UNIVERSITY OF EDUCATION, WINNEBA

ENGAGEMENT IN CONSTRUCTING UNDERSTANDING OF SELECTED CHEMISTRY CONCEPTS THROUGH THE INTEGRATION OF INDIGENOUS KNOWLEDGE

CHARITY ESENAM ASSEY

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DECLARATION

Student's Declaration

I, Charity Esenam Assey, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …………………………….

DATE: ………………………………….

Supervisor's Declaration

We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis/dissertation/project as laid down by the University of Education, Winneba.

Principal Supervisor: PROFESSOR RUBY HANSON

Signature: ……………………

Date: …………………………

Co-Supervisor: DOCTOR EMMANUEL OPPONG

Signature: ………………………

Date: ……………………………

DEDICATION

I dedicate this work to my husband, Mr. Gideon Asare Anor, my four lovely children, Afua Amoabea Anor, Ama Sarfoa Anor, Kwadwo Asare Anor and Kwadwo Baffour Kafui Anor. Also to the memory of the late Dr. Francis Aggrey Bluwey, may his soul rest in the bossom of our Lord Jesus Christ.

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To the Management and staff of Swedru Senior High School, God bless you all for your contribution and support.

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DEFINITION OF TERMS

‘Ahe’	Local drink prepared from maize
‘Akpeteshie’	Local gin
‘Alata samina’	Local soap made mostly from cocoa pod ash
‘Asaana’	Local drink prepared from maize
‘Banku‘	A food prepared from a mixture cassava dough and corn dough
‘Fufu’	A dough made from boiled pounded cassava tubers
‘Gari’	Fine to coarse granular flour prepared from cassava dough
‘Gyenkisi’	Potash from cocoa pod

ABBREVIATIONS

AEDA	Agona East District Assembly
AK	Akpeteshie
AWMA	Agona West Municipal Assembly
BL	Blacksmithing
CD	Cassava Dough
CT	Chemistry tutor
CTs	Chemistry tutors
EP	Everyday practice
FA	Farming
GSEIP	Ghana Schools Education Improvement Project
GSSHPC	Ghana Statistical Service Housing and Population Census
ICT	Information and communication Technology
IK	Indigenous Knowledge
IKP	Indigenous Knowledge practice/ Person
IKPs	Indigenous Knowledge Persons
ITS	Interrupted Time Series
JICA	Japan International Cooperation Agency
KSCE	Kenya School Certificate Examination
LS	Local Soap
MOEST	Ministry of Education Science and Technology
PO	Palm Oil
PCK	Pedagogical Content Knowledge
SEIP	Secondary Education Improvement Program
SK	Scientific Knowledge

SPSS	Statistical package for Service Solution
UNESCO	United Nations for Educational, Scientific and Cultural Organisation
USA	United States of America
WAEC	West African Examination Council
WASSCE	West African Secondary School Certificate Examination
WS	Western Science
WSK	Western Scientific Knowledge
SMASSE	Strengthening Mathematics and Science in Secondary Education

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ABSTRACT

Students' engagement in chemistry lessons is essential for construction of knowledge and understanding. The issue is with the adoption of teaching and learning strategies that encourage students' engagement. Indigenous knowledge (IK) practices have been argued to provide suitable contexts in relation to the students' everyday life experiences to reveal the relevance, practicality and applicability of concepts for effective teaching and learning. Therefore, chemistry lessons designed using suitable contextual IK practices, have the tendency to promote the meaningfulness of concepts to students thereby fostering their engagement in lessons. The study was conducted as a case study to evaluate the effect of students' engagement in 'integrated indigenous knowledge-chemistry lessons' (IIK-CLs) on students' learning outcome. Relevant data was collected from 20 purposely sampled IK experts and 8 chemistry tutors and 'integrated indigenous knowledge-chemistry lessons were consequently developed. Specific chemistry concepts were taught using the 'IIK-CLs' which engaged students in numerous activities. The behavioural, emotional and cognitive engagement of 26 randomly sampled students were assessed using observational schedule and questionnaire on all three types of engagement. The interrupted time series design was also used to evaluate the effect of the designed 'integrated 'IK-CLs on the students' learning outcome and on gender. Students' responses were analysed using Excel and statistical package for the social sciences (SPSS) and the results presented in tables and graphs. The 'IIK-CL' recorded a high percentage of students' engagement, revealed a significant improvement in students' performance and impacted positively on students learning. The integration of IK practices in the teaching of chemistry concepts promoted students' engagement and enabled the construction of knowledge and understanding.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter comprise the background of the study, statement of the problem, purpose of the study, specific objectives, research questions and hypothesis. Further, significance of the study scope of the study were also addressed. The chapter ends with assumptions of the study.

1.1 Background of the study

Students' engagement in the teaching and learning process is essential for the construction of concepts in chemistry (Eilks & Hofstein 2013). Indeed, Engagement has the potential of increasing ones' interest and devotion to an activity. Students who are engaged in the learning process develop a sense of belonging and self-worth thus, are more likely to succeed academically, graduate, and avoid engaging in delinquent behaviours (Fredricks, Blumenfeld & Paris, 2004; Beale, 2018; Fredricks, Reschly, & Christenson, 2019). The issue of students' engagement is receiving increasing recognition from researchers worldwide as a means to improve academic achievement. Several studies have suggested how beneficial engagement is to behavioural, emotional and cognitive achievements (Connell, 1990; Eccles & Midgley, 1989; Newmann, 1992). Having realised its importance to chemistry education, researchers are now concerned with activities that could be employed in the teaching and learning of chemistry that encourage students' engagement. (Finn & Rock, 1997)

Relating from the works of constructivists, the most profound changes in education over the past 25 years stem from the recognition that students actively construct their understanding when involved in the learning process (Bodner, 1986**;** Windschitl, 2002). Therefore, learning environments, experiences, and teaching strategies must be carefully structured and designed to engage students to enable the construction of knowledge and understanding of concepts in chemistry and their subsequent application in everyday life situations. As acknowledged by Eilks and Hofstein (2013), chemistry curricula as a whole or single lesson can use a different approach towards its teaching. This requires a good pedagogical content knowledge (PCK) on the part of chemistry teachers in adopting teaching strategies to explain chemistry concepts to the individual student to achieve sustainability and chemical literacy for all contrary to the purpose of chemistry teaching about six decades ago (Eilks & Hofstein, 2013), which focused on giving a limited portion of students a solid foundation in chemistry to recruit and prepare these few for future careers in chemistry related fields such as medicine and engineering.

