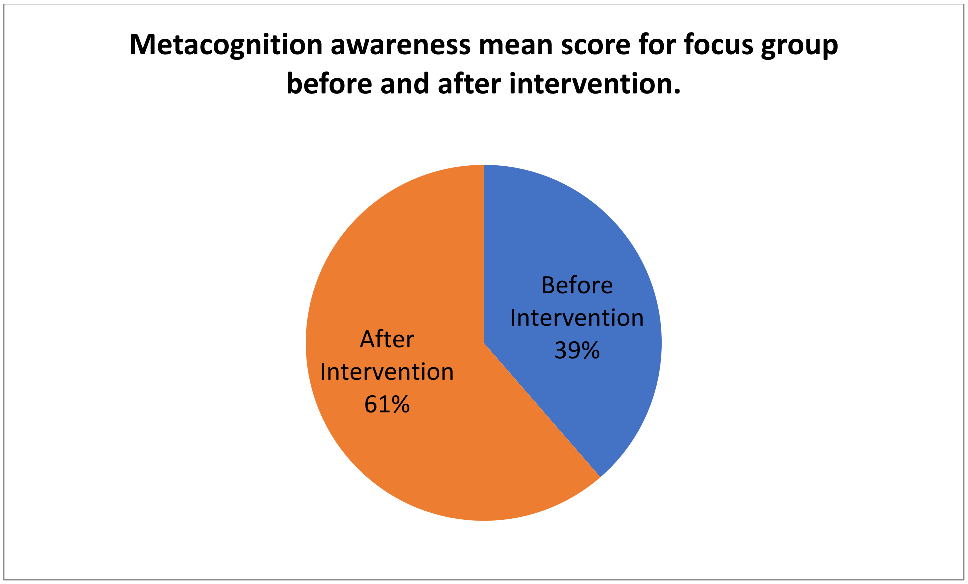

Figure 5.8: Metacognition awareness mean score before and after intervention

There is a sharp difference between the focus group metacognition awareness mean score before the indigenous Chemistry knowledge intervention and focus group mean score after the indigenous Chemistry knowledge intervention. The metacognition awareness mean score of the focus groups increased after the indigenous Chemistry knowledge intervention. This implies a sharp increase in metacognition awareness as a result of the indigenous Chemistry knowledge intervention.

5.4.12. Comparison of pen and paper test metacognition awareness scores before and after intervention

The impact of the indigenous Chemistry knowledge intervention can be found by comparing the pen and paper metacognition awareness scores after the indigenous Chemistry knowledge intervention to those before intervention. Figure 5.9 shows a comparison of the pen and paper metacognition awareness scores after the indigenous Chemistry knowledge intervention to those before the intervention.

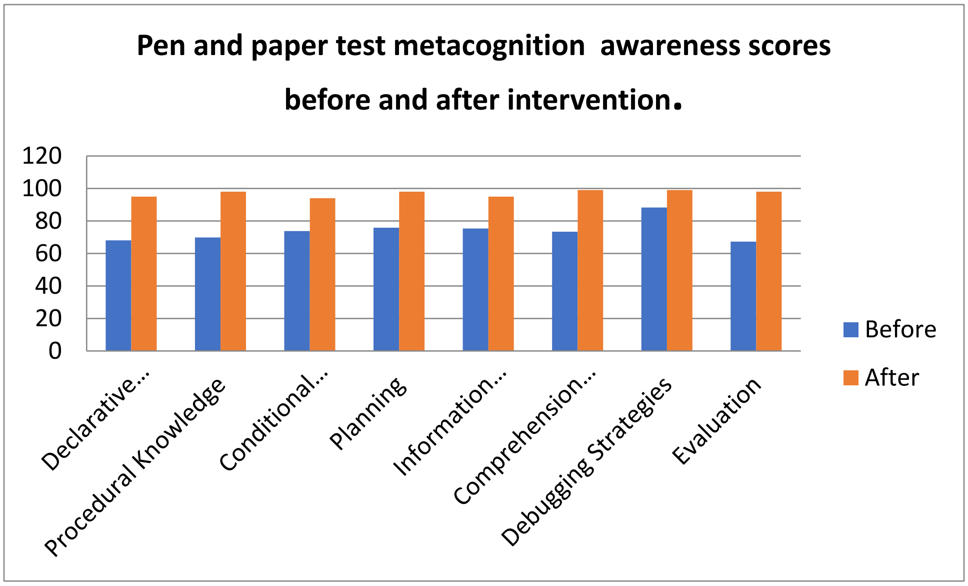

Figure 5.9: Comparison of pen and paper metacognition awareness scores

The pen and paper test metacognition awareness scores are higher after the indigenous Chemistry knowledge intervention. The indigenous Chemistry knowledge intervention had an effect of increasing the metacognition awareness. There is a consistency in the increase in metacognition awareness for both the focus groups and pen and paper test after the indigenous Chemistry knowledge intervention.

5.4.13. Metacognition awareness mean scores for pen and paper test before and after intervention.

A comparison of the pen and paper test metacognitive awareness mean scores before and after the indigenous Chemistry knowledge intervention shows changes that might have occurred as a result of the intervention. Figure 5.10 shows a comparison of pen and paper metacognitive awareness scores before and after intervention for the pre-service science teachers.

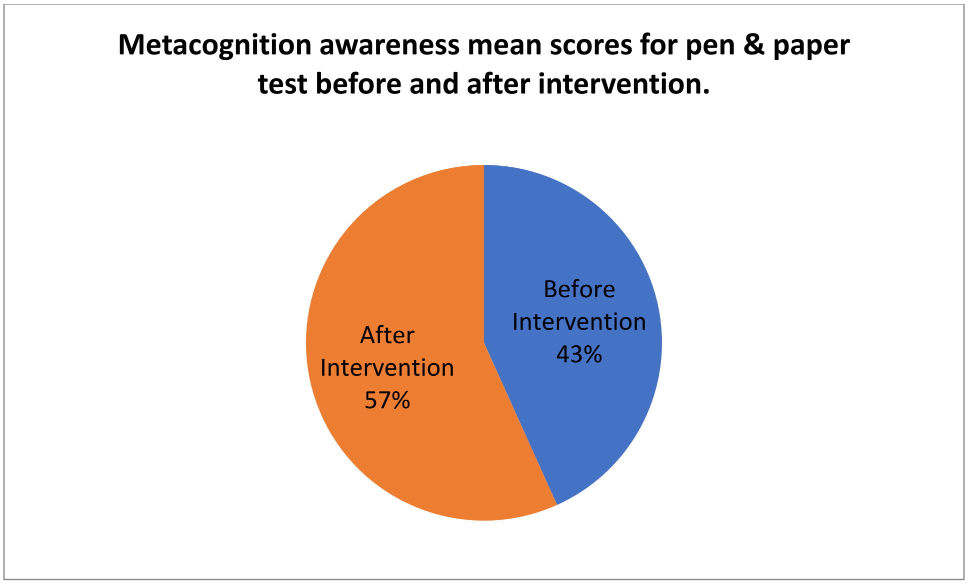

Figure 5.10: Metacognition awareness mean score before and after intervention

There is a significant difference in metacognition awareness mean scores before and after the indigenous Chemistry knowledge intervention. The metacognition awareness mean score of the pen and paper test increased after the indigenous Chemistry knowledge intervention. The implication is that there is a significant increase in metacognition awareness as a result of the indigenous Chemistry knowledge intervention.

5.4.14. Correlation of pre-service science teachers' metacognitive awareness scores before and after intervention

The correlation of metacognitive awareness scores before and after indigenous Chemistry intervention give the extent to which the changes in metacognitive awareness before the intervention influence the metacognitive awareness after intervention. Figure 5.11 gives the correlation between metacognitive awareness before intervention and the metcognition awareness after intervention of the pre-service science teachers.

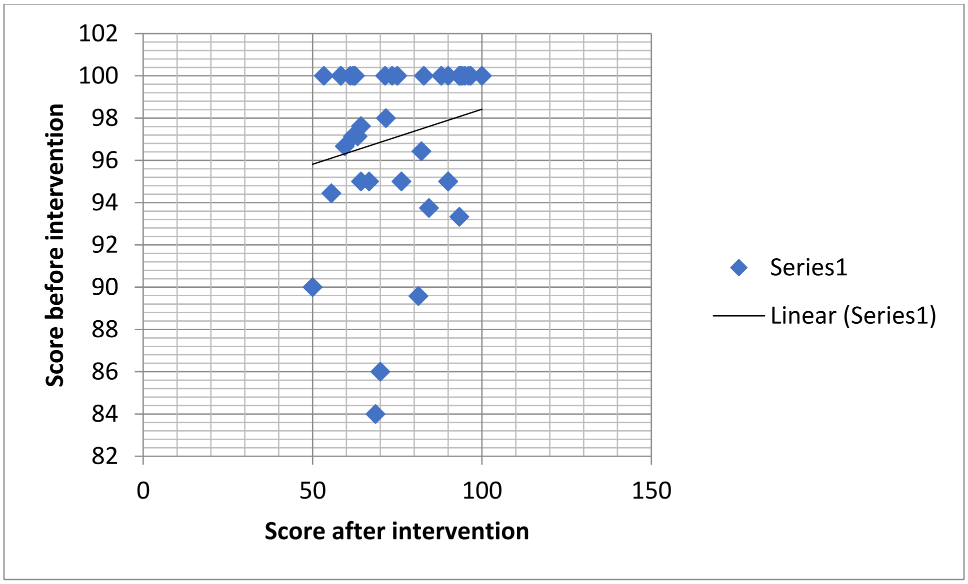

Figure 5.11: Scatter diagram for metacognition scores before and after intervention.

The scatterplot shows a strong positive correlation between the metacognitive awareness scores before and after the indigenous Chemistry intervention intervention.

5.4.15. Comparison of pre-service science teachers' Chemistry assignment two and Chemistry test two and three (average) after intervention.

Vital information which might provide an indication of the effect of an intervention in terms of performance can be given by the academic performance of pre-service science teachers in Chemistry assignments and tests after the intervention. A comparison of preservice science teachers' academic performance in Chemistry assignment two and Chemstry test two and three (average) after the intervention is shown by the linegraph in figure 5.12. The linegraph shows a positive correlation between the Chemistry assignment two scores after the intervention and test two and three (average) scores after the intervention.

Most pre-service science teachers who had high scores in Chemistry assignment two after intervention also had high scores in Chemistry test two and three (average) after intervetion. The linegraph also shows that most of the pre-service science teachers who had lower marks in Chemistry assignment two before intervention had lower marks in test two and three (average) after the intervention. Most pre-service science teachers did well in the Chemistry assignment two when compared to the Chemistry test two and three (average) in which most pre-service science teachers did badly after the intervention. This is consistent with their performance before metacognition in which the pre-service science teachers' assignment mark was higher than the test mark.

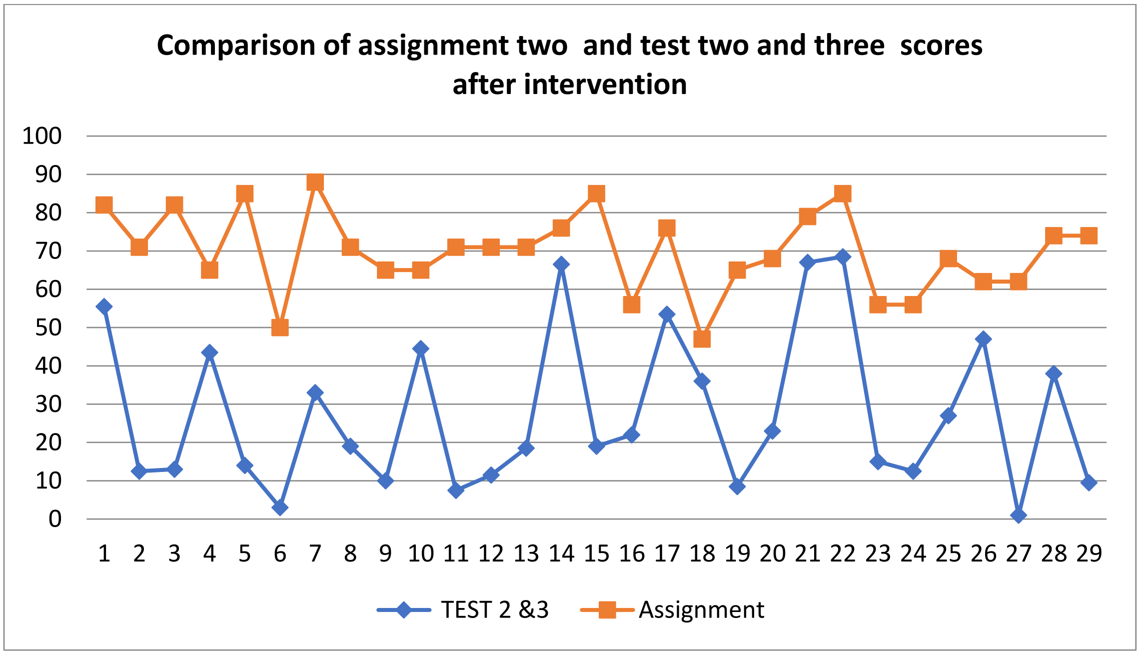

Figure 5.12: Comparison of assignment two and chemistry test two and three post-intervention.

5.4.16. Comparison of pre-service science teachers' Chemistry assignment and test mean scores before and after intervention

The change in academic performance of the pre-service science teachers can be identified by the differences in the mean scores of assignments and tests before and after the indigenous Chemistry knowledge intervention. The mean scores for assignments and tests before and after the indigenous Chemistry knowledge intervention for pre-service science teachers are shown in figure 5.13.

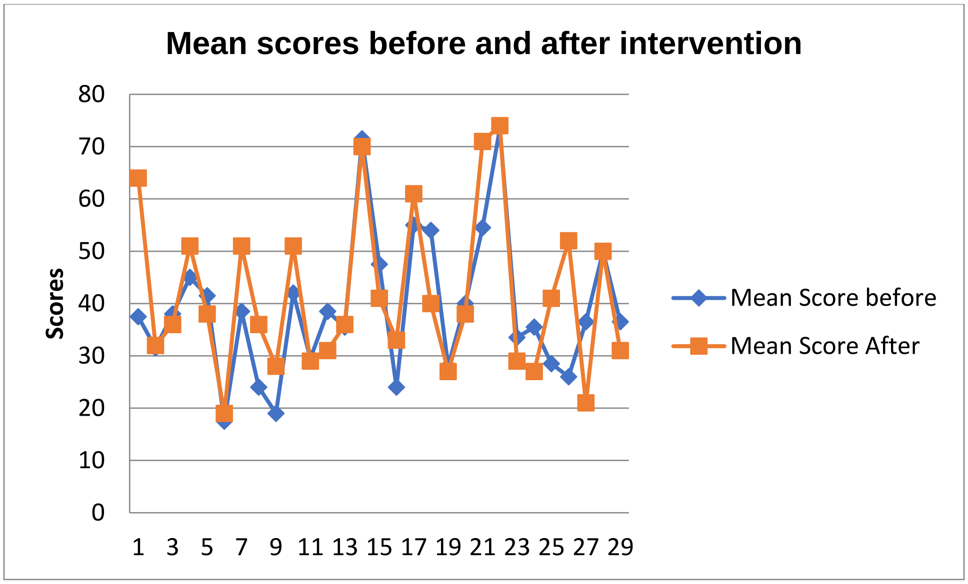

Figure 5.13: Comparison of means scores before and after intervention

The pre-service science teachers' mean scores of the Chemistry assignment one and chemistry test one before indigenous Chemistry knowledge intervention are lower than the mean scores of the assignment two and test two & three after intervention. This implies that the academic performance of the pre-service science teachers improved after the indigenous Chemistry knowledge intervention.

5.4.17. Correlation of pre-service science teachers' assignment two and test two & three after intervention.

The correlation between pre-service science teachers' performance in Chemistry assignment two after intervention and pre-service science teachers' academic performance in Chemistry test two and three (average) after intervention can be shown by a scatterplot. Figure 5.14 shows the scatterplot for the relationship between pre-service science teachers' performance in Chemistry assignment two and the pre-service science teachers' performance in chemistry test two and three (average) after intervention.

