Research Article

Pre-Service Science Teachers' Views on the Use of Indigenous Chemistry Knowledge in Chemistry Metacognition [*]

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Abstract

This study focused on the views of pre-service science teachers on the use of indigenous chemistry knowledge in chemistry metacognition. A descriptive qualitative case study design using the interpretive paradigm was employed. The social constructivist theory guided the study as cognitive functions are dependent on social interactions with other individuals and the environment. Purposively sampled 29 pre-service science teachers were the respondents who had no previous tertiary chemistry education experience. Data was collected using focus group interviews, observation and document analysis. Constant comparison analysis was used for data analysis. The study shows that; (a) pre-service science teachers know and practice indigenous chemistry knowledge in agriculture, food preservation, food processing, health-care and environmental conservation. (b) Indigenous chemistry knowledge can be effectively used in chemistry metacognition when there is an awareness of chemistry concepts / ideas in indigenous chemistry knowledge. (c) There is a positive attitude towards the use of indigenous chemistry knowledge in 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.

Keywords: Chemistry metacognition, cultural relevance, ideal chemistry education, indigenous chemistry knowledge, pre-service science teachers

1. INTRODUCTION

1.1. Indigenous Chemistry Knowledge and Chemistry Metacognition

Chemistry education is based on western and eastern oriented generation and dissemination of information that does not value indigenous chemistry knowledge (Dziva, Mpofu & Kusure 2011; Shumba, 2014). Whilst Chemistry is a subject that is abstract to both teachers and learners because it is taught in way not related to the indigenous knowledge and practices (everyday life experiences) of the learner resulting in poor academic performance (Ugwu & Diovu, 2016). Indigenous knowledge is knowledge, which has evolved in a particular society's context and is unique (Senanayake, 2006) used in that society's context daily (Austin & Hickey, 2011). Indigenous chemistry knowledge is chemistry knowledge, which has evolved in a particular society's context and is used in that society's context daily. The chemistry that is seen as abstract is actually practised using resources from the environment in the context of indigenous chemistry knowledge at levels that differ of human societies in the world unknowingly (Ugwu & Diovu 2016).

Chemistry learners are exposed to the cultural beliefs and indigenous knowledge from their culture. All leaning occurs through culture in the social context (Aikenhead & Jegede, 1999). The cultural prior knowledge from the learners' culture has a significant impact on the learning of formal

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(school) chemistry concepts and this cultural prior knowledge determines the learners' preferred learning style (Baker & Taylor, 1995). Learners' construction of meaning is done through indigenous Chemistry knowledge (prior Chemistry knowledge) (Aikenhead & Jegede, 1999). 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 (Dziva, Mpofu & Kusure 2011).

Metacognition is recognition of 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 (Taylor, 1999). 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. Metacognition promotes independent Chemistry knowledge, knowledge that is more permanent, motivates learners and improves educational achievement across different ages, intellectual abilities and subject areas (Louca, 2003; Somerville, 2017). Abilities of metacognition assist learners to transfer acquired Chemistry knowledge, skills and affective states to another context or learning task.

1.2. Research on Indigenous Knowledge and Chemistry Education

In the Asian country of Indonesia, Rahmawati and Ridwan (2017) did a study at secondary school level on the empowerment of learners' chemistry learning through an integration of learners' ethnochemistry in teaching that was culturally responsive. The results of their study were that learners developed; higher order thinking skills (creativity in problem-solving), self-confidence, stimulated responsibility and task completion, empathy for other learners, improved communication amongst themselves, curiosity and motivation. These led to the conclusion that learners were empowered in chemistry learning by the integration of ethnochemistry. Ugwu and Diovu (2016) studied the integration of indigenous practices and knowledge in chemistry teaching, learning and learners' academic achievement at senior secondary school level in the African country of Nigeria. The findings of their study were that the integration of indigenous practices and knowledge in chemistry teaching and learning improved chemistry concepts understanding and improved learners' achievement in chemistry. In Zambia, an African country that shares a border with Zimbabwe, Singh and Chibuye (2016) did a study on the effect of ethnochemistry knowledge and practices on learners' attitudes towards chemistry at secondary school level. The findings of the study showed that incorporation of ethnochemistry knowledge and practices in chemistry, improved learners' attitudes towards chemistry positively.

Most studies that have been conducted on indigenous chemistry knowledge (ethnochemistry) and chemistry education have focused on the effect of integration of indigenous chemistry knowledge on the performance of learners in chemistry and learners' attitudes towards chemistry. A study on the views of learners on the use of indigenous chemistry knowledge in chemistry metacognition has never been done before. Therefore, a gap exists in knowledge, which this study sought to fill by exploring the perceptions of pre-service science teachers on the use of indigenous chemistry knowledge on chemistry metacognition. 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.