The demand for scientific, specifically chemical literacy for all, has changed the orientation towards the teaching and learning of chemistry in such a way so as to benefit every individual student. The focus according to Hofstein and Eilks (2013) is no longer the preparation of few students for their career in science only but also on the acknowledgement that, every citizen needs a basic understanding of chemistry in decision making about daily choices and to contribute to societal debates to promote national development. This evolvement in the purpose of chemistry education has necessitated the research into and development of teaching strategies to meet this goal of learning chemistry which is considered as the central science due to its relevance in all other sciences and subjects. Kotz, Treichel and Townsend (2014) maintained that a basic knowledge in chemistry is essential for students of all other disciplines.

Although Chemistry is relevant in all disciplines, it is perceived to include numerous abstract concepts, hence creating a general opinion among learners that chemistry is relatively challenging. These ‘abstract’ concepts, if not properly taught, interfere with students' understanding by making them unable to understand and relate principles in chemistry to real life situations and aids in the development of negative attitudes towards chemistry. Students in bid to pass their examinations and progress to a higher educational level resort to rote learning which according to Anamuah-Mensah (2004) and Foster, Graham and Donaldson (2021) contribute to the poor performance of students in general and specifically in Chemistry.

In order to ascertain whether chemistry students still perform poorly in the subject, a critical analysis of the West African Senior Secondary Certificate Examination (WASSCE) Chemistry results from four (4) Senior High Schools in the Agona Municipality from 2015 to 2018 and WASSCE results nationwide from 2016 to 2018 was conducted and presented in Table 1. The 2017 chief examiner’s report on chemistry, identified the inability of students to demonstrate understanding and the application of scientific concepts as major factors leading to poor performance (WASSCE, 2017). The chief examiner therefore suggested that chemistry should be studied using methods that will enable students to understand and apply principles that are fundamental to chemistry concepts (WASSCE, 2017). It has been revealed that 83 students representing 32.4% failed Chemistry in 2015, the failure rate declined to 17.75%, (49 students) in 2016 then increased again to 19.33% (49 students) and 30.23% (104 students) in 2017 and 2018 respectively (WASSCE, 2015; 2016; 2017; 2018).

Table 1: Performance trend of four SHS in the study area in WASSCE (Chemistry)

YEAR	TOTAL NUMBER OF STUDENTS	NUMBER PASSED	NUMBER FAILED
2015	256	173	83
2016	276	227	49
2017	238	193	46
2018	344	240	104

Source: (WAEC, 2015; 2016; 2017; 2018)

Generally, the WASSCE results nationwide from 2016 to 2018 showed a decline in the performance of chemistry as tabled in Table 2. The nationwide WASSCE results in chemistry revealed that 37.05% of students failed Chemistry in 2016. The nationwide failure rate just as the four schools in the Agona Municipality decreased to 34.83% in 2017 but realised an increase to 52. 50% in 2018 (WASSCE, 2016; 2017; 2018). The deduction therefore was that the performance of the four SHS in the Agona Municipality was a true reflection of the nationwide performance in chemistry, an indication that the general aims of teaching and learning chemistry have not been fully achieved.

Table: 2 Performance trend in chemistry nationwide

YEAR	FAILURE RATES IN CHEMISTRY (%)
2016	37.05
2017	34.83
2018	52.50

Source: (WAEC, 2016; 2017; 2018)

The general aims of learning chemistry as outlined in the teaching syllabus for senior secondary schools are to provide knowledge, to help students understand, appreciate, and apply scientific methods and principles among others (Ministry of Education, 2010). These profile dimensions are to make chemistry more interesting, self-motivating and further emphasise the ability to process and link chemistry in the classroom to traditional and modern technologies for sustainable development.

To achieve the general aims of teaching and learning chemistry and further improve upon students' performance, an alternative approach to the teaching and learning of the subject ought to be considered globally and specifically in Ghanaian schools. The effective communication of chemistry to learners can be achieved through the identification of relevant starting points in imparting concepts and embedding chemistry learning in situations meaningful to the learners for content relevance and practicality and applicability for sustainable development (Ausubel, Novak, & Hanesian, 1978; Eilks, & Hofstein, 2013). It must be noted that, the applications of chemical ideas and their implications for personal, social, and economic life, are of the greatest interest to students, but according to Eilks and Hofstein (2013) chemistry teacher education pays little attention to these matters. The most effective and efficient access to suitable contexts to make chemistry relevant to students personally, socially and economically does seem likely to come through the informal, non-formal route or indigenous knowledge practices.

Indigenous knowledge refers to the local knowledge that is unique to a given culture and acquired by the local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment (Chikaire et al., 2012; Horsthemke, 2021)). Chikaire et al. (2012) further emphasized that it comprises technology, social, economic and philosophical learning as well as governance systems of a community. In using this knowledge, Howden (2001) introduced the term, ‘indigenous knowledge practices’. These indigenous practices, Howden (2001) explained, are better understood as practical, personal and contextual units which cannot be detached from the individual, the community and the environment (both physical and spiritual). Again, indigenous knowledge practices constitute the core of community development processes such as agriculture, indigenous technologies, preparation and preservation of food, the collection, storage and purification of water, and ethnic veterinary medicine (Chikaire et al. 2012; Son, Kingsbury & Hoa, 2021; Wareen & Cashman, 1988). Other researchers like Ankrah, Kwapong & Boateng, (2021) emphasised that indigenous knowledge (IK) practices form the fundamentals of interpreting meteorological and climatic phenomena, orientation and navigation on land and sea as well as in the management of natural resources.