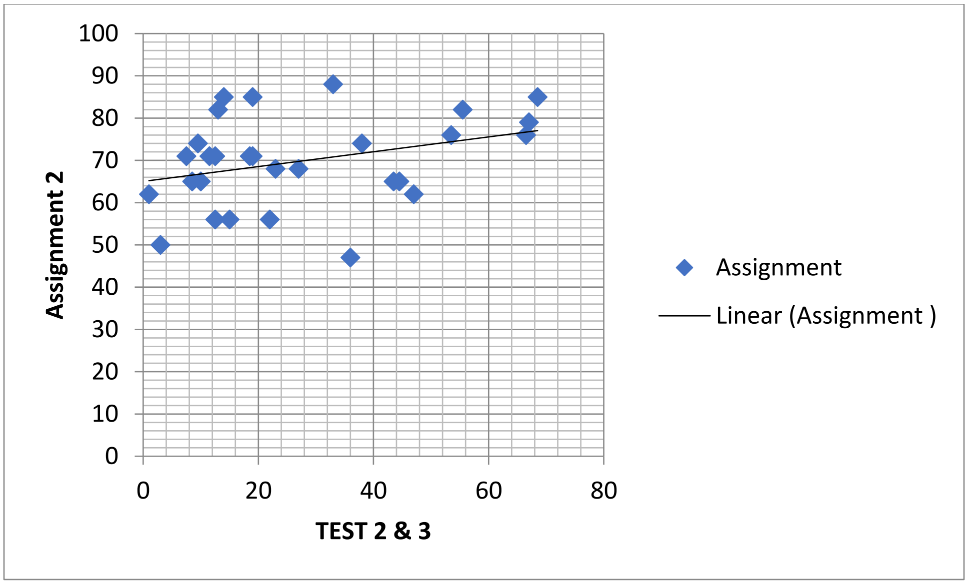

Figure 5.14: Correlation between Chemistry assignment two and test two and three.

There is a positive correlation between mean scores for Chemistry assignment two and Chemistry test two and three (average) given after the indigenous Chemistry knowledge intervention. This means that there is a positive correlation in metacognition awareness.

5.5. RESULTS FOR RESEARCH SUB-QUESTION FOUR: What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition?

The attitudes towards the use of indigenous Chemistry knowledge in Chemistry metacognition by pre-service science teachers was provided by focus group interviews.

5.5.1. Attitude towards the use of indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures.

Quite a number of attitudes were exhibited by pre-service science teachers in terms of the use of indigenous Chemistry knowledge, skills and attitudes in the Chemistry lectures. Pre-service science teachers felt that it was good, acceptable, comfortable and important to use indigenous Chemistry knowledge, skills and attitudes in the Chemistry lectures. Their reasons were that the use of indigenous Chemistry knowledge, skills and attitudes in the chemistry lectures motivates learners, improves Chemistry concepts comprehension, aids memory retention and brings reality and life experiences to the classroom.

Pre-service science teachers also felt that it was the best way to learn western Chemistry knowledge, as the examples used were from their daily life experiences which are known and understood. However, pre-service science teachers also felt that in the process of assisting in the learning and teaching of western Chemistry knowledge, indigenous Chemistry knowledge, skills and attitudes are standardised and preserved in the process.

5.5.2. Ways of utilising indigenous Chemistry knowledge and skills in Chemistry lectures.

Pre-service science teachers identified numerous ways in which indigenous Chemistry knowledge and skills might be used in Chemistry lectures. These included relating and comparing college Chemistry to indigenous Chemistry knowledge and skills as it assists in understanding college Chemistry. The indigenous Chemistry knowledge and skills can be used to improve participation and simplify college Chemistry as it is inclusive and not divorced from the home culture of the learner.

The practical aspect of indigenous Chemistry knowledge was emphasised where it was pointed out that indigenous Chemistry knowledge samples can be brought into the laboratory to be analysed. Indigenous Chemistry knowledge practical assessments can be given as assignments that can be done at home without many complications. The indigenous Chemistry knowledge can be especially used as concept introductions as learners are already familiar with them as they experience them in practice in their everyday life experiences.

5.5.3. Challenges in the use of indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures and possible solutions.

There are a number of problems which come with the use of indigenous Chemistry knowledge and skills in Chemistry lectures that were presented by pre-service science teachers. Table 5.12 shows possible problems of using indigenous Chemistry knowledge and skills in Chemistry lectures and possible solutions.

Table 5.12: Possible challenges and solutions of indigenous Chemistry in lectures

Possible challenges of using indigenous Chemistry knowledge and skills in Chemistry lectures and possible solutions.
Challenges *Since indigenous Chemistry differs from culture to culture and here at college there are different cultures, some examples not relevant to others of a different culture. Sometimes there is contradiction e.g. creating indigenous lightning and natural lightning in college Chemistry. Poisonous and allergies are not yet discovered or emphasised on. Because it is passed from generation to generation-the concepts behind is not explained but told what to do (practical application) only. Some learners won't be knowing some of the indigenous Chemistry.* *Mis-understanding of some topics. Difficult to measure. Some of the information on indigenous Chemistry knowledge is in summary form (no steps). Grasp the concept but not grasp the details of the process. Cannot be quantified. If not properly linked to college Chemistry, indigenous Chemistry might lead to confusion. Learners might not be able to dwell/ grasp scientific terms but indigenous Chemistry terms, indigenous Chemistry knowledge does not cover all aspects of college Chemistry. Indigenous Chemistry knowledge, skills and attitudes are not in detail.* *Uses experiences (e.g. meat salting. Problem of measurement). Due to multiculturism - some of the indigenous Chemistry knowledge might not be common to other learners. Most of indigenous apparatus or equipment do not have accurate measurement. Lack of materials. Might not know concentrations / quantities of indigenous Chemistry, an example is alcohol concentrations not know chemical reactions. Can cause allergies. Untidiness. Some might want to learn only Chemistry skills and attitudes. Some processes take time e.g. brewing of traditional beer. Might bring cultural shock.* ***Solutions*** *By combining with formal college Chemistry. Those that take time can be done before hand. By visiting areas where such indigenous Chemistry practices are done. Bring resource persons to explain to learners. Use the college Chemistry as a control to compare with the indigenous Chemistry. Learners have to be responsible for cleaning the environment and take care of the apparatus. More research being done, both should be involved (included) in the learning, educate the facilitators on how to link the two. Use indigenous Chemistry as examples in certain areas which are relevant. Aspect of measurement of quantities. Making an oral research and compiling the research to write a book. Research much on indigenous and see everything that is similar to college chemistry.*

Even if the Chemistry concepts are done in Indigenous Chemistry knowledge and skills the focus is on summary and not in details. Indigenous Chemistry knowledge and skills are difficult to measure or quantify as well as the apparatus or equipment do not give accurate measurement if they are there. Indigenous Chemistry knowledge and skills tend to be crude and untidy most of the time making them unattractive even though they are useful. Proper linking of indigenous Chemistry knowledge and skills should be done to avoid confusion or misconceptions since they are based on personal experiences by the pre-service science teachers.

Indigenous Chemistry knowledge and skills do not cover all the concepts / ideas of college Chemistry (western chemistry knowledge) which can lead to challenges at times in terms of prior Chemistry knowledge. There is a probability that pre-service science teachers might end up emphasising more on to the indigenous Chemistry knowledge and skills than rather on college formal (western) Chemistry. Some indigenous Chemistry knowledge processes take a lot of time such as fermentation in brewing traditional beer and wine. However, pre-service teachers suggested that these problems of using indigenous Chemistry knowledge and skills in Chemistry lectures can be overcome through a number of ways. These include combining indigenous Chemistry knowledge and formal (western) Chemistry knowledge, inviting resource persons for indigenous Chemistry knowledge and skills as well as having educational tours of areas in which they are practised.

College (western) Chemistry might be used as a control when using indigenous Chemistry ideas as prior knowledge in Chemistry lectures. Pre-service science teachers can use western apparatus and instruments and be responsible by cleaning up their work benches (working environment) so as to solve the problems of inaccuracy and untidiness. Chemistry lecturers and facilitators (resource persons) should be educated on how to properly link indigenous Chemistry knowledge and college (western) Chemistry knowledge. Application of relevant indigenous Chemistry knowledge and skills must be done where applicable only. Research focusing entirely on indigenous Chemistry knowledge and skills should be done for the purposes of coming up with comprehensive written text to compare to. Indigenous Chemistry knowledge processes that take time can be done in advance so that pre-service science teachers can make use of them in their Chemistry lectures.

5.5.4. Advantages and disadvantages of using indigenous Chemistry knowledge and skills in Chemistry lectures.

The use of indigenous Chemistry knowledge and skills in Chemistry lectures (western Chemistry knowledge) comes with it some advantages and disadvantages. Some of the advantages and disadvantages of using indigenous Chemistry knowledge and skills in Chemistry lectures as presented by pre-service science teachers are shown in table 5.13.

Table 5.13: Pros and cons of using indigenous Chemistry in lectures.

Advantages and disadvantages of using indigenous Chemistry knowledge and skills in Chemistry lectures themes.
Advantages *Learners easily grasp concepts. No qualification that is needed. It can be a hub for home grown solutions. Captivate students' interest and motivation. Provides creativity. Promotes research and development. Making understanding better. Makes learning easy. Gives relevance. Information easily accessible. A lot of cultures. Raw material is local, available and cheap. Provides better understanding. Brings together the modernised learners and the sophisticated. Gives a clear picture of what is being taught. Makes it easy for learners to understand the concept as learners are well versed in indigenous Chemistry knowledge* . *Helps in following safety in a laboratory. Learners have hands-on experience. It prepares learners for after college-life. It brings reality. It promotes memory retention (empowers memory) as learners will be learning from the known to the unknown. Have an idea of what you are learning about. Common to everyone and readily available. Understand better what is being spoken/taught about them since you can relate. Learners will understand better because the concepts are being simplified. Helps to maintain the interest(motivation) of learners since they can relate.* ***Disadvantages*** *Some are out-dated. Might kill college Chemistry technical terminology among learners. Wrongly prescribe something for someone. Some of them not scientifically proven. Supports the ones in contact with the indigenous knowledge. Learners might end up dwelling much in indigenous Chemistry knowledge than on the college Chemistry concepts. Practice might be dangerous or harmful to the health of a person (Allergic to some of the indigenous Chemistry knowledge substances) There is no specificity in indigenous Chemistry. Measurements are not reliable. Some of the indigenous Chemistry knowledge method might not give enough results that can be evaluated. Reactions take a lot of time/ slow. Tends to discriminate against the ones who grew up in urban areas as compared to the ones who grew up in rural areas. Dilution of cultures of other learners' cultures (cultural shock).*

Pre-service science teachers identified numerous advantages of using indigenous Chemistry knowledge and skills in Chemistry lectures (western Chemistry knowledge). College Chemistry (western Chemistry) concepts are grasped easily by learners. A learner does not need to have a prior qualification in order to learn and make use of indigenous Chemistry knowledge and skills. The use of indigenous Chemistry knowledge might act as the hub for home (local) Chemistry solutions in college Chemistry. Making use of indigenous Chemistry knowledge and skills in Chemistry lectures (western Chemistry knowledge) promotes research and development in Chemistry. Since most pre-service science teachers are well versed in indigenous Chemistry knowledge and skills, their college Chemistry becomes relevant, motivating, creative and is easier to understand.

In college Chemistry, safety is of paramount importance and the use of indigenous Chemistry knowledge and skills assists in enhancing safety as most do not have harmful effects. Indigenous Chemistry knowledge and skills are common, readily available and are part of pre-service science teachers' everyday life experience, bringing realia in the Chemistry lectures. Pre-service science teachers' relating to Indigenous Chemistry knowledge and skills presents the college Chemistry in a simplified manner which keeps their motivation sustained for a long period. However, there are a few disadvantages of using indigenous Chemistry knowledge and skills in Chemistry lectures that were identified by pre-service science teachers. These include learners might focus more on indigenous Chemistry knowledge than the college Chemistry (western Chemistry knowledge). The college Chemistry (western Chemistry knowledge) technical terminology might be negatively affected.

Some indigenous Chemistry knowledge processes are out-dated which might lead to some inaccuracies in terms of Chemistry concepts / ideas and measurements. The use of indigenous Chemistry knowledge and skills in Chemistry lectures is of more benefit to those pre-service science teachers who are exposed to and practice indigenous Chemistry knowledge and skills in their everyday life experiences. Some of the practical results obtained may be difficult to analyse. Cultural dilution or shock might result from the use of indigenous Chemistry knowledge and skills in Chemistry lectures. Some indigenous Chemistry knowledge reactants and products might present health hazards to some learners who might be allergic to them since indigenous Chemistry substances do not come with warnings about their harmful effects or allergies.

5.5.5. Best approaches in using indigenous Chemistry knowledge and skills in Chemistry lectures.

Teaching and learning approaches play an important role in educational settings. Chemistry lectures (western Chemistry knowledge) can make use of Chemistry knowledge and skills to enhance the teaching and learning. The best approaches for using indigenous Chemistry knowledge and skills in Chemistry lectures is shown in table 5.14.

Table 5.14: Best approaches using indigenous Chemistry in Chemistry lectures.

Best approaches in using indigenous Chemistry knowledge and skills in Chemistry lecture themes.
Field trips. Practical. Research. Consulting experts/Resource persons. Demonstration. Samples, Practical. Experimentation. Related media (pictures, videos). Role play. Group discussion. Discovery. Project. Discussion. Case studies as examples/ illustrations. Survey. Indigenous Chemistry knowledge must be used during the introduction of the lesson. Some of the knowledge can be used as assumed knowledge (prior knowledge) to teach exotic (college) Chemistry. *It can be used as demonstration. The teacher has an understanding of indigenous Chemistry can select and make use of it. Standardisation. To simplify concepts. Hands on approach. Adoption of it into formal Chemistry. Relating every concept to the indigenous Chemistry concepts, as examples of realia. Can be used for reference used to exemplify Chemistry concepts in daily life applications. When introducing a lesson, used as teaching and learning media. Using indigenous Chemistry knowledge as examples. Assignments given must involve research on indigenous Chemistry knowledge. When introducing a lesson, used as teaching and learning media.*

5.5.6. Issues on indigenous Chemistry knowledge and skills that were not discussed previously.

Pre-service science teachers mentioned some aspects of indigenous Chemistry knowledge and skills that were not covered by the focus group discussions. Some of the indigenous Chemistry knowledge and skills that were left out in the focus group discussions are given in table 5.15.

Table 5.15: Information not covered about indigenous chemistry knowledge

Information not covered previously about indigenous Chemistry knowledge and skills.
Government should appoint a committee to do studies in indigenous Chemistry knowledge. Somethings have to be tested. Indigenous Chemistry knowledge books should be published so that there is no distortion. Should be encouraged in most parts of the lecture as it signifies who we are and where we are going. They are our everyday life experiences. Indigenous Chemistry knowledge, skills and attitudes should be introduced in schools/colleges. They are related to college Chemistry. No groundwork/documentation. Empower people with indigenous Chemistry knowledge. It should be included in the curriculum and made compulsory for every student to learn. *College Chemistry should be taught with indigenous Chemistry knowledge. Indigenous Chemistry knowledge has a husband-and-wife relationship (strong bond/relationship) with college Chemistry. Applicable and effective. It should be learnt every day. College Chemistry should be made of the indigenous Chemistry knowledge, skills and attitudes so that learners are able to use the Chemistry after leaving schools as they are available compared to the resources used in college Chemistry which is not available at home. They are based on culture. There should be a shift in attitudes towards the current undermining of indigenous Chemistry knowledge, skills and attitudes.*

The indigenous Chemistry knowledge and skills should be introduced in schools and colleges as it represents daily life experiences of learners. Some of the indigenous Chemistry knowledge and skills aspects that were not discussed in the focus groups are that a committee should be set up by the government that studies indigenous Chemistry knowledge and skills. College Chemistry must consist of indigenous Chemistry knowledge and skills as the pre-service science teachers can make use of it after college. Pre-service science teachers suggested that the publication of books on indigenous Chemistry knowledge and skills must be done to preserve the invaluable indigenous Chemistry knowledge and skills to avoid their distortion. This will lead to some of the pre-service teachers who are not exposed and do not practise indigenous chemistry knowledge and skills being empowered with it. The original value of indigenous Chemistry knowledge and skills will be restored as pre-service science teachers appreciate their usefulness.