1.3. Research Questions

The study is guided by the following research questions:

- Which indigenous Chemistry knowledge is known and practised by pre-service science teachers?
- How can indigenous Chemistry knowledge be effectively utilised in Chemistry metacognition?
- What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition?

2. METHOD

2.1. Research Design

A descriptive qualitative case study design using the interpretive paradigm was employed to study the views of learners towards the use of indigenous Chemistry knowledge in Chemistry metacognition. A descriptive case study design is concerned with interpretation and description of situations, circumstances, conditions and events that are contemporary in nature and from a social constructivist perspective (Merriam, 1998). A qualitative research approach focuses on peoples' meaning systems, experiences and beliefs from their perspective. Its roots are the cultural and social anthropology, history, philosophy, sociology and psychology suggests Mohajan (2018). The interpretive paradigm was employed to study pre-service science teachers' views on the use of indigenous chemistry knowledge in 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 states 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.

2.2. Participants

The study was conducted at a secondary school teachers' college in Zimbabwe with the respondents being post ordinary level pre-service science teachers who had no exposure to tertiary level chemistry education before. The data collection and analysis were conducted in eight weeks in the pre-service science teachers' first term at college of 2020. The respondents were 29 pre-service science teachers from the science department of a secondary teacher training college in Zimbabwe. The demographic profiles of pre-service science teachers in that participated in the study shown in in Figure 1 to 3.