Indigenous Knowledge (IK) however, refers to indigenous knowledge practices that interprets how the world functions from the cultural perspective unique to a particular group of indigenous people. African IK practices have existed over centuries with unique educational systems even before Western education was introduced (Thaman, 2014). Indeed, the introduction of Western education implied that learners were confronted with the principles of western education against that of their highly geographical expressive cultures. Thaman (2009) confirmed the conflict by stressing that, the purpose, content, and processes of Western knowledge transmission conflicts with those of indigenous education. According to Kaino (2013) various tribes possess unique IK practices that can be meaningfully integrated into the western school content to improve the learning outcome of students. Kaino (2013) noted that the artifacts available in the traditional environments are important tools that can be reliably used to facilitate the understanding of the principles of Western education. Convincingly, Thaman (2002) further argued that western education cannot in any indigenous environment, exclude IK, since IK consists of values that can practically and efficiently support western education.

Indigenous knowledge (IK) is acquired by continuously and carefully observing nature and further adopting the trial-and-error methods of providing solution to problems (Battiste, 2005; Son, Kingsbury, & Hoa, 2021). An individual born in a community, is initially exposed to the culture of the community and hence these methods of solving problems. Observation and imitation, as a means of IK acquisition imparts many concepts in chemistry although it has no structured syllabus and specialsed vocabulary or terms (Chang & Overby, 2019). Experiences in communities of Ghana, witness many IK practices that are based on the principles of science (scientific practices). Indigenous Knowledge (IK) practices include placing charcoal in soup to prevent spoilage, decantation in porridge preparation, the use of ashes as a cleansing agent, preparation of alcohol and food among others. Others include precautionary and quality control measures such as smelling, tasting, observing and feeling as practiced specifically in chemistry. All these indigenous practices have been sustained by imparting the principles from one generation to another generation. Although IK practices may differ from community to community, they all confirm a way of life which is accompanied by discovering strategies to resolve problems for human and environmental sustainability.

Indeed, there is a growing consensus that the problems currently confronting the world, specifically Africans, can be resolved by initially understanding the dynamics of every situation within the local context (Angioni, 2003; Dei, 2002). Such dynamics suggests the inclusion of IK practices in the teaching and learning process to provide appropriate situational contexts for explaining chemical phenomena (Angioni, 2003; Dei, 2002;

Eilks, & Hofstein, 2013 UNESCO, 2021). The use of domain-specific and prior knowledge from indigenous knowledge (IK) practices can provide suitable contexts for teaching chemistry concepts to enhance understanding. The integration of IK practices in the teaching and learning of chemistry concepts makes learning meaningful as it relates to the everyday life experience of students thereby stimulating, maintaining and stabilising students' learning (Slovinsky, Kapanadze & Bolte, 2021).

This suggests that, a thoughtfully structured chemistry lesson with context from students’ environment is capable of encouraging behavioural, emotional and cognitive engagement and improve students’ academic achievement as a whole (Brown, Friedrichsen & Abell, 2013; Hewson & Ogunniyi, 2011; Keane, 2006; Mbah, Johnson & Chipindi, 2021; Parsons, Taylor & Crease, 2021; Simonsmeier et al, 2021). It must however be noted that the integration process does not mean changing something Western into something Indigenous. The goal is not to replace Western knowledge with Indigenous knowledge, neither is it to merge the two into one. Rather, weaving or braiding together two distinct knowledge systems in appropriate contexts so that learners can construct an understanding of chemistry concepts (Antoine et al., 2018).

1.2 Statement of the Problem

There have been efforts to improve the performance of students in science and chemistry in particular, globally and specifically across Ghana (Eilks, & Hofstein, 2013). However, students persistently recorded significant levels of failure. The West African Examinations Council has expressed concern over this decline in the performance of candidates in science (Kale-Derry, 2019). Specifically, the statistics of WAEC results for Ghana and four Senior High Schools in the Agona Municipality in particular as shown in Tables 1 and 2 are evidence of this. The analysis revealed that

32.4%, 17.6%, 19.3%, and 30.2% of students from the study area who desired to offer any chemistry related course could not satisfy the minimum requirements to access tertiary education in the years 2015, 2016, 2017, and 2018 respectively. Generally, 37.05%, 34.83% and 52.50% of students nationwide were unable to access tertiary education in the year 2016, 2017, and 2018. This problem of poor performance if not re-examined and addressed will continue to result in the production of graduates not only with low self-esteem, but with significant negative impact on national development. It is believed that the poor performance of students in chemistry was due to the teaching approach that ignored the use of IK in engaging students in the learning process for knowledge construction (Bamidele & Oloyede, 2013; Brown, Friedrichsen & Abell, 2013) to promote chemical literacy for all and not only those who want to pursue their career in chemistry related courses (Eilks & Hofstein, 2013).

In spite of the fact that IK have consistently been marginalised and even denigrated, though contemporary research still proves that IK sustains millions of populations economically, socially, spiritually and even provides a set of principles in most fields of technology (Ogunniyi, 2011; Parsons, Taylor & Crease, 2021). According to researchers, education that promotes sustainability can be achieved through the complementary use by scientists of the two strengths- Scientific and IK (Hewson & Ogunniyi, 2011; Keane, 2006; Parsons, Taylor & Crease, 2021) where students see the relevance of learning a particular concept to their daily lives. Others such as Brown, Friedrichsen and Abell (2013), Kibirige and Van Rooyen (2007) and Simonsmeier et al, 2021) reiterated that, the challenge in science specifically, chemistry can be solved by using domain-specific and prior knowledge from IK practices as starting points to enhance understanding. Hence, for the integration of IK practices into chemistry teaching to be beneficial to students, consideration should be given to the use of appropriate situational contexts from the students' environment. This apart, lessons that reveal the relevance of concepts to students' everyday life and encourage students' engagement should be designed.