5.6. DISCUSSION

The purpose of this embedded mixed methods case study was to explore the influence of indigenous Chemistry knowledge on Chemistry metacognition. This was achieved through interrogating; the indigenous Chemistry knowledge held by the respondents, the relevance and effectiveness of indigenous Chemistry knowledge to Chemistry metacognition as well as the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition.

An indication by the results shows that pre-service science teachers had a vast amount of indigenous Chemistry knowledge in agriculture, environmental conservation, food processing, food preservation and health-care which were complemented by indigenous Chemistry knowledge in other areas. The results of this study are in agreement with Mapara's (2009) findings, which indicated that indigenous knowledge which includes the areas of medicine, agriculture, craft skills, zoology and botany among others, are still held by local people even after years of colonisation. These results are consistent with Ugboma (2014), whose findings showed that the majority of the population possess and utilise indigenous knowledge. Senanayake's (2006) findings showed that indigenous knowledge experts are ordinary people of the society.

There is a need for this indigenous Chemistry knowledge to be known before it can be used in teaching and learning. George (1999) suggests that indigenous knowledge is not usually presented in the same way learning resources are, so the facilitator must be exposed to the indigenous knowledge first and realise its meaning and its relationships to what is taught before using it in class. These findings assisted in ascertaining the indigenous Chemistry knowledge which the pre-service science teachers have which made it possible for the indigenous Chemistry knowledge intervention phase to take place.

The results suggest a relevance of indigenous Chemistry knowledge to Chemistry metacognition as it is the prior knowledge for Chemistry metacognition. Metacognition requires a learner to have prior knowledge in order for one to learn it. Prior knowledge is required for the development of metacognitive skills as it facilitates and assist in the development of the cognitive skills states AIshammari, (2015). The Chemistry concepts in indigenous Chemistry knowledge are the same as those found in western Chemistry knowledge, hence their relevance to Chemistry metacognition. As a result of this relevancy, there are calls for the integration of indigenous knowledge into science education.

Aspects of culture of non-western science learners such as indigenous knowledge (traditional and empirical knowledge), ways of knowing as well as indigenous world views should be taken into account and incorporated as science learning foundations (Quigley ,2009). This is in agreement with Ugwu and Diovu (2016), who opine that indigenous knowledge and their practices' integration into the teaching of chemistry enhances learners' Chemistry understanding and achievement. Another finding was that there are many similarities between indigenous Chemistry and western (college) Chemistry that exist. Tsuji and Ho (2002) emphasised the importance and benefits of identifying similarities between indigenous Chemistry knowledge and western Chemistry knowledge ways of knowledge construction and transmission so as to enhance understanding of the natural world.

Results from this study imply that indigenous Chemistry knowledge is quite effective in improving Chemistry metacognition as there was an increase in terms of metacognition awareness after the indigenous Chemistry knowledge intervention. This is in agreement with Schraw (1998), who identified four ways of classroom metacognition awareness promotion. These are: highlighting metacognition importance, knowledge of cognition improvement, regulation of cognition improvement and metacognitive awareness environment fostering. This is a new insight into the relationship between indigenous Chemistry knowledge and Chemistry metacognition which has never been studied before. According to Schraw (2000), the reliability of the Metacognitive Awareness Inventory (MAI) in measuring metacognition is extremely high. A study by Van Aswegen (2015) focused on using stories to develop the metacognitive awareness of intermediate phase young learners in South Africa. Most studies have focused on the impact of metacognition on academic performance.

The suggestion from the results is that the indigenous Chemistry knowledge improved the performance of the pre-service science teachers in Chemistry after the intervention. This correlates with the results of a previous study by Ugwu and Diovu (2016), which showed that indigenous knowledge and practices' integration into the teaching of Chemistry improved understanding of Chemistry concepts as well as enhancing learners' achievement. Aikenhead and Jegede (1999) found that all learning happens through culture in the social context. These results are in line with social constructivist learning theory's primary beliefs and comprehension of the classroom, where knowledge is a result of social construction (culture) and is an active process. However, most studies (Aurah, Koloi-Keaikitse, Isaacs and Finch, 2011; Rahman, Jumani, Chaudry, Chitsti and Abbasi, 2010) have focused on the impact of metacognition on academic performance. These studies have shown that learners who are highly metacognitive performed better academically than those who were lower metacognitively.

Moreover, the results show a positive attitude towards the use of indigenous Chemistry knowledge in Chemistry metacognition by pre-service science teachers. The findings contradict Shizha's (2007) findings, which showed a negative attitude by pre-service science teachers towards the incorporation of indigenous science into formal science. Other contradictory findings were those of Dziva, Mpofu and Kusure (2011), which showed that science teachers had a negative attitude towards the incorporation of indigenous knowledge in formal science classrooms. The pre-service science teachers were of the opinion that indigenous Chemistry knowledge improves their comprehension, assists in memory retention and brings their everyday life experiences into the classroom.

There are a number of major implications for Chemistry curriculum development that arise from the findings of this study. The first being that there appears to be a need for a Chemistry curriculum that values and identifies learners' indigenous Chemistry knowledge use in the Chemistry classroom (Lee, 2011; Quigley, 2009; Aikenhead, 2005; Aikenhead and Jegede ,1999) to provide equitable Chemistry education, as this study has demonstrated.

The second is implication is the realisation that only relevant indigenous (cultural) knowledge which the facilitators understand (Hartman, 2001a) can assist learners in terms of Chemistry metacognition in the Chemistry curriculum. The third implication is that there must be a deliberate effort by the Chemistry curriculum for the promotion of culturally based Chemistry metacognitive skills (Taylor, 1999), as they are non-domain specific and can be used in other domains for in-depth subject understanding.

5.7 SUMMARY

The results of the focus group interview and observations as well as the discussion of the results was the focus of this chapter. These were looked at before the intervention and after the intervention. The next chapter deals with the conclusions, recommendations and limitations of the study.

CHAPTER 6
CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS OF THE STUDY

6.1. INTRODUCTION

The conclusions, recommendations and limitations of this thesis are presented in this chapter. A brief overview of the research is presented first before the conclusions and recommendations are presented. Finally, suggestions for further research and the limitations of the study are presented at the end.

6.2. OVERVIEW

This embedded mixed methods case study's purpose was to determine the influence of indigenous Chemistry knowledge on Chemistry metacognition, resulting in a model of Chemistry metacognition. Due to this cause, the focus of the study was on pre-service science teachers' indigenous Chemistry knowledge and Chemistry metacognition. Chemistry is found to be difficult and challenging subject by pre-service science teachers as they struggle with the Chemistry knowledge, skills and attitudes which is shown by their poor academic performance at the teachers' college in Chemistry. (Mudzakir, 2017; Wheeldon, 2017; Cam, Topcu and Sulun, 2015). Teaching and learning of science that is effective considers the prior knowledge, skills and attitudes of learners that is culturally constructed which they bring into formal science and teaching institutions, opines Lee (2011).

According to Lee (2011), the connecting of a learners' cultural experiences to the formal science institutional practices results in effective science teaching and learning. The marginalisation or ignoring of non-Westerners' culturally based prior knowledge, experiences, language and beliefs results in extra challenges to the learners in the already challenging learning environment of formal science teaching and learning institutions. (Lee, 2011; Quigley, 2009). For Gay (2000), the provision of relevant and effective experiences of learning for learners are brought about by making use of non-Westerners' prior knowledge and experiences when it comes to culturally relevant pedagogy and andragogy.

Chemistry teaching and learning that is ideal comes from the African philosophical orientation, which is culturally relevant and locally contextualised in terms of the generation and dissemination of knowledge, that meets the needs and provides practical solutions to the everyday life chemical problems and challenges of the community. Independent knowledge, more permanent knowledge, learner motivation and improved achievement in education across all age groups, subject areas as well as intellectual abilities are all promoted by metacognition (Smith, Black and Hooper, 2017; Somerville, 2017; Philly-Cormick. and Garrison, 2007; Louca, 2003). The skills of metacognition can be learned and taught by any individual irrespective of subject specialisation, grade (level) or age (Dawson 2008; Louca, 2003).

Chemistry metacognition is the recognition of the value of indigenous Chemistry knowledge (prior knowledge) with an accurate assessment of the demands of a challenging western Chemistry learning activity and what understanding and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic indigenous Chemistry knowledge in a specific situation reliably and efficiently. The brief overview shows that research on indigenous Chemistry knowledge's influence on Chemistry metacognition is required with the aim of using culturally contextualised indigenous Chemistry knowledge in Chemistry metacognition.

6.3. CONCLUSIONS BASED ON RESEARCH SUB-QUESTIONS

This study examined the influence of indigenous Chemistry knowledge on Chemistry metacognition. The metacognition awareness of pre-service science teachers before the indigenous Chemistry knowledge intervention was compared to the metacognition awareness after the indigenous Chemistry metacognition intervention. After examining the eight-week metacognition awareness outcomes of 29 pre-service science teachers in Bulawayo, the descriptive analysis produced a number of major findings. The major conclusions arrived at from these major findings during the study are presented in this section. Recommendations pertaining to each research main finding will be also done in this section. The research sub-questions of the study were based on the main research question: How does indigenous Chemistry knowledge influence Chemistry metacognition?

6.3.1. Conclusions and recommendations for research sub-question one

How much indigenous Chemistry knowledge is possessed by pre-service science teachers? Focus groups interviews of between five to seven pre-service science teachers were conducted orally, in which semi-structured questions were posited for the purpose of capturing the indigenous Chemistry knowledge, skills and attitudes possessed and practiced. Analysis of the data from these focus groups exhibited that pre-service science teachers are repositories of indigenous Chemistry knowledge, skills and attitudes. The findings showed that pre-service science teachers possess and practice a vast amount of indigenous Chemistry knowledge in agriculture, environmental conservation, food processing, food preservation and health-care, complemented by more in other areas.

From these findings, the conclusion drawn is that Chemistry educators such as teachers and lecturers have access to indigenous Chemistry knowledge that is held and practiced by Chemistry learners in their everyday lives for survival. This indigenous Chemistry knowledge represents alternative Chemistry concepts or Chemistry misconceptions from the Chemistry learners' social-cultural life which can either promote or disrupt the western Chemistry teaching and learning process. It is recommended that the indigenous Chemistry knowledge of chemistry learners should be identified and applied constructively in the Chemistry curriculum at teachers' colleges, thereby contextualising the western Chemistry education.

6.3.2 Conclusions and recommendations for research sub-question two

How relevant is indigenous Chemistry knowledge to Chemistry metacognition? Semi-structured focus group questions that looked at characteristics of indigenous Chemistry knowledge were presented to the pre-service science teachers. The analysis showed that there are some Chemistry ideas / concepts in indigenous Chemistry knowledge that are beneficial, useful, reliable, give positive experiences and are similar to western Chemistry ideas and concepts. The findings suggest that indigenous Chemistry knowledge is relevant to chemistry metacognition as it is the prior knowledge for Chemistry metacognition since it utilises empirical Chemistry ideas and concepts.

Thus, the learners' indigenous Chemistry knowledge assists in the understanding of western Chemistry concepts as it comes from learners' everyday socio-cultural life experiences. It can be concluded that Chemistry metacognition can be successfully taught or increased in Chemistry learners by applying indigenous Chemistry knowledge in Chemistry education. What is recommended is that Chemistry educators should be capacitated with the knowledge and skills for identifying learners' indigenous Chemistry knowledge that is relevant to Chemistry metacognition.

6.3.3. Conclusions and recommendations for research sub-question three

How effective is indigenous Chemistry knowledge in Chemistry metacognition? Metacognitive awareness scores of pre-service science teachers were ascertained before and after indigenous Chemistry knowledge intervention using focus group interviews as well as individual pen and paper tests for triangulation purposes. Observation of the application of indigenous Chemistry knowledge by pre-service science teachers before and after the intervention of using indigenous Chemistry knowledge in Chemistry metacognition through the teaching methodologies of collaboration, scaffolding and modelling was also done. The analysis of the metacognitive awareness scores and the application of indigenous Chemistry knowledge showed an increase in both the metacognitive awareness scores and application of indigenous Chemistry knowledge.

The evidence suggests that indigenous Chemistry knowledge is quite effective in influencing Chemistry metacognition positively as there was an improvement of metacognition awareness after the intervention. The evidence also suggests that the intervention increased the academic performance of the pre-service science teachers in Chemistry. The conclusion drawn from the evidence is that Chemistry metacognition and the academic performance of Chemistry learners are significantly influenced using indigenous Chemistry knowledge. The recommendation is that a deliberate systemic concretization of the importance of using indigenous Chemistry knowledge in Chemistry education for the purposes of Chemistry metacognition should be made to Chemistry learners and educators as well as other stakeholders.

6.3.4. Conclusions and recommendations for research sub-question four

What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition? Attitudes towards the use of indigenous Chemistry knowledge in Chemistry metacognition came from focus group interviews. Analysis of the data showed that pre-service science teachers felt that it was acceptable, good and comfortable and their reasons were that it motivated learners, improved Chemistry concepts comprehension, assisted memory retention and brought realia into the Chemistry classroom.

The findings show very positive attitudes towards the use of indigenous Chemistry knowledge in Chemistry metacognition by pre-service science teachers in Chemistry lectures. The conclusion drawn from these findings is that pre-service science teachers favour the inclusion and use of indigenous Chemistry knowledge in Chemistry lectures for purposes of Chemistry metacognition. The recommendation is that Chemistry curriculum developers at teachers' colleges must harness the multicultural indigenous Chemistry knowledge from pre-service science teachers for establishment of a course in indigenous Chemistry knowledge at the tertiary institutions.

6.4. ADDRESS OF THE MAIN RESEARCH QUESTION

How does indigenous Chemistry knowledge influence Chemistry metacognition? Figure 6.1 shows the process of Chemistry metacognition.

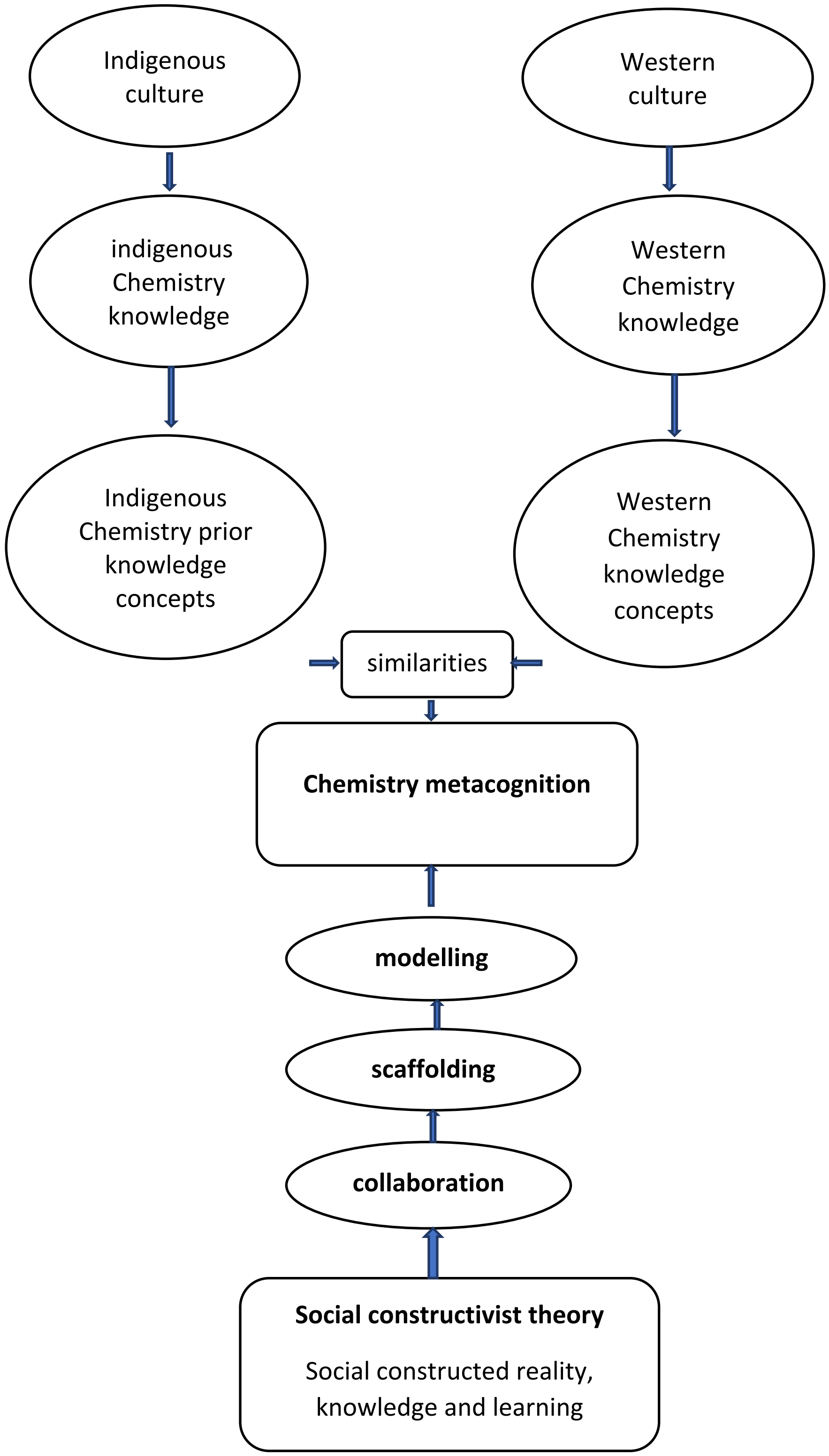

Figure 6.1: Chemistry metacognition process

In sections 2.9 and 6.3, Chemistry metacognition was defined as the recognition of the value of indigenous Chemistry knowledge (prior knowledge) with an accurate assessment of the demands of a challenging western Chemistry learning activity and what understanding and skills are needed as well as the intelligence required to make the right deduction on how to use one's elaborate and systematic indigenous Chemistry knowledge in a specific situation reliably and efficiently.