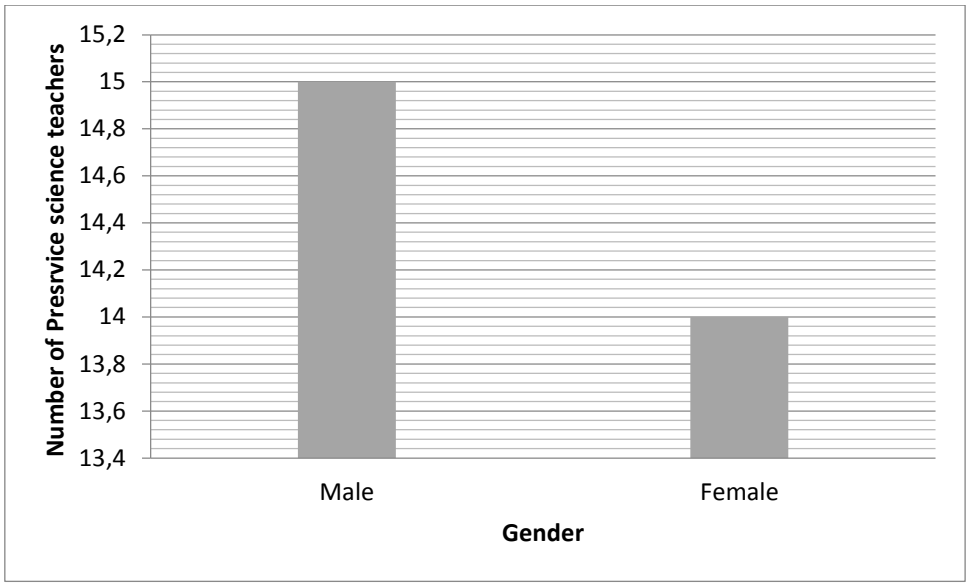

Figure 1. Gender distribution of pre-service science teachers

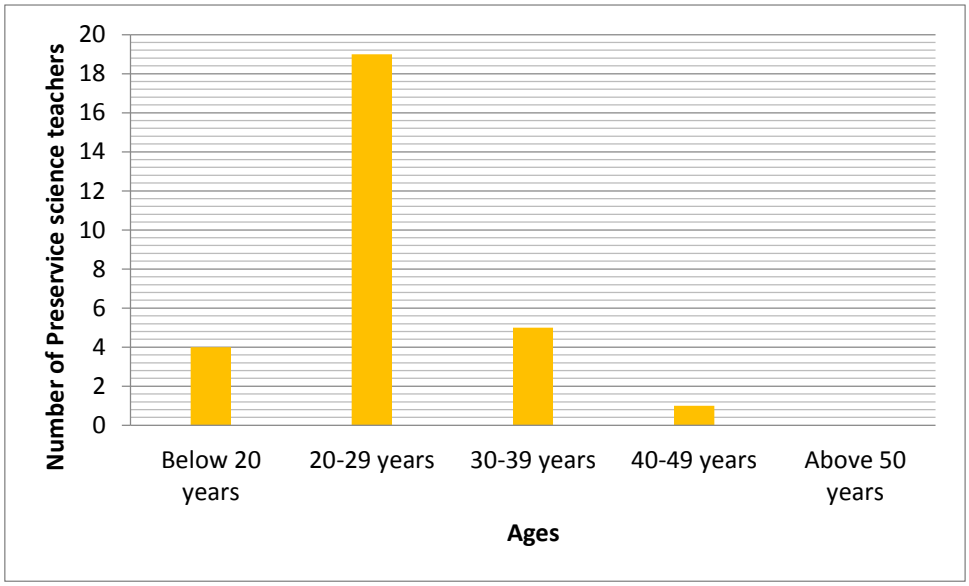

Figure 2. Age distribution of pre-service science teachers

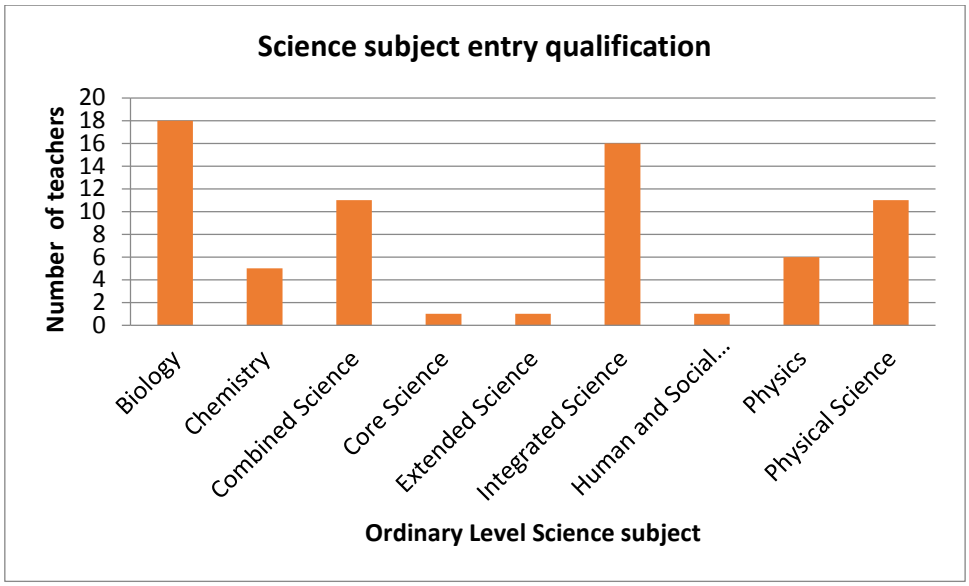

Figure 3. Science subject entry qualification of pre-service science teachers

2.3. Data Collection

The pre-service science teachers were purposively sampled who participated in the study. Focus groups, observation and document analysis were used in exploring the views of pre-service science teachers on the use of indigenous chemistry knowledge in chemistry metacognition. Focus group interviews were used for identifying the cultural indigenous chemistry knowledge held and practised by pre-service science teachers. The function of observations was to assess and find out the extent to which pre-service science teachers used 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. Document analysis was used for identifying the cultural indigenous chemistry knowledge held and practised by pre-service science teachers.

2.4. Data Analysis

The data was analysed using constant comparison analysis to identify the indigenous Chemistry knowledge that is known and practised by of the pre-service science teachers. 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. These were done though the components of qualitative data analysis which are data collection, data reduction, data display and conclusion drawing as well as verification suggests Miles, Huberman and Saldana (2014).

The first stage of data analysis involved organizing the indigenous chemistry knowledge experiences, perceptions, behaviours and emotions of the participants into the categories (themes) of agriculture, environmental conservation, food processing, food preservation and health care. The second stage of data analysis involved the segregating and labelling (coding) of themes into those with chemistry ideas / concepts, beneficial characteristics, common characteristics with western chemistry knowledge, important uses in chemistry lectures and those with affective impacts.

3. FINDINGS

3.1. Which Indigenous Chemistry Knowledge is Known and Practised by Pre-Service Science Teachers?

Quite a large amount of Indigenous Chemistry knowledge and skills known and practised by pre-service science teachers for survival purposes. Many uses and effectiveness of indigenous Chemistry knowledge and skills were found in agriculture, environmental conservation, food processing, food preservation and health care. Indigenous environmental conservation knowledge, skills and attitudes are an area of specialisation that is known and practised by pre-service science teachers. Most of the pre-service teachers' environmental conservation majored mainly on soil, tree, plant nutrients and animal conservation.

3.2. How can Indigenous Chemistry Knowledge be Effectively Utilised in Chemistry Metacognition?

Pre-service science teachers are aware of chemistry concepts/ideas that are in some of the indigenous chemistry knowledge they know and practice as shown in Table 1.

Table 1. Indigenous Chemistry knowledge with known 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 fertilizer. Cow dung fertilizer- dosage too much 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 is rotten sadza/ food and rotten fruits. Cooking sadza- endothermic and exothermic reactions. Smoking food- chemical treatment. Fire exothermic and oxidation/ reduction reactions.