There are numerous IK practices which are common to respective local communities in Ghana that can be explored and categorised to teach various concepts in chemistry to improve students' performance. The critical challenge however, is to identify the appropriate IK practices and their application in the teaching of selected concepts in chemistry, to strategically and thoughtfully plan integrated indigenous knowledge-chemistry lessons (IIK-CLs) with the principle of students' engagement, to assess the impact of the IIK-CLs on students' behavioural, emotional and cognitive engagement and to evaluate the impact of the IIK-CLs on students' academic achievement in chemistry

1.3 The Purpose of the study

The purpose of this study was to engage chemistry students in 'integrated indigenous knowledge-chemistry lessons' IIK-CLs to enable them construct knowledge and understanding of selected chemistry concepts.

1.4 Specific Objectives

The specific objectives of the study were to:

1. identify the various IK practices in the Agona East and West municipalities.
2. investigate the IK practices used by chemistry teachers in four selected schools in the municipalities.
3. assess the level of students behavioural, emotional and cognitive engagements in 'IIK-CLs'.

4. evaluate the impact of the use of the 'integrated 'IIK-CLs' on learning outcome of students.
5. determine the effect of gender on 'IIK-CLs' on gender.

1.5 Research Questions

The research questions underlying this study were:

1. Which IK practices are known and practised in the Agona East and West municipalities
2. What IK practices are used by the chemistry teachers in the Agona East and West municipalities in teaching and learning chemistry?
3. What is the level of students' behavioural, emotional and cognitive engagements in 'IIK-CLs'?
4. What is the impact of the IIK-CLs on students' learning outcome?
5. What is the effect of gender on the 'IIK-CLs'?

1.6 Null Hypothesis

H_0. There is no statistically significant difference in the mean achievement scores of male and female students taught using 'IIK-CLs'.

1.7 Significance of the Study

To achieve the aim of teaching and learning chemistry in terms of sustainability, chemical literacy for all and further improve upon students' academic performance, an alternative approach to the teaching and learning of chemistry ought to be devised. This study therefore sought to develop an indigenous knowledge approach as an alternative means of teaching chemistry through the integration of relevant IK practices in suitable contexts. It will enable students to construct knowledge path with understanding and be able to apply chemistry concepts in relevant situations for personal and national development. The study is in line with the millennium development goal 4 which is to ensure education for sustainable development (UNESCO, 2021). The study will therefore be significant in the following ways:

1. Student development- The study will enhance the acquisition of knowledge and its application to ensure chemical literacy and promote sustainable development.
2. Theory development – It will serve as a source of reference for other academics and for researchers who want to conduct further research on the topic under discussion.
3. Curriculum development – The study will serve as a resource to curriculum planners when considering the inclusion of IK practices as part of the instructional materials and activities in the chemistry curriculum.
4. Resource material – The 'IIK-CLs' will serve as a resource material for chemistry teachers.
5. School-community relationship – The study will foster good school-community relationships

1.8 Scope of Study

The study was conducted in the Agona East and West Municipalities of the Central Region of Ghana. It was focused on the exploration and categorisation of IK practices under selected chemistry concepts in SHS. The population of the study included IK experts in three selected towns in the municipality. All chemistry students in Swedru SHS and all chemistry teachers in the four selected schools in the municipalities. The sample size comprises of 20 IK people, 8 chemistry teachers and 26 chemistry students. The study focused on the designing of indigenous knowledge-chemistry lessons to teach factors affecting rate of chemical reactions, properties of metal and distillation. There are however designed IIK-CLs on some other chemistry concepts in Appendix J.

1.9 Limitation of the Study

1. Data collected did not cover all IK practices.
2. Lessons designed were context specific
3. The study was carried out in the Agona East and West municipalities only.

1.10 Assumptions of the study

Research assumption refers to realistic expectations statements or principles which are believed to be true based on logical reasoning but without proof or verification. (Wargo, 2015). It can therefore be referred to as an act of faith with no empirical evidence to support the claim. According to Wargo (2015) every research is based on assumption primarily because they form the foundation and provide the basis for the research. Indeed, Bryman and Bell (2015) argued that these assumptions depended on the understanding and perception of nature by the researcher. Assumptions provide significant guidelines for the entire research process such as; the research approach and design, data collection and analysis, and interpretation of findings (Cohen, Manion & Morrison, 2018).

The assumption underlining this research was based on the theory of constructivism (Vygotsky 1986). The constructivists' idea states that the learner is a social being who makes meaning of the environment. Students bring to the classroom ideas based on prior experiences to enable them to construct meaning of new knowledge (Ferguson (2007). The assumptions of this research were that:

1. Students from different cultural backgrounds interpret science concepts differently (Jegede & Okebukola, 1991; Snively & Corsiglia, 2001).

2. Some scientific concepts, specifically chemistry concepts are embedded in IK practices which are passed on from generation to generation
3. The best way to facilitate teaching and learning of chemistry to enhance knowledge, understanding, chemical literacy for all and sustainable development is to integrate IK practices from the learners' environment into the chemistry concepts.
4. Chemistry teachers use some indigenous knowledge practices during the teaching and learning of chemistry concepts.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter focused on the review of relevant literature that guided the study. Hence, the theoretical frameworks underlining the study was addressed. The literature review considered the nature of science and scientific knowledge, nature of chemistry, chemistry education, performance in chemistry, indigenous knowledge, relationship between indigenous knowledge and science, framework and strategies for integration, integration of indigenous knowledge, usefulness and attendant challenges and indigenous knowledge practices in the Agona East and West Municipalities. The chapter also considered the knowledge gap, and conceptual frameworks.

2.1 Theoretical Framework

A theoretical framework is the research from previous literature that defines a study's core theory and concepts. According to Creswell, (2018) a theoretical framework is a summary of theory regarding a particular problem that is developed through a review of previous research on the variables involved. Previous research serves as the basis for future research and is used to craft a logical argument for a need for the research (Creswell, 2018)

The theoretical framework of the study was based on the theory of constructivism by Vygotsky who proposed that individuals are active participants in the creation of their own knowledge (Schreiber & Valle, 2013). Vygotsky believed that learning takes place primarily in social and cultural settings, rather than solely within the individual. Bruner (2009) suggested a theory of instruction based on the constructivist approach and stated that a theory of instruction should address predisposition towards learning, how knowledge can be structured to promote understanding, and the most effective sequences in which to present a concept to learners.