Pre-service science teachers in this study recognized the value of the indigenous Chemistry knowledge they possessed in vast amounts and practice in their everyday social cultural lives as Chemistry prior knowledge that is relevant in the western Chemistry teaching and learning process. The demands of challenging western Chemistry problems in the topics atomic structure and stoichiometry were accurately assessed by the pre-service science teachers intellectually in terms of understanding and skills required to solve them. The pre-service science teachers could apply their vast indigenous Chemistry knowledge, skills and attitudes reliably and efficiently as Chemistry prior knowledge in examples, describing and explaining western Chemistry concepts in Chemistry lectures to solve Chemistry problems. This study shows that indigenous Chemistry knowledge is quite effective in positively influencing Chemistry metacognition as there was an improvement of metacognition awareness after the intervention.

6.5. MAJOR CONTRIBUTIONS OF THE STUDY TO CHEMISTRY EDUCATION LITERATURE

Four important major contributions to the literature on the influence of indigenous Chemistry knowledge on Chemistry metacognition have been made by this study due to the research in these four areas being relatively new and there is still limited related literature in this area. Figure 6.2 shows the major contributions of the study.

First, the research participants were first year post ordinary level science pre-service science teachers who had no experience of Chemistry education at a tertiary level and found the Chemistry to be challenging, particularly for those who had no previous Chemistry education at any level of education. This study should contribute to the development of methods of identifying and collecting ideological, rational, communal and empirical indigenous Chemistry knowledge possessed by Chemistry learners for use in Chemistry education at this level. The sacred nature of some of the indigenous Chemistry knowledge as well as its visual or oral forms of transmission might pose challenges in terms of its accurate collection for use in Chemistry education.

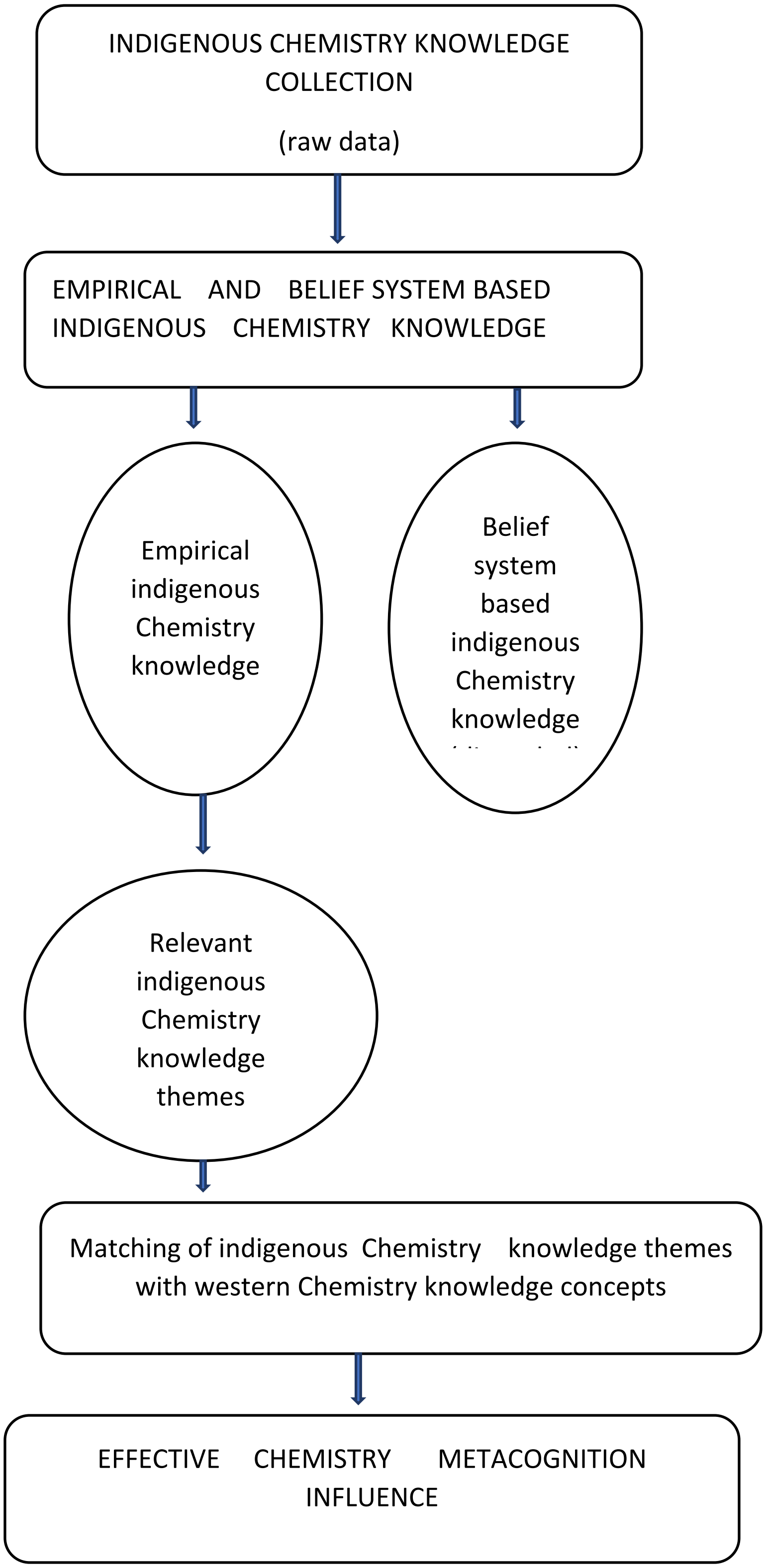

Figure 6.2: Contributions of study to chemistry education

Second, the study looked at the relevance of indigenous Chemistry knowledge in Chemistry metacognition research of which is almost non-existent when compared to the research on the effect of metacognition on academic performance (Van Aswegen, 2015; Aurah, Koloi-Keaikitse, Isaacs and Finch,2011; Rahman, Jumani, Chaudry, Chitsti and Abbasi ,2010). The findings of this study should enhance the literature on the relationship between indigenous Chemistry knowledge and Chemistry metacognition, particularly on how the former influences the latter.

Third, the effectiveness of indigenous Chemistry knowledge on Chemistry metacognition was looked at in this study, which is not familiar to most Chemistry educators. The findings of this study might attract other Chemistry educators to the effect of indigenous Chemistry knowledge on Chemistry metacognition. There is more in-depth Chemistry learning and improved academic performance by Chemistry learners who have acquired Chemistry metacognition skills. Finally, this study on the influence of indigenous Chemistry knowledge on Chemistry metacognition improved the originality of the research. Although the impact of metacognition on academic performance has been analysed since the 1970s (Akman and Alagoz, 2018), the influence of indigenous Chemistry knowledge on Chemistry metacognition has never been done before. This study therefore contributes to new literature in this area.

6.6. FURTHER RESEARCH SUGGESTIONS

Similar studies could be conducted on the same topic of the influence of indigenous Chemistry knowledge on Chemistry metacognition but from different regions of the country and at universities of education.

6.7. LIMITATIONS OF THE STUDY

A number of limitations were encountered in this study. The first and most serious one was the failure to obtain a voice recorder for recording the focus group interviews into printed transcripts due to lack of financial resources. This was overcome through the use of a webcam on a laptop to record the video and audio of the focus group interviews, though there was poor quality of the audio for those respondents who were further from the laptop. This poor audio challenge was overcome through the researcher taking focus group interview notes.

The second limitation was the researchers' outdated nine-year-old dual processor laptop. The laptop would freeze at times and its battery was in bad shape as it could not operate without being connected to the electricity mains. This was compounded by the national electricity load shedding which was at its peak of 18 hours a day (4am to 10pm) for some days from January to March, which were the data collection and data analysis stages of the research. This resulted in some of the data collection stages such as focus group interviews and lecture observations not being recorded. This could have resulted in some useful non-verbal expressions being missed by the researcher. This challenge was overcome by swapping some Chemistry lectures slots which coincided with the electricity load shedding days with physics lectures to reduce the number of lectures not recorded to a level that did not significantly affect the data collection and analysis.

The third limitation was that the two Chemistry practical assessments were conducted after the intervention stage, which was a week before the Covid-19 induced lockdown. This was because the one and only laboratory assistant who is responsible for preparation of all the practicals in the science department (Chemistry included) was on vacation leave from January to mid-March 2020. This made it impossible to have a Chemistry practical observation lecture before the indigenous Chemistry knowledge intervention for comparison with the one after the intervention. However, on a positive note, the Chemistry practical observations after the intervention provided invaluable observations of indigenous Chemistry knowledge applications by the pre-service science teachers. The two chemistry practical reports after the two practicals were done towards the end of march just before the Covid-19 lockdown was enforced on the 28th of March 2020. There were very few Chemistry practical reports that were submitted due the Covid-19 induced lockdown. The Chemistry practical reports are normally submitted a week after the practical is done, which was the week the Covid -19 lockdown was implemented.

6.8. SUMMARY

This chapter dealt with the conclusion, recommendations, further research suggestions and limitations of the study. These concisely highlighted the research's sub-questions and answers, leading to the main research question answer, possible future research, some constraints of the research and how they were solved.

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APPENDIXES

APPENDIX 1:

METACOGNITION AWARENESS FOCUS GROUP INTERVIEW GUIDE

(Adapted from MAI by Schraw and Dennison, 1994)

UNIVERSITY OF SOUTH AFRICA

COLLEGE OF EDUCATION

SCIENCE AND TECHNOLOGY EDUCATION DEPARTMENT

My name is Tavonga Tawanda a PhD in Natural Science Education student researcher with the University of South Africa in the department of Science and Technology Education. The research is entitled: The influence of indigenous knowledge on Chemistry metacognition; a focus on pre-service science teachers in Zimbabwe.

You have invited because you have the desired characteristics for this study in terms of Chemistry learning and have not been exposed to tertiary level Chemistry. This study is expected to collect important information that could simplify and contextualize the teaching and learning of Chemistry concepts for life-long survival and problem-solving skills.

All information provided will be for research purposes only and will be treated with utmost confidentiality. Please answer the questions below. Your responses will be used only for research purposes and will be kept confidential. While your participation is voluntary, your honesty is greatly appreciated.

Discussion guide for focus group interview

Welcome to the focus group interview and thank you very much for volunteering. Your time is appreciated a lot.

Introduction

The design of the discussion of this focus group interview is meant to assess your metacognition awareness. The discussion of this focus group interview will take 2 hours or less. In order to facilitate in the recollection of this focus group discussion, may the discussion the video taped? (the video recorder is switched on if the response is yes)

Anonymity

Although the discussion of the focus group will be taped, you are assured that the discussion shall be anonymous. The tapes shall be stored safely in a facility that is locked up to the time they are word for word transcribed after which they shall be destroyed. The focus group interview transcribed notes will not contain information which will enable individual respondents to be linked to specific statements. You must attempt to answer and comment as truthfully and accurately as possible. It will be appreciated a lot by I and other participants in this focus group interview if the comments from other focus group members are not discussed outside this focus group. There might be discussions or questions that you are not willing to participate in or answer, you should not do so. However, please attempt to be involved and answer as much as possibly you can.

Ground rules

- The rule that is most important is that only one person at a time speaks. There might be a temptation to talk whilst another participant is talking, but may you please wait for them to finish first.
- There will be no answers that are wrong or correct.
- There is no particular order in speaking.
- When you must say something, please do go ahead. It is important to get the views of everyone even though the focus group interview has many participants.
- It is not necessary to be in agreement with other participants' views.
- Any questions from anyone (answers)
- Fine, we may begin.

Metacognition awareness focus group interview questions for pre-service science teachers.

Knowledge about cognition

Declarative knowledge

Question 1. As a Chemistry learner, what are your views on how you learn Chemistry?

………

………

………

Probes:

Do you understand your intellectual strengths and weaknesses?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you know the kind Chemistry information which is important to learn? Are you good at information organisation?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you know what is expected for you to learn by the Chemistry lecturer? Are you good at remembering the information?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you have control on the way you learn? Are you a good judge on the way you understand something?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you learn more when you are interested in the topic?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Procedural knowledge

Question 2. In your Chemistry learning, are strategies involved?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Probes:

Do you use strategies that worked previously? Do you have a particular purpose for every strategy you use?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Are you aware of the strategies you use when studying? Do you find yourself automatically making use of learning strategies that are helpful?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Conditional knowledge

Question 3. Under which circumstance is your Chemistry learning at its best?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Probes:

Do you learn well when you have an idea about the topic?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you apply different strategies of learning that depend on the situation? Are you able to motivate yourself when you need to?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Do you use your intellectual strength used to compensate for the weaknesses you have? Do you know when every strategy you use will be most effective?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Regulation of cognition

Planning

Question 4. Is there any mental preparation for Chemistry learning by you before the lecture?

………

………

Probes:

Do you pace yourself when learning so that you have enough time?

………

………

Do you think what is actually needed before beginning the task?

………

………

Do you set particular goals before you begin a task?

………

………

Do you ask yourself questions about the material to be learnt before you begin?

………

………

Do you think about a number of ways of solving a problem and select the best way?

………

………

Do you carefully read instructions before you begin a task? Do you organise your time for accomplishing your goals the best way?

………

………

Information management strategies

Question 5. How do you handle new information in Chemistry learning?

………

………

Probes:

Do you slow down when you are face information that is important?

………

………

Do focus your attention consciously on information that is important?

………

………

Do you focus on the significance and meaning of information that is new?

………

………

For information to be made more meaningful for you, do you create your own examples?

………

………

Do you draw diagrams or pictures to assist you in understanding whist learning?

………

………

Do you attempt to translate in your own words the new information?

………

………

To help you learn, do you make use of the text's organisational structure?

………

………..

Do you ask yourself If what you are reading is related to what you already know?

………

………

Do you attempt to breakdown studying into steps that are smaller? Do you focus on the overall meaning of the information than specifics?

………

………

Comprehension monitoring

Question 6. Do you assess your own learning whilst learning Chemistry?

………

………

Probes:

Do you ask yourself periodically if your goals are being met by you?

………

………

Before answering, do you consider a number of alternatives to the problem?

………

……….

When solving a particular problem, do you ask yourself if you have considered all possible options?