These Chemistry ideas/concepts are the same chemistry 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). Pre-service science teachers gave a number of benefits associated with indigenous Chemistry knowledge and skills from their experiences in their daily lives. Table 2 gives a list of beneficial characteristics of indigenous Chemistry knowledge and skills as given by pre-service science teachers.

Table 2. Beneficial characteristics of indigenous chemistry knowledge

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 staffs 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.

There are some common characteristics between indigenous Chemistry knowledge and western Chemistry knowledge that were identified by pre-service science teachers as shown in Table 3.

Table 3. Common characteristics between indigenous and western chemistry knowledge

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. Save the same purpose-processes. College chemistry is a modification of indigenous chemistry knowledge. Similar process. Time periods – set time for the processes. Practical application, practice, the concepts behind, putting theory into practice. Processes, they sometimes serve the same purposes e.g. healing. There are measurements that are done. Opaque beer fermentation.
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.

The importance of using indigenous chemistry knowledge in formal chemistry lectures was emphasised by pre-service science teachers because of the reasons shown in Table 4.

Table 4. Importance of the use of indigenous chemistry knowledge in chemistry lectures.

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 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.

The use of indigenous Chemistry knowledge and skills in Chemistry lectures (western Chemistry knowledge) comes with it some advantages and disadvantages as shown in Table 5.

Table 5. Advantages and disadvantages of using indigenous Chemistry knowledgein Chemistry lectures.

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).

3.3. What are the attitudes of pre-service science teachers towards the use of indigenous Chemistry knowledge in Chemistry metacognition?

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.

4. DISCUSSION and CONCLUSION

The results indicate that pre-service science teachers know and practice a vast amount of indigenous chemistry knowledge in agriculture, food preservation, food processing, health-care and environmental conservation, which was 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. These results are also consistent with the findings of Ugwu and Diovu (2016) and Singh and Chibuye (2016) which, showed that there are many chemistry concepts in indigenous knowledge that are known and practised by learners knowingly and unknowingly in their daily life experiences.

The findings indicate that indigenous Chemistry knowledge can be effectively used in chemistry metacognition when there is an awareness by pre-service science teachers (learners) and educators of chemistry concepts / ideas in indigenous Chemistry knowledge (Chemistry prior knowledge) that actually use chemistry concepts that are known to them in their everyday lives. This is consistent with Alshammari (2015)'s study which showed that for any learner to develop metacognitive skills, prior knowledge must be present to facilitate and help in the development of the cognitive skills.

The study's findings further show that indigenous Chemistry knowledge can be effectively used in Chemistry metacognition when indigenous Chemistry knowledge's; immerse educational value, motivating effect, importance, in-depth learning, improved academic performance, advantages, benefits, and best teaching methodologies are known and made use off in chemistry tertiary institutions involved chemistry education. Semali, Grim and Maretzki (2006)'s study showed that indigenous knowledge complements and provides relevance to science-based knowledge which supports this study's findings. The findings of a study on the incorporation of indigenous Chemistry knowledge into chemistry teaching and learning by Ugwu and Diovu (2016) showed that learners improved understanding of chemistry ideas/concepts and academic achievement. The incorporation of indigenous Chemistry knowledge into chemistry knowledge improved learners' chemistry learning through, motivation, cultural identity, engagement, collaboration and higher order thinking skills in a study by Rahmawati and Ridwan (2017).

The study's 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.

Analysis of the data from the focus groups exhibited that pre-service science teachers are repositories of indigenous Chemistry knowledge, skills and attitudes. 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.

Data analysis showed that there are some chemistry ideas/concepts in indigenous Chemistry knowledge that are known and practised as chemistry concepts/ideas by pre-service science teachers that are beneficial, useful, and reliable, give positive experiences and are the same with western chemistry ideas/concepts. The findings suggest that indigenous Chemistry knowledge can be utilised effectively in Chemistry metacognition as there is empirical evidence of the immerse value, importance and benefits of indigenous Chemistry knowledge ideas/concepts which can be used as

realia since they are used for survival purposes in the everyday life experiences of pre-service science teachers. As a result, 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 indigenous Chemistry knowledge can be used successfully in Chemistry metacognition by learners in chemistry education. What is recommended is that chemistry educators should be capacitated with the knowledge, skills and attitudes for identifying learners' indigenous Chemistry knowledge that is effectively used in Chemistry metacognition.

Analysis of the data showed that pre-service science teachers felt that it was acceptable, good and comfortable to use indigenous Chemistry knowledge in Chemistry metacognition. 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.

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The data used in this study was confirmed by the researchers that it belongs to the years before 2020.

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