Bruner (2000) further explained that a good method for structuring knowledge should result in simplifying, generating new ideas and providing an increasing ability to apply knowledge gain in relevant situations. Bruner's theory also says that individuals are able to make meaning of a reality that exists in the environment and added that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge.

The relevance of this theory to the study is based on the fact that children are social beings and live in a cultural setting and come to the classroom with indigenous knowledge practices that they have grown up experiencing. These IK practices form relevant previous knowledge unto which related concepts can be developed to make understanding of chemistry concepts easier thereby improving students' learning outcome. Additionally, engaging students in the learning process through the integration of appropriate indigenous knowledge practices from their environments will reveal the relevance of learning the concepts to their daily lives to give them the satisfaction as social beings from cultural settings whose practices have scientific implications and relevant to classroom knowledge. The use of constructivist strategies in teaching 'integrated indigenous knowledge-chemistry lessons' (IIK-CLs) will therefore provide viable mental models to enhance new ways of conceptualising computing and applying the fundamental principles of chemistry. It is against this background that relevant literature was reviewed.

2.2 Nature of Science and Scientific Knowledge

Science is a discipline with its nature characterised by investigations into events in the natural world to obtain evidence needed for explaining a phenomenon. It consists basically of a body of knowledge, the process by which knowledge is produced, and the application of knowledge to explain the world (Carpi & Egger, 2011). Science also describes a process used to add an existing knowledge base and a social enterprise to enable people to understand their surroundings (Meichtry, 1999). This process adopts a systematic procedure which includes collection, analyses and presentation of knowledge in explaining a phenomenon and contributing to knowledge to be applied in solving problems. (Lederman, 2013).

Additionally, Carpi and Egger (2011) attest to science as a human activity through which problems and questions associated with natural phenomena can be identified, defined and solutions proposed and tested. Indeed, the nature of science is revealed in the scientific processes through which problems are solved. Hence, the nature of science recognises science as a concerted human effort to understand the world with observable physical evidence. A model of the scientific process which defines the nature of science as depicted by Carpi and Egger (2011) is illustrated in Figure 1.

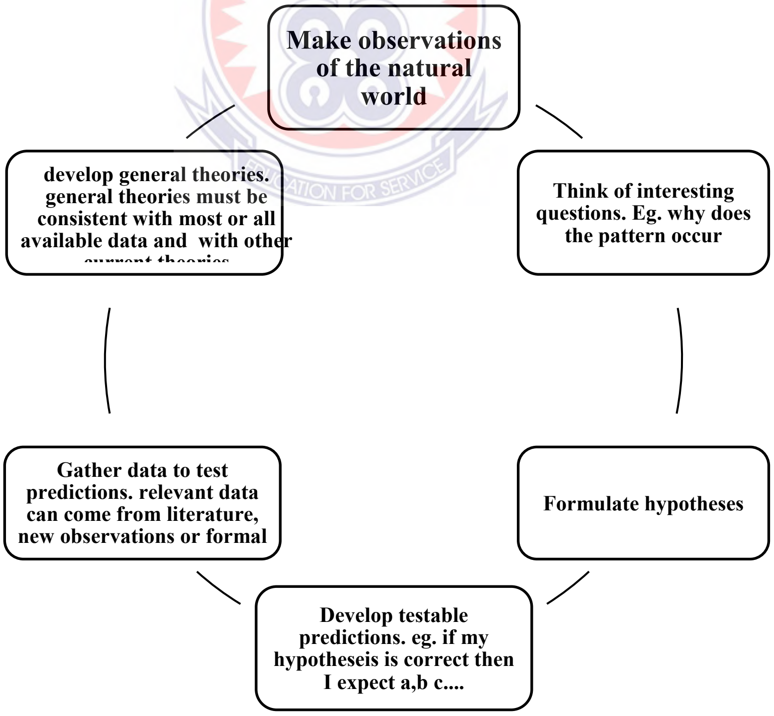


Figure 1: An illustration of the scientific model

Source: Carpi & Egger (2011)

Kimball (1968) also developed a theoretical model of the nature of science after comprehensively examining literature on the nature and philosophy of science. The statements of the model as presented by Kimball are as follows:

curiosity is the fundamental driving force of science, science is a dynamic, ongoing activity, science aims at comprehensiveness and simplifications, there are many methods of science, the methods of science are characterized by attributes which are in the realm of values than techniques, science has a unique attribute of openness, tentativeness and uncertainty mark all of science Figure 2.

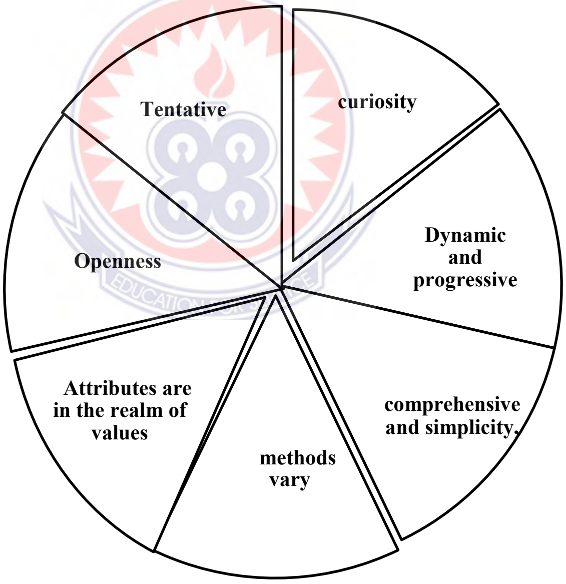


Figure 2: Theoretical model of the nature of science

Source: Kimball (1968)

Kimball's theoretical model of the nature of science is reiterated by McComas and Oslon, (1998) in their fourteen tenets of the nature of science. These tenets are;

1. science is an attempt to explain natural phenomena

2. people from all cultures contribute to science
3. scientific knowledge while durable has a tentative character
4. scientific knowledge relies heavily but not entirely observation, experimental evidence, rational argument and uncertainty
5. there is no one way to do science
6. new knowledge is reported openly and clearly, science requires accurate record keeping, peer review and reproducibility
7. science is part of social and cultural traditions
8. science ideas are affected by social and historical setting

The above model and tenets are an indication that science originated from nature which includes people and their culture. Thus, according to Hodson (2009) since scientific ideas are affected by cultural, social and historic settings it is useful to think of science as a culture in just the same way as music and art when describing the nature of science. Due to its nature, Hodson (2009) proposed that the teaching of science can be compared to the way an anthropologist teaches about another culture. The implication of these statements are that science evolved from the culture of people with a particular knowledge, a certain language, custom, practices, traditions, attitudes and values thus teaching science as art and music are taught in relation to culture makes science more meaningful to the learner.