………

………

To assist you in understanding relationships that are important, do you review periodically?

………

………

Do you find yourself analysing the usefulness of your strategies when studying?

……

……

Do you find yourself regularly pausing to check your comprehension?

……

……

When learning a new concept, do you ask yourself how well you are doing?

……

……

Debugging strategies

Question 7. When faced by challenges in Chemistry learning, what do you do?

……

……

Probes:

When you don't understand something, do you ask others?

……

……

When you fail to understand something, do you change strategies?

……

……

When you get confused, do you re-evaluate your assumptions?

……

……

When new information is not clear, do you stop and go back over the new information?

……

………

When you get confused, do you stop and re-read?

………

………

Evaluation

Question 8. After a Chemistry lecture, do you analyse the effectiveness of your strategies and performance?

……

……

Probes:

When you are done with a test, do you know how well you performed?

………

………

When you are done with a task, do you ask yourself if an easier way for doing things available?

………

………

Do you summarise what your learned at the end of the lecture?

………

………

Do you ask yourself how well you accomplished your goals when you are done?

………

………

After solving a particular problem, do ask yourself if you considered all available options?

………

………

Do you ask yourself if you learned as much as you could possibly have once the lecture is over?

……

……

APPENDIX 2:

METACOGNITION AWARENESS INDIVIDUAL PEN AND PAPER TEST

(Adapted from MAI by Schraw and Dennison, 1994)

COLLEGE OF EDUCATION

SCIENCE AND TECHNOLOGY EDUCATION DEPARTMENT

Metacognition awareness paper and pen test for pre-service science teachers

My name is Tavonga Tawanda a PhD in Natural Science Education student researcher with the University of South Africa in the department of Science and Technology Education. The research is entitled: The influence of indigenous knowledge on Chemistry metacognition; a focus on pre-service science teachers in Zimbabwe.

You have invited because you have the desired characteristics for this study in terms of Chemistry learning and have not been exposed to tertiary level Chemistry. This study is expected to collect important information that could simplify and contextualize the teaching and learning of Chemistry concepts for life-long survival and problem-solving skills.

All information provided will be for research purposes only and will be treated with utmost confidentiality. Please answer the questions below. Your responses will be used only for research purposes and will be kept confidential. While your participation is voluntary, your honesty is greatly appreciated.

Instructions to respondents

Please feel free to express your feelings and beliefs as accurately and honestly as possible

Please NOTE that your name should NOT be indicated on the test paper.

Question 1. As a Chemistry learner, what are your views on how you learn Chemistry?

………

………

………

………

(i). Do you understand your intellectual strengths and weaknesses?

……………………………………………………………………………………………………..

(ii). Do you know the kind Chemistry information which is important to learn?

………………………………………………………………………………………………………

(iii). Are you good at information organisation?

……………………………………………………………………………………………………

(iv). Do you know what is expected for you to learn by the Chemistry lecturer?

……………………………………………………………………………………………………

(v). Are you good at remembering the information?

……………………………………………………………………………………………………

(vi). Do you have control over the way you learn?

……………………………………………………………………………………………………

(vii). Are you a good judge on the way you understand something?

……………………………………………………………………………………………………

(viii). Do you learn more when you are interested in the topic?

………………………………………………………………………………………………………

Question 2. In your Chemistry learning, are strategies involved?

………………………………………………………………………………………………………

(i). Do you use strategies that worked previously?

………………………………………………………………………………………………………

(ii). Do you have a particular purpose for every strategy you use?

…………………………………………………………………………………………………

(iii). Are you aware of the strategies you use when studying?

……………………………………………………………………………………………………

(iv). Do you find yourself automatically making use of learning strategies that are helpful?

……

Question 3. Under which circumstance is your Chemistry learning at its best?

………………………………………………………………………………………………………

(i). Do you learn well when you have an idea about the topic?

………

(ii). Do you apply different strategies of learning that depend on the situation?

………

(iii). Are you able to motivate yourself when you need to?

……

(iv). Do you use your intellectual strength used to compensate for the weaknesses you have?

……

(v). Do you know when every strategy you use will be most effective?

……

Question 4. Is there any mental preparation for Chemistry learning by you before the lecture?

……

(i). Do you pace yourself when learning so that you have enough time?

……

(ii). Do you think what is actually needed before beginning the task?

……

(iii). Do you set particular goals before you begin a task?

……

(iv). Do you ask yourself questions about the material to be learnt before you begin?

………

(v). Do you think about a number of ways of solving a problem and select the best way?

……

(vi). Do you carefully read instructions before you begin a task?

……

(vii). Do you organise your time for accomplishing your goals the best way?

……

Question 5. How do you handle new information in Chemistry learning?

……

(i). Do you slow down when you are face information that is important?

……

(ii). Do focus your attention consciously on information that is important?

……

(iii). Do you focus on the significance and meaning of information that is new?

……

(iv). For information to be made more meaningful for you, do you create your own examples?

……

(v). Do you draw diagrams or pictures to assist you in understanding whist learning?

……

(vi). Do you attempt to translate in your own words the new information?

……

(vii). To help you learn, do you make use of the text's organisational structure?

……

(viii). Do you ask yourself If what you are reading is related to what you already know?

……

(ix). Do you attempt to breakdown studying into steps that are smaller?

……

(x). Do you focus on the overall meaning of the information than specific?

……

Question 6. Do you assess your own learning whilst learning Chemistry?

………

(i). Do you ask yourself periodically if your goals are being met by you?

……

(ii). Before answering, do you consider a number of alternatives to the problem?

……

(iii). When solving a particular problem, do you ask yourself if you have considered all possible options?

……

(iv). To assist you in understanding relationships that are important, do you review periodically?

………

(v). Do you find yourself analysing the usefulness of your strategies when studying?

……

(vi). Do you find yourself regularly pausing to check your comprehension?

……

(vii). When learning a new concept, do you ask yourself how well you are doing?

……

Question 7. When faced by challenges in Chemistry learning, what do you do?

……

(i). When you don't understand something, do you ask others?

……..

(ii). When you fail to understand something, do you change strategies?

………

(iii). When you get confused, do you re-evaluate your assumptions?

……

(iv). When new information is not clear, do you stop and go back over the new information?

……

(v). When you get confused, do you stop and re-read?

…….

Question 8. After a Chemistry lecture, do you analyse the effectiveness of your strategies and performance?

……….

(i). When you are done with a test, do you know how well you performed?

……

(ii). When you are done with a task, do you ask yourself if an easier way for doing things available?

………

(iii). Do you summarise what your learned at the end of the lecture?

……….

(iv). Do you ask yourself how well you accomplished your goals when you are done?

……….

(v). After solving a particular problem, do ask yourself if you considered all available options?

……..

(vi). Do you ask yourself if you learned as much as you could possibly have once the lecture is over?

……

APPENDIX 3:

INDIGENOUS CHEMISTRY KNOWLEDGE FOCUS GROUP INTERVIEW GUIDE

UNIVERSITY OF SOUTH AFRICA

COLLEGE OF EDUCATION

SCIENCE AND TECHNOLOGY EDUCATION DEPARTMENT

My name is Tavonga Tawanda a PhD in Natural Science Education student researcher with the University of South Africa in the department of Science and Technology Education. The research is entitled: The influence of indigenous knowledge on Chemistry metacognition; a focus on pre-service science teachers in Zimbabwe.

You have invited because you have the desired characteristics for this study in terms of Chemistry learning and have not been exposed to tertiary level Chemistry. This study is expected to collect important information that could simplify and contextualize the teaching and learning of Chemistry concepts for life-long survival and problem-solving skills.

All information provided will be for research purposes only and will be treated with utmost confidentiality. Please answer the questions below. Your responses will be used only for research purposes and will be kept confidential. While your participation is voluntary, your honesty is greatly appreciated.

Discussion guide for focus group interview

Welcome to the focus group interview and thank you very much for volunteering. Your time is appreciated a lot.

Introduction

The design of the discussion of this focus group interview is meant to collect your indigenous Chemistry knowledge, skills and attitudes that you possess. The discussion of this focus group interview will take 2 hours or less. In order to facilitate in the recollection of this focus group discussion, may the discussion the taped? (the recorder is switched on if the response is yes)

Anonymity

Although the discussion of the focus group will be taped, you are assured that the discussion shall be anonymous. The tapes shall be stored safely in a facility that is locked up to the time they are word for word transcribed after which they shall be destroyed. The focus group interview transcribed notes will not contain information which will enable individual respondents to be linked to specific statements. You must attempt to answer and comment as truthfully and accurately as possible. It will be appreciated a lot by I and other participants in this focus group interview if the comments from other focus group members are not discussed outside this focus group. There might be discussions or questions that you are not willing to participate in or answer, you should not do so. However, please attempt to be involved and answer as much as possibly you can.

Ground rules

- The rule that is most important is that only one person at a time speaks. There might be a temptation to talk whilst another participant is talking, but may you please wait for them to finish first.
- There will be no answers that are wrong or correct.
- There is no particular order in speaking.
- When you must say something, please do go ahead. It is important to get the views of everyone even though the focus group interview has many participants.
- It is not necessary to be in agreement with other participants' views.
- Any questions from anyone (answers)
- Fine, we may begin.

Indigenous Chemistry knowledge, skills and attitudes focus group questions for pre-service science teachers

Question 1. What do you think indigenous knowledge, skills and attitudes are?

Indigenous……………………………………………………………………………………………

Knowledge……………………………………………………………………………………………

Skills…………………………………………………………………………………………………

Attitudes……………………………………………………………………………………………..

Probes:

How do you get knowledge(understanding), skills and attitudes?

………

………

Does knowledge, skills and attitudes depend on locality, place, culture or society?

……

……

Are knowledge, skills and attitudes unique to a particular locality, culture and society?

……

……

Question 2. What indigenous knowledge, skills and attitudes do you know or possess?

……

……

Probes:

Do you know your knowledge, skills and attitudes that are specifically from your locality, culture and society?

……

……

Which aspects of your knowledge, skills and attitudes are specifically from your culture or society?

……

……

How do you identify or see that the knowledge, skills and attitudes are from your locality, culture or society?

……

……

Question 3. Which indigenous knowledge, skills and attitudes is practised in your community in agriculture, environmental conservation, food processing, food preservation, health care and other aspects of community life in general?

……

……

Probes:

Do you have cultural or societal unique methods of farming, environmental conservation, food processing, food preservation, healthcare practices (medical practices and medicines).

………

………

Are staple foods the same in different localities, culture and societies? How is fresh meat and vegetables preserved in your culture? How is sadza (thick porridge) prepare in your locality, culture and society?

………

………

Question 4. Which indigenous knowledge, skills and attitudes do you think uses Chemistry ideas / concepts?

………

………

Probe:

Can you identify the Chemistry that is cultural in your agriculture, environmental preservation, food processing, food preservation, health care and other community activities?

………

………

Question 5. What do you like best about indigenous Chemistry knowledge, skills and attitudes?

………

………

Probe:

Are you aware of characteristics of indigenous Chemistry knowledge, skills and attitudes that are beneficial? How efficient are indigenous Chemistry knowledge, skills and attitudes?

………

………

Question 6. How useful or reliable is indigenous Chemistry knowledge, skills and attitudes in your everyday life?

………

……………………………………………………………………………………………………

Probe:

To what extent are indigenous chemistry knowledge, skills and attitudes useful? Can you depend on indigenous chemistry knowledge, skills and attitudes?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Question 7. What kind of experiences have you had with indigenous knowledge, skills and attitudes Chemistry knowledge?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Probes:

Where the indigenous Chemistry knowledge, skills and attitudes experiences positive or negative?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

How easy or difficult are the indigenous Chemistry knowledge, skills and attitudes to master?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Question 8. What does indigenous Chemistry knowledge, skills and attitudes, have in common with formal school/college Chemistry?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Probes:

Is there any relationship between indigenous Chemistry knowledge, skills and attitudes and formal college Chemistry?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

What type of relationship is there?

……

……

Question 9. How do you feel about using indigenous Chemistry knowledge, skills and attitudes in the Chemistry lectures?

……

……

Probes:

Would you like the use of indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

How important is the use of indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

Question 10. How would you use indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

Probes:

How would you apply indigenous Chemistry knowledge, skills and attitudes effectively in Chemistry lectures?

……

……

Of what assistance is indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

Question 11. What problems do you see in using indigenous Chemistry knowledge skills and attitudes in Chemistry lectures and how can these problems to overcome?

……

……

Probes:

What challenges are likely to result from using indigenous Chemistry knowledge skills and attitudes in Chemistry lectures?

……

……

In which ways can these challenges be solved?

……

……

Question 12. What are the advantages and disadvantages of using indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

………………………………………………………………………………………………………

Probes:

What benefits are there in using indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

Could the use indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures have negative consequences?

……

……

May state these negative consequences?

……

……

Question 13. What do you think is the best approach in using indigenous Chemistry knowledge, skills and attitudes in Chemistry lectures?

……

……

Probes:

How can indigenous Chemistry knowledge, skills and attitudes effectively in Chemistry lectures?

……

……

What teaching methodologies can be used in using indigenous Chemistry knowledge, skills and attitudes in chemistry lectures?

……

……

Question 14. Is there anything else you would like to say about indigenous Chemistry knowledge, skills and attitudes?

……

……

Probes:

Was anything on indigenous Chemistry knowledge, skills and attitudes left out which you would like to point out?

……

……

……

……

……

Has everything on indigenous Chemistry knowledge, skills and attitudes been discussed?

……

……

……

……

……

APPENDIX 4:

APPLICATION OF INDIGENOUS CHEMISTRY KNOWLEDGE OBSERVATION GUIDE

UNISA college of education

UNIVERSITY OF SOUTH AFRICA

COLLEGE OF EDUCATION

SCIENCE AND TECHNOLOGY EDUCATION DEPARTMENT

Application of indigenous Chemistry knowledge observation schedule for pre-service science teachers

Name of the lecturer:

Date:

Lecture session:

Topic:

The application of indigenous Chemistry knowledge in Chemistry and science education lectures			
This schedule is intended to capture the level of pre-service science teachers' application of indigenous Chemistry knowledge.			
Topic	Low	Medium	High
	Indigenous knowledge ideas / concepts are mentioned in relation to Chemistry concepts by pre-service science teachers	Pre-service science teachers explain in indigenous knowledge concepts / ideas a Chemistry concept.	Application of ideas / concepts from indigenous knowledge by pre-service science teachers in Chemistry concepts
	Pre-service science teachers mention indigenous knowledge concepts /ideas that are related to Chemistry concepts.	There is description of indigenous knowledge ideas / concepts in Chemistry concepts by pre-service science teachers.	Indigenous knowledge ideas / concepts are applied by pre-service science teachers in Chemistry concepts

Description of lecture	Reflective notes (hunches, themes, insights)

APPENDIX 5:

ETHICS CLEARANCE

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2019/07/24

Ref: **2019/07/24/63816997/18/MC**
Name: Mr T Tawanda
Student No.: 63816997

Dear Mr Tawanda

Decision: Ethics Approval from 2019/07/24to 2024/07/24

Researcher(s): Name: Mr T Tawanda
E-mail address: tavongatawanda@gmail.com
Telephone: +263 71 229 2208

Supervisor(s): Name: Prof AV Mudau
E-mail address: mudauav@unisa.ac.za
Telephone: +27 12 429 6353

Title of research:

The influence of indigenous knowledge on chemistry metacognition; a focus on pre-service science teachers in Zimbabwe.

Qualification: D. Ed in Natural Science Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2019/07/24 to 2024/07/24.