Scientific knowledge (SK) on the other hand is knowledge acquired through the scientific process which involves observation, experimentation and data collection. It is tentative, public, replicable, probabilistic, humanistic, historic, unique, holistic and empirical (Hanne & Hepburn, 2020). Scientific knowledge involves the application of laws and theories formulated from scientific research.

These laws and theories are revisionary and tentative. The latter emphasises the inconclusiveness of all knowledge claims in science. While the revisionary component emphasises the revision of existing scientific knowledge in response to changing theoretical context. (Cotham & Smith, 1981). Rubba and Anderson (1978) described the nature of SK as amoral, creative, developmental, simplicity, testable and unified. Table 3 explained their attribute

Table 3: The proposed nature of scientific knowledge

Nature of scientific knowledge	Meaning
Amoral	SK cannot be judge as morally good or bad
Creative	SK is partially a product of human creativity
Developmental	SK is tentative
Simplicity	SK attempts to achieve simplicity of explanation as opposed to complexity
Testable	SK is capable of empirical test
Unified	The specialized sciences contribute to an interrelated network of laws theories and concepts

Source: Rubba &Anderson (1978)

In summary, scientific knowledge systems built through making predictions about the world in such a way that they are testable which most often results in the development of new knowledge that still remains tentative.

2.3 Nature of Chemistry

Science education is well recognised, as a distinct field within education concerned with the teaching and learning of the discrete science disciplines (Taber, 2017). Nested within science education, Taber noted, are sub-fields such as chemistry education, biology education and physics education. Chemistry is the scientific discipline involved with the elements and compounds composed of atoms, ions and molecules (Chang & Overby, 2019). The study of this discipline includes the composition, structure, properties and the changes these compounds undergo during a reaction with other substances. (Taber, 2017). Chemistry according to Chang (2005) is referred to as the central science because it occupies an intermediate position between physics and biology. Additionally, the relevance of the subject is not only in the other sciences but also in other disciplines including mathematics, geography, and the general arts and visual arts.

The history of chemistry represents a time span from ancient history to the present. By 1000 BC, civilisations used technologies that eventually formed the basis of the various branches of chemistry. Examples include extracting metals from ores, making pottery and glazes, fermenting beer and wine, extracting chemicals from plants for medicine and perfume, rendering fat into soap, making glass, and making alloys like bronze (Boyle, 2006). These processes obviously indicate that chemistry originated from indigenous societies.

Researchers in chemistry have provided some definitions for the subject. Boyle (2006) defined chemistry as a subject of material principles of mixed bodies. Glaser as reviewed in Neville (1965) defined chemistry as the scientific act by which one learns to dissolve bodies and draw from them the different substances the bodies are composed of, and how to reunite the bodies again to promote them to higher perfection. Chemistry is also defined as the art of resolving mixed compounds or aggregate bodies into their principles and composing such bodies from those principles (Stahl, 1730). Dumas, in Kim (2014) viewed chemistry as the science concerned with the law and effect of molecular forces. Furthermore, Chang (2005) defined chemistry as the study of matter and the changes matter underwent.

Indeed, a review of the definitions from the 16_{th} century to the 19_{th} century revealed that all the researchers in chemistry view the subject in a similar manner which is, studying, analysing and manipulating matter to satisfy human needs. Additionally, chemistry evolved from indigenous societies, even before civilisation in seeking solutions to problems.

The principal chemistry sub-disciplines as noted by Laidlaw et al (2015) are presented below:

1. Analytical chemistry is the analysis of material samples to gain an understanding of their chemical composition and structure. Analytical chemistry incorporates standardized experimental methods in chemistry. These methods may be used in all sub-disciplines of chemistry, excluding purely theoretical chemistry.
2. Inorganic chemistry is the study of the properties and reactions of inorganic compounds. The distinction between organic and inorganic disciplines is not absolute and there is much overlap, most importantly in the sub-discipline of organometallic chemistry.
3. Organic chemistry is the study of the structure, properties, composition,

mechanisms, and reactions of organic compounds. An organic compound is defined as any compound based on a carbon skeleton.

4. Physical chemistry is the study of the physical and fundamental basis of chemical systems and processes. In particular, the energetics and dynamics of such systems and processes are of interest to physical chemists. Important areas of study include chemical thermodynamics, chemical kinetics, electrochemistry, statistical mechanics, spectroscopy, and more recently, iatrochemistry. Physical chemistry has a large overlap with molecular physics. Physical chemistry involves the use of infinitesimal calculus in deriving equations. It is usually associated with quantum chemistry and theoretical chemistry. Physical chemistry is a distinct discipline from chemical physics, but again, there is very strong overlap.

Laidlaw et al (2015) further explained that early chemistry was analytical in nature only as an experimental data, with the other specialties evolving from it.

The ministry of education teaching syllabus for chemistry in senior high schools in Ghana is structured in such a way to include all the principal sub-disciplines to prepare the elective chemistry student to take the challenge of higher learning. The chemistry concepts taught were, properties of metals under periodic chemistry, factors affecting rate of chemical reactions and distillation under separation and purification of organic compounds all in form 2. The structure of concepts for the senior high school from form one to form three is as follows:

Table 4: The structure of the chemistry syllabus (Ministry of Education, 2010)

SHS FORM ONE	SHS FORM TWO	SHS FORM THREE
Chemistry as a discipline	Energy and energy changes	Chemical industry
Measurement of physical quantities	Energy cycles and bond enthalpies	Extraction of metals
Basic laboratory practices	Periodic chemistry	Extraction of crude oil and petroleum processing
Particulate nature of matter	Transition chemistry	Environmental pollution
Structure of the atom	Rates of reaction	Biotechnology
Periodicity	Chemical equilibrium	Cement and its uses

Interatomic bonding Hybridization and shapes of molecules Carbon-12 scale Solutions Chemical equations Nuclear chemistry Solids and liquids Gases and their properties Kinetic model of matter	Acids and bases concept Properties of acids, bases, acid-base indicators Classification of acids and bases Concept of Ph Buffer solution Solubility of substances Salt and chemical salt Oxidation-reduction processes Reducing agents Balancing redox reactions Redox titration Electrochemical cells Electrolytic cell Corrosion of metals Bonding in carbon Classification of organic compounds Identification of elements in organic compounds Separation and purification of organic compounds Alkanes, alkenes, alkynes, benzene, alkanols, alkanoic acids and their derivative alkyl alkanoates	Fats and oils Proteins Carbohydrates Synthetic polymers

Source: Ministry of Education (2010)

Indeed, the fact that chemistry evolved from early indigenous societies is an indication that chemistry concepts can be taught effectively with reference to IK practices relevant to the concept to ensure sustainability and chemical literacy of the individual student and not only preparing students to take the challenge for higher learning.

2.4 Chemistry Education

Chemistry education is a specialsed area within science education that has in recent years become increasingly recognised as a discrete area of research (Taber, 2017). According to Taber (2013) the core foci of chemistry education research are learning and teaching of chemistry. Indeed, modern curricula for chemistry education emphasize not only the learning of scientific theories and knowledge, but also the science-related skills needed for recognising and understanding science in questions about everyday life, for future career choices, and for decisions which students currently have to make on personal and societal issues (Burmeister, Rauch & Eilks, 2012). Hence aspects of chemistry education include understanding how students learn chemistry, how best to teach chemistry, and how to increase interest and improve learning outcomes by changing teaching methods and appropriate training of chemistry instructors. The integration of IK into the teaching of chemistry can address the aspects of chemistry mentioned and achieve the goal of sustainable development.

Education for Sustainable Development (ESD) requires the need to empower learners of all ages with the knowledge, skills, values and attitudes to address the interconnected global challenges such as climate change, environmental degradation, loss of biodiversity, poverty and inequality (UNESCO, 2021). Learning of chemistry must therefore prepare students to find solutions for the challenges of today and the future by making concepts relevant to their daily lives to enable them make informed decisions and take individual and collective action for sustainability. Additionally, to achieve sustainable chemistry education, three important criteria for change within science and technology education (and hence chemistry education) are put forward as student relevance, practicality within the society, and civil commons values (Chowdhury, Holbrook, Rannikmäe, 2020). Chowdhury et al. (2020) further explained that relevance implies the use of community resources and the incorporation of local issues and practices into the chemistry curriculum. The learning is intended to relate to the community, especially at a local level. The intention is that the learning is viewed by students as meaningful, timely, important, and useful. Practicality means activity-based learning (thinking and doing leading to action). The quality of the chemistry education is thus measured in terms of student actions, not from what the teacher is able to provide. This action relates to the competencies to be developed for a democratic approach. Values involve cultural and social issues, personal interdependence, and informed judgement, both from a holistic view of the world and from the local society perspective. It is heavily related to well-reasoned, socio-scientific decision making.

Indeed, chemistry being the central science according to Chang (2005) requires a critical approach in teaching and learning of the subject to develop in students the competency for sustainable development. Consequently, stakeholders of chemistry including chemistry researchers have been concerned with identifying effective methods of teaching and learning the subject at secondary school level. The aim primarily is to change students' attitude towards the subject in order to attain education for sustainability. (Eilks & Hofstein, 2013; Taber, 2017).

Indeed, one of the themes of the 26th IUPAC international conference was cognition in chemistry education. This theme interrogates the way chemistry is best learnt. As discussed, the best way is to link chemistry concepts relevant IK practices in their environment to establish the importance of chemistry in the day-to-day functioning of society (Hofstein et al., 2011).

2.4.1 Students' Engagement and Chemistry Teaching Strategies

Teaching strategies refer to procedures and methods by which objectives of teaching are realised. Research has suggested strategies that are useful to the teaching of chemistry to make the study of the subject meaningful to learners. Chemistry education researchers have unanimously agreed on strategies that encourage students' engagement in lessons to enable them construct their knowledge and understanding of concepts. Students' engagement has received increased attention in research policy and practice due to its potential to address problems related to low achievements, high school dropout rates, alienation and lack of interest among students (Fredricks et al., 2019). The focus of chemistry education researchers now is to investigate activities that foster students' engagement behaviourally, emotionally and cognitively in lessons to primarily develop in learners a sense of belonging, joy and to the feeling of accomplishment in learning a particular chemistry concept (Eilks and Hofstein 2013).

According to Fredricks et al. (2004), behavioural engagement is most commonly defined in three ways. The first definition Fredricks et al. (2004) explained entailed positive conduct, such as following the rules and adhering to classroom norms, as well as the absence of disruptive behaviors such as skipping school and getting in trouble (Finn & Rock, 1997). The second included students' participation in learning which is reflected in behaviours such as effort, persistence, concentration, attention, asking questions, and contributing to class discussion (Fredricks et al., 2004; Fredricks et al., 2019. Lastly, the involvement in school-related activities such as athletics or school governance. Activities that encourage behavioural engagement will enable students to adhere to school rules since lessons are tailored to their needs, resulting in increasing participation in lessons for knowledge construction and application.