*The **low risk** application was reviewed by the Ethics Review Committee on 2019/07/24 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa

3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No field work activities may continue after the expiry date **2024/07/24**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2019/07/24/63816997/18/MC** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof PM Sebate
ACTING EXECUTIVE DEAN
Sebatpm@unisa.ac.za

Approved - decision template – updated 16 Feb 2017

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX 6:

MHTESTD CLEARANCE LETTER

All official communications should be addressed to:
"The Secretary for Higher & Tertiary Education
Telephones: 795891-5, 796441-9, 730055-9
Fax Numbers: 792109, 728730, 703957
E-mail: thesecretary@mhet.ac.zw
Telegraphic address: "EDUCATION"

ZIMBABWE

Reference:

MINISTRY OF HIGHER AND TERTIARY EDUCATION, SCIENCE AND TECHNOLOGY DEVELOPMENT
P. BAG CY 7732
CAUSEWAY

11 September 2019

Mr Tavonga Tawanda
Hillside Teachers College
P.Bag 2
Hillside
BULAWAYO

Mr Tawanda

REQUEST FOR AUTHORITY TO CARRY OUT RESEARCH ON "THE INFLUENCE OF INDIGENOUS KNOWLEDGE ON CHEMISTRY METACOGNITION; A FOCUS ON PRE-SERVICE SCIENCE TEACHERS IN ZIMBABWE": MINISTRY OF HIGHER AND TERTIARY EDUCATION, SCIENCE AND TECHNOLOGY DEVELOPMENT

Reference is made to your letter in which you requested for permission to carry out a research on **"THE INFLUENCE OF INDIGENOUS KNOWLEDGE ON CHEMISTRY METACOGNITION; A FOCUS ON PRE-SERVICE SCIENCE TEACHERS IN ZIMBABWE": MINISTRY OF HIGHER AND TERTIARY EDUCATION, SCIENCE AND TECHNOLOGY DEVELOPMENT**.

Accordingly, please be advised that the Head of Ministry has granted you permission to carry out the research.

It is hoped that your research will benefit the Ministry and it would be appreciated if you could supply the office of the Permanent Secretary with a final copy of your study, as the findings would be relevant to the Ministry's strategic planning process.

S. Nhenjana (Mr)
Deputy Director - Human Resources
FOR: PERMANENT SECRETARY

APPENDIX 7:

UCE CLEARANCE LETTER

UNITED COLLEGE OF EDUCATION

All communications to be addressed to
"The Principal"
United College of Education
P.O. Box 1156
Bulawayo Zimbabwe

Reference:
Telephone: (263 29) 2229466, 2201162
Email: ucecollege@yahoo.com
Fax: (263 29) 2214101

Mr Tavonga Tawanda

Hillside Trs College

Bulawayo

17/09/19

REF: Request for permission to conduct a pilot study at United College of Education

The above matter refers;

I write to inform you that your request for permission to conduct a pilot study at this institution has been granted. The head of department will assist you

Wish you success

Thank you

R Mavunga

(Vice Principal)

VICE PRINCIPAL
Min. of Higher & Tertiary Educ. Science & Tech. Development
United College of Education
17 SEP 2019
P.O. BOX 1156, BULAWAYO
ZIMBABWE TEL: 09-219462

APPENDIX 8:

HTC CLEARANCE LETTER

APPENDIX G: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

UNISA

Hillside Teachers' College

P. Bag 2

Hillside

Bulawayo

Zimbabwe

MINISTRY OF HIGHER & TERTIARY EDUCATION SCIENCE & TECHNOLOGY DEVELOPMENT
HILLSIDE TEACHERS' COLLEGE
18 SEP 2019
PRINCIPAL
P BAG 2 HILLSIDE BULAWAYO

Approved

12 September 2019

17 SEP 2019
VICE PRINCIPAL

The Principal

Hillside Teachers' College

P. Bag 2

Hillside

Bulawayo

Zimbabwe

Dear Sir/ Madam

REF: **Request for permission to conduct research at Hillside Teachers' College.**

I, Tavonga Tawanda I am doing research under supervision of Prof A.V. Mudau, a professor in the Department of Science and Technology Education towards a PhD at the University of South Africa. Prof A.V. Mudau's contact details are mudauav@unisa.ac.za and +27124296353. My University of South Africa ethical clearance certificate is 2019/07/24/63816997/18/MC. I have also attached a letter requesting permission to conduct research in the Ministry of Higher and Tertiary Education, Science and Technology Development permission and the ministry's' letter granting the permission.

I am requesting for permission to conduct research at Hillside Teachers' College. The research is entitled: The influence of indigenous knowledge on chemistry metacognition; a focus on pre-service science teachers in Zimbabwe. The study will entail a qualitative single case study in which the metacognition awareness level of pre-service science teachers will be assessed before and after an intervention stage using focus groups, observations and document analysis. The aim of the study is to explore the use of culturally contextualized

APPENDIX 9:

METACOGNITION AWARENESS SCORES

Group 1

Group 1 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	$^{3}/_{8}$ = 37.5
Procedural Knowledge	$^{4}/_{4}$ = 100
Conditional Knowledge	$^{5}/_{5}$ = 100
Planning	$^{7}/_{7}$ = 100
Information Management Strategies	$^{8}/_{10}$ =80
Comprehension Monitoring	$^{7}/_{7}$ = 100
Debugging Strategies	$^{3}/_{5}$ = 60
Evaluation	$^{4}/_{6}$ = 66.67

Group 1 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	Pre-service science teacher B Score (%)	Pre-service science teacher C Score (%)	Pre-service science teacher D Score (%)	Pre-service science teacher E Score (%)	Average score of A to E Scores (%)
Metacognition components						
Declarative Knowledge	$^{6}/_{8}$ = 75	$^{6}/_{8}$ = 75	$^{5}/_{8}$ = 62.5	$^{3}/_{8}$ = 37.5	$^{5}/_{8}$ = 62.5	62.5
Procedural Knowledge	$^{4}/_{4}$ = 100	$^{4}/_{4}$ = 100	$^{3}/_{4}$ = 75	$^{4}/_{4}$ =100	$^{4}/_{4}$ = 100	95
Conditional Knowledge	$^{5}/_{5}$ = 100	$^{4}/_{5}$ = 80	$^{4}/_{5}$ = 80	$^{5}/_{5}$ = 100	$^{4}/_{5}$ = 80	88
Planning	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	100
Information Management Strategies	$^{10}/_{10}$ = 100	$^{10}/_{10}$ = 100	$^{10}/_{10}$ = 100	$^{8}/_{10}$ = 80	$^{10}/_{10}$ = 100	96
Comprehension Monitoring	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	$^{7}/_{7}$ = 100	$^{6}/_{7}$ = 85.71	$^{6}/_{7}$ = 85.71	94.28
Debugging Strategies	$^{5}/_{5}$ = 100	$^{5}/_{5}$ = 100	$^{4}/_{5}$ = 80	$^{2}/_{5}$ = 40	$^{5}/_{5}$ = 100	84
Evaluation	$^{6}/_{6}$ = 100	$^{6}/_{6}$ = 100	$^{6}/_{6}$ = 100	$^{5}/_{6}$ = 83.33	$^{5}/_{6}$ = 83.33	93.33

Group 2

Group 2 focus group metacognition awareness

Metacognition components	**Score (%)**
Declarative Knowledge	$^{3}/_{8}$ = 37.5
Procedural Knowledge	$^{3}/_{4}$ = 75
Conditional Knowledge	$^{4}/_{5}$ = 80
Planning	$^{5}/_{7}$ = 71.43
Information Management Strategies	$^{5}/_{10}$ = 50
Comprehension Monitoring	$^{4}/_{7}$ = 57.14
Debugging Strategies	$^{5}/_{5}$ = 100
Evaluation	$^{1}/_{6}$ = 16.67

Group 2 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Average of A to F Scores (%)**
Metacognition components							
Declarative Knowledge	$^{6}/_{8}$=75	$^{5}/_{8}$=62.5	$^{6}/_{8}$=75	$^{8}/_{8}$=100	$^{7}/_{8}$=87.5	$^{7}/_{8}$=87.5	81.25
Procedural Knowledge	$^{2}/_{4}$=50	$^{1}/_{4}$ = 25	$^{4}/_{4}$=100	$^{3}/_{4}$= 75	$^{2}/_{4}$=50	$^{3}/_{4}$=75	62.5
Conditional Knowledge	$^{3}/_{5}$=60	$^{3}/_{5}$=60	$^{4}/_{5}$=80	$^{4}/^{5}$=80	$^{3}/_{5}$=60	$^{5}/_{5}$=100	73.33
Planning	$^{3}/_{7}$=42.86	$^{2}/_{7}$=28.57	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{3}/_{7}$=42.86	$^{5}/_{7}$=71.43	64.29
Information Management Strategies	$^{8}/_{10}$=80	$^{7}/_{10}$=70	$^{8}/_{10}$=80	$^{7}/_{10}$=70	$^{5}/_{10}$=50	$^{5}/_{10}$=50	66.67
Comprehension Monitoring	$^{6}/_{7}$=85.71	$^{4}/_{7}$=57.14	$^{6}/_{7}$=85.71	$^{3}/_{7}$=42.86	$^{4}/_{7}$=57.14	$^{3}/_{7}$=42.86	61.90
Debugging Strategies	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	96.67
Evaluation	$^{5}/_{6}$=83.33	$^{3}/_{6}$=50	$^{5}/_{6}$=83.33	$^{3}/_{6}$=50	$^{2}/_{6}$=33.33	$^{2}/_{6}$=33.33	55.55

Group 3

Group 3 focus group metacognition awareness

Metacognition components	**Score (%)**
Declarative Knowledge	$^{5}/_{8}$=62.5
Procedural Knowledge	$^{2}/_{4}$=50
Conditional Knowledge	$^{1}/_{5}$=20
Planning	$^{4}/_{7}$=57.14
Information Management Strategies	$^{4}/_{10}$=40
Comprehension Monitoring	$^{4}/_{7}$=57.14
Debugging Strategies	$^{5}/_{5}$=100
Evaluation	$^{2}/_{6}$=33.33

Group 3 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Average of A to F Scores (%)**
Metacognition components							
Declarative Knowledge	$^{5}/_{8}$=62.5	$^{5}/_{8}$=62.5	$^{5}/_{8}$=62.5	$^{5}/_{8}$=62.5	$^{5}/_{8}$=62.5	$^{3}/_{8}$=37.5	58.33
Procedural Knowledge	$^{4}/_{4}$=100	$^{1}/_{4}$=25	$^{3}/_{4}$= 75	$^{2}/_{4}$=50	$^{2}/_{4}$=50	$^{2}/_{4}$=50	58.33
Conditional Knowledge	$^{3}/_{5}$=60	$^{2}/_{5}$=40	$^{5}/_{5}$=100	$^{1}/_{5}$=20	$^{3}/_{5}$=60	$^{2}/_{5}$=40	53.33
Planning	$^{6}/_{7}$=85.71	$^{3}/_{7}$=42.86	$^{6}/_{7}$=85.71	$^{3}/_{7}$=42.86	$^{4}/_{7}$=57.14	$^{4}/_{7}$=57.14	61.90
Information Management Strategies	$^{7}/_{10}$=70	$^{6}/_{10=}$ 60	$^{8}/_{10}$=80	$^{8}/_{10}$=80	$^{6}/_{10}$=60	$^{8}/_{10}$=80	71.67
Comprehension Monitoring	$^{6}/_{7}$=85.71	$^{6}/_{7}$=85.71	$^{6}/_{7}$=85.71	$^{3}/_{7}$=42.86	$^{4}/_{7}$=57.14	$^{5}/_{7}$=71.43	71.43
Debugging Strategies	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{4}/_{5}$=80	93.33
Evaluation	$^{5}/_{6}$=83.33	$^{3}/_{6}$=50	$^{6}/_{6}$=100	$^{1}/_{6}$=16.67	$^{4}/_{6}$=66.67	$^{3}/_{6}$=50	61.11

Group 4

Group 4 focus group metacognition awareness

Metacognition components	**Score (%)**
Declarative Knowledge	$^{1}/_{8}$=12.50
Procedural Knowledge	$^{0}/_{4}$=00
Conditional Knowledge	$^{3}/_{5}$=60
Planning	$^{4}/_{7}$=57.14
Information Management Strategies	$^{6}/_{10}$=60
Comprehension Monitoring	$^{5}/_{7}$=71.43
Debugging Strategies	$^{5}/_{5}$=100
Evaluation	$^{3}/_{6}$=50

Group 4 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Pre-service science teacher G Score (%)**	**Average of A to G Scores (%)**
Metacognition components								
Declarative Knowledge	$^{7}/_{8}$=87.50	$^{4}/_{8}$=50	$^{6}/_{8}$=75	$^{6}/_{8}$=75	$^{1}/_{8}$=12.50	$^{7}/_{8}$=87.50	$^{5}/_{8}$=62.50	64.29
Procedural Knowledge	$^{2}/_{4}$=50	$^{2}/_{4}$=50	$^{3}/_{4}$= 75	$^{3}/_{4}$ =75	$^{1}/_{4}$= 25	$^{3}/_{4}$ =75	$^{0}/_{4}$=00	50
Conditional Knowledge	$^{3}/_{5}$=60	$^{3}/_{5}$=60	$^{4}/_{5}$=80	$^{4}/_{5}$=80	$^{1}/_{5}$=20	$^{5}/_{5}$=100	$^{4}/_{5}$=80	68.57
Planning	$^{6}/_{7}$=85.71	$^{4}/_{7}$=57.14	$^{6}/_{7}$=85.71	$^{7}/_{7}$=100	$^{3}/_{7}$=42.86	$^{5}/_{7}$=71.43	$^{5}/_{7}$=71.43	73.47
Information Management Strategies	$^{9}/_{10}$=90	$^{7}/_{10}$=70	$^{8}/_{10}$=80	$^{6}/_{10}$=60	$^{6}/_{10}$=60	$^{8}/_{10}$=80	$^{5}/_{10}$=50	70
Comprehension Monitoring	$^{6}/_{7}$=85.71	$^{4}/_{7}$=57.14	$^{5}/_{7}$=71.43	$^{5}/_{7}$=71.43	$^{3}/_{7}$=42.86	$^{6}/_{7}$=85.71	$^{3}/_{7}$=42.86	65.31
Debugging Strategies	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{4}/_{5}$=80	$^{3}/_{5}$=60	82.86
Evaluation	$^{6}/_{6}$=100	$^{1}/_{6}$=16.67	$^{3}/_{6}$=50	$^{4}/_{6}$=66.67	$^{3}/_{6}$=50	$^{5}/_{6}$=83.33	$^{3}/_{6}$=50	59.52

Group 5

Group 5 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	$^{5}/_{8}$=62.50
Procedural Knowledge	$^{4}/_{4}$=100
Conditional Knowledge	$^{4}/_{5}$=80
Planning	$^{6}/_{7}$=85.71
Information Management Strategies	$^{5}/_{10}$=50
Comprehension Monitoring	$^{3}/_{7}$=42.86
Debugging Strategies	$^{2}/_{5}$=40
Evaluation	$^{3}/_{6}$=60

Group 5 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	Pre-service science teacher B Score (%)	Pre-service science teacher C Score (%)	Pre-service science teacher D Score (%)	Average of A to D Scores (%)
Metacognition components					
Declarative Knowledge	$^{7}/_{8}$=87.50	$^{7}/_{8}$=87.50	$^{7}/_{8}$=87.50	$^{6}/_{8}$=75	84.38
Procedural Knowledge	$^{3}/_{4}$ =75	$^{4}/_{4}$=100	$^{4}/_{4}$=100	$^{4}/_{4}$=100	93.75
Conditional Knowledge	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{4}/_{5}$=80	90
Planning	$^{7}/_{7}$=100	$^{6}/_{7}$=85.71	$^{5}/_{7}$=71.43	$^{5}/_{7}$=71.43	82.14
Information Management Strategies	$^{10}/_{10}$=100	$^{5}/_{10}$=50	$^{6}/_{8}$=75	$^{8}/_{10}$=80	76.25
Comprehension Monitoring	$^{5}/_{7}$=71.43	$^{5}/_{7}$=71.43	$^{7}/_{7}$=100	$^{4}/_{7}$=57.14	90
Debugging Strategies	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{4}/_{5}$=80	90
Evaluation	$^{5}/_{6}$=83.33	$^{4}/_{6}$=66.67	$^{6}/_{6}$=100	$^{3}/_{6}$=50	75

Average metacognition awareness of the focus groups

Metacognition Component	Average group score (%)
Declarative Knowledge	42.5
Procedural Knowledge	65
Conditional Knowledge	68
Planning	74.28
Information Management Strategies	56
Comprehension Monitoring	65.71
Debugging Strategies	80
Evaluation	45

Average metacognition awareness of pen and paper test

Metacognition Component	**Average group score (%)**
Declarative Knowledge	68.1
Procedural Knowledge	69.83
Conditional Knowledge	73.79
Planning	75.86
Information Management Strategies	75.34
Comprehension Monitoring	73.4
Debugging Strategies	88.28
Evaluation	67.24

STATISTICAL METHOD FOR THE VALIDATION OF DATA

PEARSON PRODUCT MOMENT CORRELATION

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\text{sqrt}[n(\sum x^2) - (\sum x)^2] \cdot \text{sqrt}[n(\sum y^2) - (\sum y)^2]}$$

Where:

r_{xy} is the correlation coefficient between X and Y.

n is the size of the sample.

X is the average focus groups scores on the X variable.

Y is the average pen and paper tests scores on the Y variable.

XY is the product of each average focus groups score times its corresponding average pen and paper score.

X^2 is the average focus group score squared.

Y^2 is the average pen and paper score squared.

Pearson Product Moment Correlation (N=8)

Correlation of the average focus groups score with average pen and paper test.

Metacognition component	X (focus group)	Y (pen and paper test)	XY	X^2	Y^2
Declarative Knowledge	42.5	68.10	2894.25	1806.25	4637.61
Procedural Knowledge	65	69.83	4538.95	4225	4876.23
Conditional Knowledge	68	73.79	5634.88	5517.52	5754.74
Planning	74.28	75.86	5634.88	5517.52	5754.74
Information Management Strategies	56	75.34	4219.04	3136	5676.12
Comprehension Monitoring	65.71	73.4	4823.11	4317.80	5387.56
Debugging Strategies	80	88.28	7062.4	6400	7793.36
Evaluation	45	67.24	3025.8	2025	4521.22
	$\Sigma X=496.49$	$\Sigma Y=591.84$	$\Sigma XY=37216.15$	$\Sigma X^2=32051.57$	$\Sigma Y^2=44091.8$

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\text{sqrt}[n(\sum x^2) - (\sum x)^2] \cdot \text{sqrt}[n(\sum y^2) - (\sum y)^2]}$$

$$= \frac{8(37216.15) - (496.49)(591.84)}{\text{sqrt}[8(32051.57) - (496.49)^2] \cdot \text{sqrt}[8(4409.8) - (591.84)^2]}$$

$$= \frac{297729.2 - 293842.6416}{\text{sqrt}[(9910.2399)] \cdot \text{sqrt}[(2459.8144)]}$$

$$= \frac{3886.5584}{99.55018785 \times 49.59651601}$$

$$= \frac{3886.5584}{4937.342486}$$

$= 0.78717618$

$= 0.79$

The coefficient of determination (r^2)

$r^2 = (0.79)^2$

$= 62.41\%$

METACOGNITION AWARENESS ASSEESMENT TWO

Group 1

Group 1 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	$^8/_8$ = 100
Procedural Knowledge	$^4/_4$ = 100
Conditional Knowledge	$^5/_5$ = 100
Planning	$^7/_7$ = 100
Information Management Strategies	$^{10}/_{10}$ =100
Comprehension Monitoring	$^7/_7$ = 100
Debugging Strategies	$^5/_5$ = 100
Evaluation	$^6/_6$ =

Group 1 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	Pre-service science teacher B Score (%)	Pre-service science teacher C Score (%)	Pre-service science teacher D Score (%)	Pre-service science teacher E Score (%)	Pre-service science teacher F Score (%)	Average score of A to E Scores (%)
Metacognition components							
Declarative Knowledge	$^8/_8$ = 100	$^8/_8$ = 100	$^8/_8$ = 100	$^8/_8$ = 100		$^8/_8$ = 100	100
Procedural Knowledge	$^4/_4$ = 100	$^4/_4$ = 100	$^4/_4$ = 100	$^4/_4$ =100		$^4/_4$ = 100	100
Conditional Knowledge	$^5/_5$ = 100	$^5/_5$ = 100	$^5/_5$ = 100	$^5/_5$ = 100		$^5/_5$ = 100	100
Planning	$^7/_7$ = 100	$^7/_7$ = 100	$^7/_7$ = 100	$^7/_7$ = 100		$^7/_7$ = 100	100
Information Management Strategies	$^{10}/_{10}$ = 100	$^{10}/_{10}$ = 100	$^{10}/_{10}$ = 100	$^{10}/_{10}$ = 100		$^{10}/_{10}$ =100	100
Comprehension Monitoring	$^7/_7$ = 100	$^7/_7$ = 100	$^7/_7$ = 100	$^7/_7$ = 100		$^7/_7$ = 100	100
Debugging Strategies	$^5/_5$ = 100	$^5/_5$ = 100	$^5/_5$ = 100	$^5/_5$ = 100		$^5/_5$ = 100	100
Evaluation	$^6/_6$ = 100	$^6/_6$ = 100	$^6/_6$ = 100	$^6/_6$ = 100		$^6/_6$ =100	100

Group 2

Group 2 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	${}^{7}/_{8}$ = 87.5
Procedural Knowledge	${}^{4}/_{4}$ = 100
Conditional Knowledge	${}^{4}/_{5}$ = 80
Planning	${}^{7}/_{7}$ = 100
Information Management Strategies	${}^{9}/_{10}$ = 90
Comprehension Monitoring	${}^{7}/_{7}$ = 100
Debugging Strategies	${}^{5}/_{5}$ = 100
Evaluation	${}^{6}/_{6}$ = 100

Group 2 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Average of A to F Scores (%)**
Metacognition components							
Declarative Knowledge	${}^{5}/_{8}$=62.5	${}^{7}/_{8}$=87.5	${}^{7}/_{8}$=87.5	${}^{8}/_{8}$=100	${}^{8}/_{8}$=100	${}^{8}/_{8}$=100	89.58
Procedural Knowledge	${}^{4}/_{4}$=100	${}^{4}/_{4}$ = 100	${}^{4}/_{4}$=100	${}^{4}/_{4}$= 100	${}^{4}/_{4}$=100	${}^{4}/_{4}$=100	100
Conditional Knowledge	${}^{5}/_{5}$=100	${}^{4}/_{5}$=80	${}^{4}/_{5}$=80	${}^{5}/{}^{5}$=100	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	93.33
Planning	${}^{7}/_{7}$=100	${}^{6}/_{7}$=85.7	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	97.62
Information Management Strategies	${}^{10}/_{10}$=100	${}^{8}/_{10}$=80	${}^{9}/_{10}$=90	${}^{10}/_{10}$=100	${}^{10}/_{10}$=100	${}^{10}/_{10}$=100	95
Comprehension Monitoring	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	${}^{7}/_{7}$=100	100
Debugging Strategies	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	${}^{5}/_{5}$=100	100
Evaluation	${}^{6}/_{6}$=100	${}^{6}/_{6}$=100	${}^{6}/_{6}$=100	${}^{5}/_{6}$=83.3	${}^{5}/_{6}$=83.33	${}^{6}/_{6}$=100	94.44

Group 3

Group 3 focus group metacognition awareness

Metacognition components	**Score (%)**
Declarative Knowledge	$^{8}/_{8}$=100
Procedural Knowledge	$^{4}/_{4}$=100
Conditional Knowledge	$^{5}/_{5}$=100
Planning	$^{6}/_{7}$=85.71
Information Management Strategies	$^{10}/_{10}$=100
Comprehension Monitoring	$^{7}/_{7}$=100
Debugging Strategies	$^{5}/_{5}$=100
Evaluation	$^{6}/_{6}$=100

Group 3 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Average of A to F Scores (%)**
Metacognition components							
Declarative Knowledge	$^{8}/_{8}$=100	$^{8}/_{8}$=100	$^{8}/_{8}$=100		$^{8}/_{8}$=100	$^{8}/_{8}$=100	100
Procedural Knowledge	$^{4}/_{4}$=100	$^{4}/_{4}$=100	$^{4}/_{4}$= 100		$^{4}/_{4}$=100	$^{4}/_{4}$=100	100
Conditional Knowledge	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100		$^{5}/_{5}$=100	$^{5}/_{5}$=100	100
Planning	$^{6}/_{7}$=87.71	$^{7}/_{7}$=100	$^{7}/_{7}$=100		$^{7}/_{7}$=100	$^{7}/_{7}$=100	97.14
Information Management Strategies	$^{10}/_{10}$=100	$^{9}/_{10}$= 90	$^{10}/_{10}$=100		$^{10}/_{10}$=100	$^{10}/_{10}$=100	98
Comprehension Monitoring	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100		$^{7}/_{7}$=100	$^{7}/_{7}$=100	100
Debugging Strategies	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100		$^{5}/_{5}$=100	$^{5}/_{5}$=100	100
Evaluation	$^{6}/_{6}$=100	$^{6}/_{6}$=100	$^{6}/_{6}$=100		$^{6}/_{6}$=100	$^{6}/_{6}$=100	100

Group 4

Group 4 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	$^{8}/_{8}$=100
Procedural Knowledge	$^{4}/_{4}$=100
Conditional Knowledge	$^{5}/_{5}$=100
Planning	$^{7}/_{7}$=100
Information Management Strategies	$^{10}/_{10}$=100
Comprehension Monitoring	$^{7}/_{7}$=100
Debugging Strategies	$^{5}/_{5}$=100
Evaluation	$^{6}/_{6}$=100

Group 4 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Pre-service science teacher E Score (%)**	**Pre-service science teacher F Score (%)**	**Pre-service science teacher G Score (%)**	**Average of A to G Scores (%)**
Metacognition components								
Declarative Knowledge		$^{7}/_{8}$=87.5		$^{8}/_{8}$=100	$^{8}/_{8}$=100	$^{8}/_{8}$=100	$^{7}/_{8}$=87.50	95
Procedural Knowledge		$^{3}/_{4}$=75		$^{4}/_{4}$ =100	$^{4}/_{4}$= 100	$^{4}/_{4}$ =100	$^{3}/_{4}$=75	90
Conditional Knowledge		$^{5}/_{5}$=100		$^{5}/_{5}$=100	$^{3}/_{5}$=60	$^{5}/_{5}$=100	$^{3}/_{5}$=60	84
Planning		$^{7}/_{7}$=100		$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100	100
Information Management Strategies		$^{10}/_{10}$=100		$^{10}/_{10}$=100	$^{10}/_{10}$=100	$^{5}/_{10}$=50	$^{8}/_{10}$=80	86
Comprehension Monitoring		$^{7}/_{7}$=100		$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{6}/_{7}$=85.71	97.14
Debugging Strategies		$^{5}/_{5}$=100		$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	100
Evaluation		$^{6}/_{6}$=100		$^{6}/_{6}$=100	$^{6}/_{6}$=100	$^{6}/_{6}$=100	$^{5}/_{6}$=83.33	96.67

Group 5

Group 5 focus group metacognition awareness

Metacognition components	Score (%)
Declarative Knowledge	$^{8}/_{8}$=100
Procedural Knowledge	$^{4}/_{4}$=100
Conditional Knowledge	$^{5}/_{5}$=100
Planning	$^{7}/_{7}$=100
Information Management Strategies	$^{10}/_{10}$=100
Comprehension Monitoring	$^{7}/_{7}$=100
Debugging Strategies	$^{5}/_{5}$=100
Evaluation	$^{6}/_{6}$=100

Group 5 Metacognition awareness pen and paper awareness test

	Pre-service science teacher A Score (%)	**Pre-service science teacher B Score (%)**	**Pre-service science teacher C Score (%)**	**Pre-service science teacher D Score (%)**	**Average of A to D Scores (%)**
Metacognition components					
Declarative Knowledge	$^{7}/_{8}$=87.50	$^{7}/_{8}$=87.50	$^{8}/_{8}$=100	$^{8}/_{8}$=100	93.75
Procedural Knowledge	$^{4}/_{4}$ =100	$^{4}/_{4}$=100	$^{4}/_{4}$=100	$^{4}/_{4}$=100	100
Conditional Knowledge	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{5}/_{5}$=100	$^{5}/_{5}$=100	95
Planning	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{6}/_{7}$=85.71	$^{7}/_{7}$=100	96.43
Information Management Strategies	$^{10}/_{10}$=100	$^{10}/_{10}$=100	$^{8}/_{10}$=80	$^{10}/_{10}$=100	95
Comprehension Monitoring	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100	$^{7}/_{7}$=100	100
Debugging Strategies	$^{5}/_{5}$=100	$^{4}/_{5}$=80	$^{5}/_{5}$=100	$^{5}/_{5}$=100	95
Evaluation	$^{6}/_{6}$=100	$^{6}/_{6}$=100	$^{6}/_{6}$=100	$^{6}/_{6}$=100	100

Average metacognition awareness of the focus groups

Metacognition Component	**Average group score (%)**
Declarative Knowledge	98
Procedural Knowledge	100
Conditional Knowledge	96
Planning	97
Information Management Strategies	98
Comprehension Monitoring	100
Debugging Strategies	100
Evaluation	100

Average metacognition awareness of pen and paper test

Metacognition Component	**Average group score (%)**
Declarative Knowledge	95
Procedural Knowledge	98
Conditional Knowledge	94
Planning	98
Information Management Strategies	95
Comprehension Monitoring	99
Debugging Strategies	99
Evaluation	98

STATISTICAL METHOD FOR THE VALIDATION OF DATA

PEARSON PRODUCT MOMENT CORRELATION

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\text{sqrt}[n(\sum x^2) - (\sum x)^2] \cdot \text{sqrt}[n(\sum y^2) - (\sum y)^2]}$$

Where:

r_{xy} is the correlation coefficient between X and Y.

n is the size of the sample.

X is the average focus groups scores on the X variable.

Y is the average pen and paper tests scores on the Y variable.

XY is the product of each average focus groups score times its corresponding average pen and paper score.

X^2 is the average focus group score squared.

Y^2 is the average pen and paper score squared.

Pearson Product Moment Correlation (N=8)

Correlation of the average focus groups score with average pen and paper test.

Metacognition component	X (focus group)	Y (pen and paper test)	XY	X^2	Y^2
Declarative Knowledge	98	95	9 310	9 604	9 025
Procedural Knowledge	100	98	9 800	10 000	9 604
Conditional Knowledge	96	94	9 024	9 216	8 836
Planning	97	98	9 506	9 409	9 604
Information Management Strategies	98	95	9 310	9 604	9 025
Comprehension Monitoring	100	99	9 900	10 000	9 801
Debugging Strategies	100	99	9 900	10 000	9 801
Evaluation	100	98	9 800	10 000	9 604
	Σ X= 789	Σ Y= 776	Σ = 76 550	Σ X^2= 77 833	Σ Y^2= 75 300

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\text{sqrt}[n(\sum x^2) - (\sum x)^2] \cdot \text{sqrt}[n(\sum y^2) - (\sum y)^2]}$$

$$= \frac{8(76\ 550) - (789)(776)}{\text{sqrt}[8(77\ 833) - (789)^2] \cdot \text{sqrt}[8(75\ 300) - (776)^2]}$$

$$= \frac{612\ 400 - 612\ 264}{\text{sqrt}[(622\ 664) - (622\ 521)] \cdot \text{sqrt}[(602\ 400) - (602\ 176)]}$$

$$= \frac{136}{\text{sqrt}[(143)] \cdot \text{sqrt}[(224)]}$$

$$= \frac{136}{179}$$

= 0.759776536

=0.76

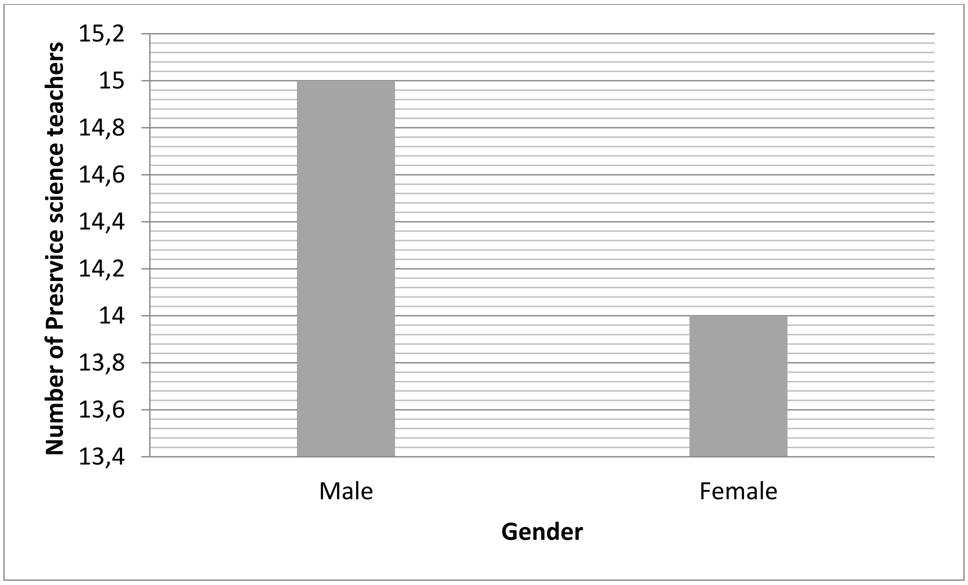
The coefficient of determination (r^2)

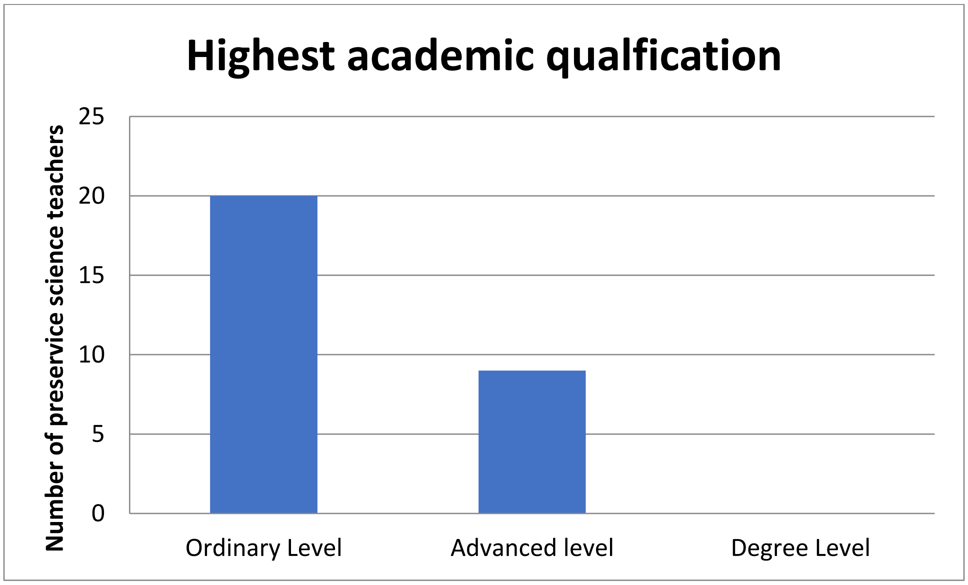
$r^2 = (0.76)^2$

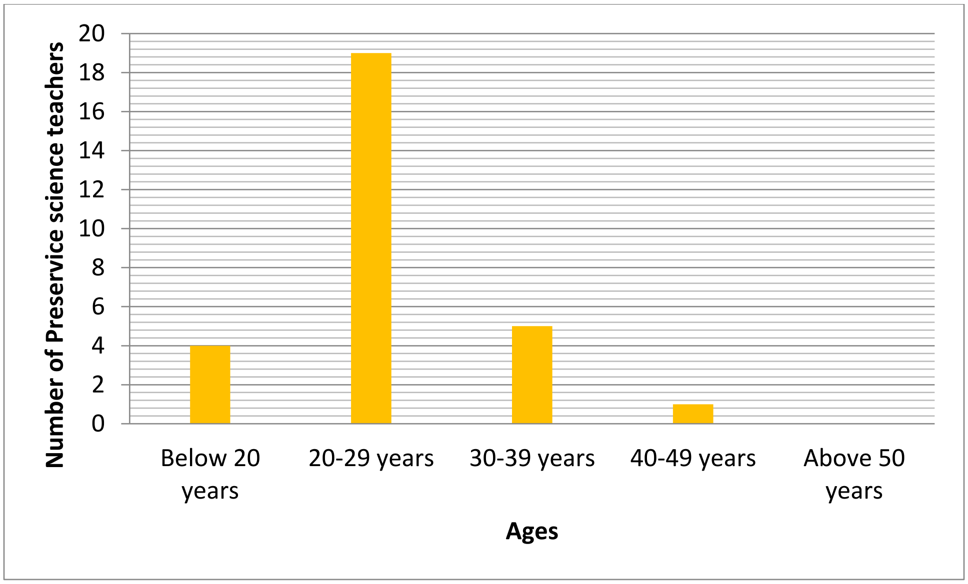
= 57.76%

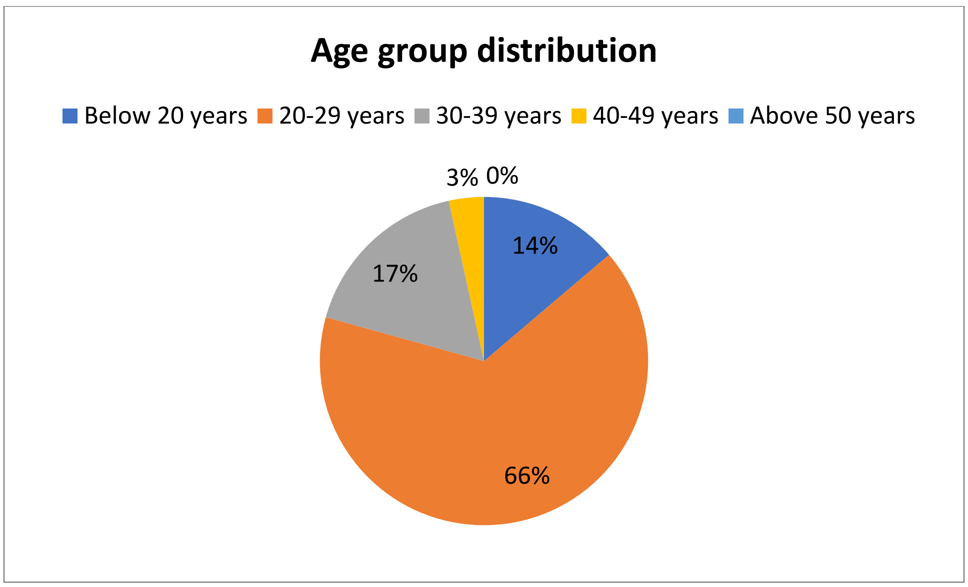
APPENDIX 10:

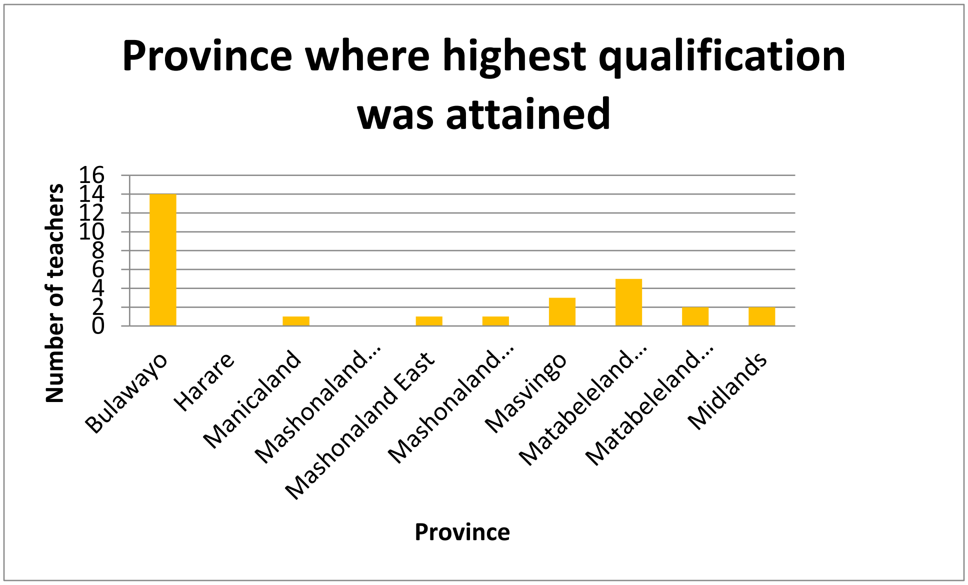
DEMOGRAPHIC DATA

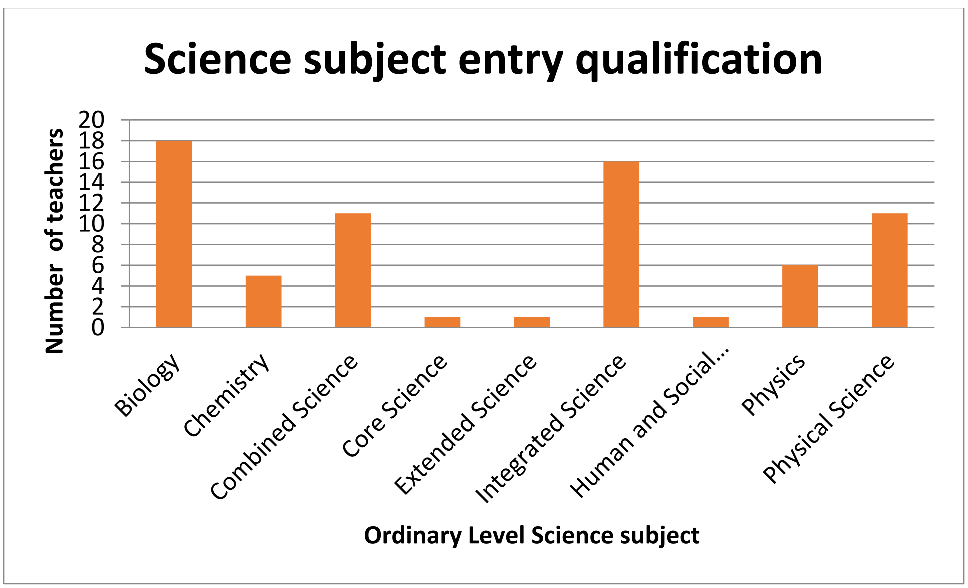


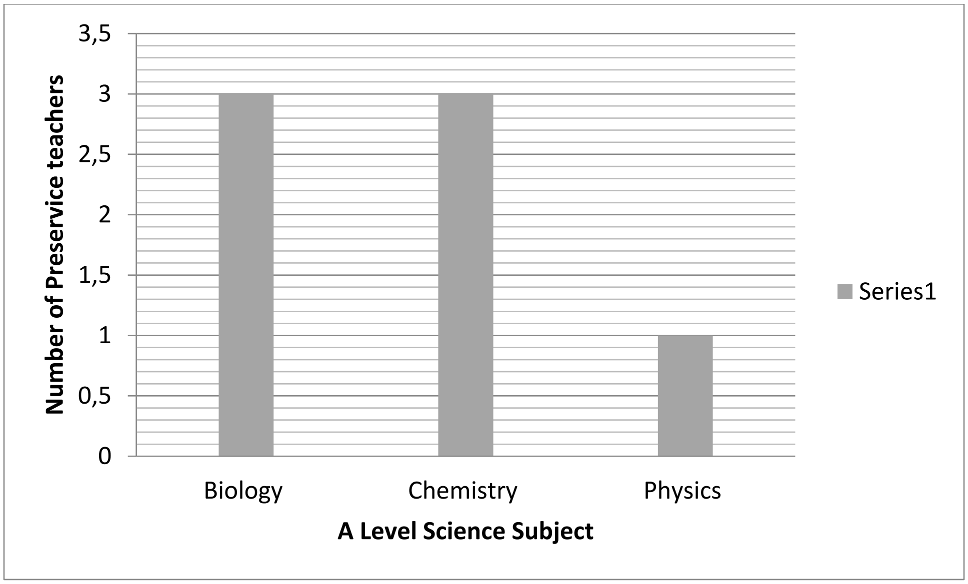



Number of Preservice science teachers
20
18
16
14
12
10
8
6
4
2
0
Below 20 years
20-29 years
30-39 years
40-49 years
Above 50 years
Ages


Age group distribution
Below 20 years
20-29 years
30-39 years
40-49 years
Above 50 years
3%
0%
14%
17%
66%


Province where highest qualification was attained
Number of teachers
16
14
12
10
8
6
4
2
0
Bulawayo
Harare
Manicaland
Mashonaland…
Mashonaland East
Mashonaland…
Masvingo
Matabeleland…
Matabeleland…
Midlands
Province


Science subject entry qualification
Number of teachers
20
18
16
14
12
10
8
6
4
2
0
Biology
Chemistry
Combined Science
Core Science
Extended Science
Integrated Science
Human and Social…
Physics
Physical Science
Ordinary Level Science subject


3,5
3
2,5
2
1,5
1
0,5
0
Number of Preservice teachers
Biology
Chemistry
Physics
A Level Science Subject
Series1

APPENDIX 11:

CHEMISTRY PERFORMANCE SCORES

STUDENT NUMBER	ASS 1 %	TEST 1 %	Mean Score Before	Average TEST 2 &3	ASS2 %	TEST 2 %	TEST 3 %	Mean Score-After	PRAC 1 %	PRAC 2 %
1	50	25	38	56	82	66	45	64		64
2	56	7	32	13	71	9	16	32	52	
3	59	17	38	13	82	20	6	36		
4	56	34	45	44	65	54	33	51		
5	69	14	42	14	85	20	8	38	72	56
6	28	7	18	3	50	6	0	19		56
7	53	24	39	33	88	29	37	51	52	
8	38	10	24	19	71	11	27	36	56	60
9	38	0	19	10	65	6	14	28		
10	50	34	42	45	65	60	29	51	52	
11	56	3	30	8	71	9	6	29		
12	56	21	39	12	71	17	6	31		
13	50	21	36	19	71	31	6	36		
14	91	52	72	67	76	74	59	70	60	60
15	88	7	48	19	85	26	12	41		52
16	34	14	24	22	56	42	2	33		
17	72	38	55	54	76	74	33	61	52	56
18	63	45	54	36	47	37	35	40		
19	56	0	28	9	65	11	6	27	52	56
20	59	21	40	23	68	26	20	38		
21	75	34	55	67	79	71	63	71		
22	81	66	74	69	85	74	63	74		60
23	50	17	34	15	56	14	16	29		52
24	50	21	36	13	56	17	8	27	68	56
25	50	7	29	27	68	34	20	41		68
26	38	14	26	47	62	57	37	52		60
27	59	14	37	1	62	0	2	21	56	68
28	72	28	50	38	74	49	27	50		52
29	59	14	37	10	74	17	2	31	56	60

APPENDIX 12:

EDITORS CERTIFICATE

Academic consultancy
"Perfection is our DNA"

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academicconsultancy3@gmail.com3
22 November 2020

To whom it may concern

This letter is to confirm that I, Keegan Bruce Schmidt, freelance copy-editor, have edited and proofread thesis for Doctor of Philosophy in Natural science Education: **THE INFLUENCE OF INDIGENOUS KNOWLEDGE ON CHEMISTRY METACOGNITION: A FOCUS ON PRE-SERVICE SCIENCE TEACHERS IN ZIMBABWE BY TAVONGA TAWANDA** for grammar and spelling. I have not changed any of the ideas presented in this paper and only the grammar and spelling has been altered for the purposes of clarity. This is to confirm that I have edited the document to a level I deem satisfactory.

Keegan Schmidt
Qualifications:
- BIS (University of Pretoria)
- BIS Hons (University of Pretoria)

APPENDIX 13:
TURNITIN REPORT

The influence of indigenous knowledge on chemistry metacognition: a focus on pre-service science teachers in Zimbabwe

ORIGINALITY REPORT

16%	12%	10%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	uir.unisa.ac.za Internet Source	1%
2	hdl.handle.net Internet Source	1%
3	www.tandfonline.com Internet Source	1%
4	Submitted to Mount St. Marys College Student Paper	<1%
5	studentsrepo.um.edu.my Internet Source	<1%
6	mafiadoc.com Internet Source	<1%
7	Submitted to University of Bedfordshire Student Paper	<1%
8	İNEL EKİCİ Didem. "Examination of pre-service science teachers activities using problem based	<1%