Emotional engagement is the aspect of engagement that deals with students' feeling about a particular content in terms of interest, boredom, happiness, anxiety, and other affective states, any of which factors could affect learners' involvement with learning or their sustained effort in a lesson. Students who have emotionally engaged in lessons feel the sense of belonging and values for the lesson which are expressed in terms of relevance or meaningfulness of the activity to their daily lives. According to Beale (2018), Emotional engagement can be a highly advantageous educational tool but getting students emotionally engaged in lessons is sometimes difficult, given the abstract nature of some subject matter. It has been demonstrated in the context of chemistry education that students attend more readily to their studies if the subject matter presented to them is perceived as useful and relevant. Activities that encourage emotional engagement should reveal the relevance of concepts for the individual in meeting students' curiosity and interest, giving them necessary and useful skills for coping in their everyday life today and in future. Li and Lerner, (2013) and Skinner et al., (2008) also noted that, the emotional engagement has a positive correlation to cognitive engagement which implied that students who are emotionally engaged in a lesson have a high potential of also being cognitively engaged.

Cognitive engagement is defined as the extent to which students' are willing and able to take on the learning task at hand. This includes the amount of effort students are willing to invest in working on the task. One set of definitions focuses on psychological investment in learning, expressed in the desire to go beyond the requirements. Cognitive engagement has been identified as a major part of overall learning engagement where students learning is reflected quantitatively by their response to questions through the understanding and application of concepts. Hong et al., (2020) noted that an effective cognitive engagement should enable learners to immerse themselves in in-depth reflective learning processes that are situated in realistic problem-solving tasks. Chemistry learning strategies should incorporate activities that encourage active participation to help students develop skills, values and competencies that are necessary to help them attain self-worth and become responsible citizens.

A study conducted by Linnansaari et al., (2015) was aimed at addressing the problem of decreasing number of Finnish students' engagement in learning science. The research was conducted using smartphones programmed to emit a signal during every science lesson and otherwise randomly. The results of their study revealed that situation grade and gender had significant effects on students' pre-conditions of engagement and actual engagement. This implied that learners' grade and gender should be much considered when planning a science lesson to enable the adoption of appropriate situational contexts for students' engagement. Hadzigeorgiou, (2018) suggested that in choosing engagement strategies one should consider key factors such as personal identity, maturity, purpose for learning science, and students' awareness of the significance of the object or topic of study to influence students' engagement with science thus, buttressing the outcome of the study by Linnansaari et al., (2015).

Hadzigeorgiou, (2018) also used storytelling to engage students to learn the nature of science. Hadzigeorgiou 2018 emphasised that the use of narratives, which incorporate actual events from the history of science, can help illustrate the human and the larger socio-cultural context in which scientific knowledge was developed. He again noted that a recent empirical study provided evidence that integrating actual events from history to help students learn science ideas can indeed be understood by 9th graders.

A study by Rahmawati et al., (2019) engaged science students in learning about environmental pollution through the integration of ethno pedagogy in a wastewater treatment project. The results showed that ethno pedagogy integration in science learning aided students' conceptual understanding.

Again, a more recent study by Zidny and Eilks. (2020) focused on integrating perspectives from indigenous and Western science into chemistry learning. Zidny and Eilks used a planned lesson with the integration of the indigenous knowledge into western knowledge and engaged students in a discussion to learn a chemistry concept. Zidny and Eilks concluded that learning by integrating perspectives of indigenous and western science aided students' insight and revealed that chemistry learning can be enriched by an interconnected system of worldviews in order to find solutions to sustainability issues.

According to Fredricks et al., (2004) research has not capitalised on the potential of engagement as a multidimensional construct that encompasses behaviour, emotion, and cognition, rather, many of the studies of engagement include one or two types but did not consider all three. Fredrickes et al., further added that, combining all three components of engagement in a study, offers some level of richness which leads to the challenge of defining and studying each and their combination in conceptually subtle ways which also allows for rich characterisations of individuals. This study considered all the three components of students' engagement in an 'integrated indigenous knowledge-chemistry lesson' to provide a holistic picture of the impact of the lesson on engagement since engagement has been proven to help students construct knowledge and understanding and therefore an antidote to low academic achievement.

Various chemistry teaching strategies have been discussed in the literature, each with principles governing its use. Strategies adopted in the teaching of chemistry concepts should consequently result in understanding the nature, methods and principles of chemistry that help explain every-day phenomena. These strategies should further help the student to appreciate the impact of chemistry and chemistry-based technologies on society (Barnea & Dori, 2000; Dori & Sasson, 2008). The integration of relevant IK practices into the teaching of chemistry will highlight chemistry in indigenous practices which will help students appreciate the subject as crucial to their existence. Chemistry teaching strategies should thus focus on the learner as an individual and a citizen from an indigenous community to produce the best results (Marks & Eilks, 2009; Sadler, 2011).

The most discussed teaching strategies in literature adopted for instruction in chemistry are based on the constructivist perspective of teaching and learning (Burmeister et al., 2012).

The constructive perspective is guided by the principle that students must remain actively involved and not treated passively in the learning process. (Cook, Kennedy & McGuire, 2013). The constructivist perspective holds the view that Learners come to school not as a blank slate but as beings with preconceptions or prior knowledge about the natural world. Prior knowledge influences new knowledge that learners will construct from new learning experiences (Phillips, 1995). Constructivist Strategies therefore probe, reconstruct and assess the learner's understanding of science concepts, principles, laws and theories by relating the scientific concepts to students' prior knowledge and engaging them in activities relevant to the concept being learnt, to enable students construct their own understanding.

Principles of constructivist teaching are based on research about the human brain in relation to learning. These principles Caine and Caine (1991) proposed should be brain-compatible. The constructivist teaching principles are;

- The brain is a parallel processor. It simultaneously processes many different types of information, including thoughts, emotions, and cultural knowledge. Hence, for effective teaching and learning, the teacher should employ a variety of strategies.
- Learning engages the entire physiology. It is therefore important for the teaching process to address all the physiological aspects of the individual learner.
- In order to teach effectively, teachers must understand the mental models used by students to perceive the world and the assumptions they make to support those models.
- The search for meaning is innate. Effective teaching recognises that meaning is

personal and unique, and that students' understandings are based on their own unique experiences. These experiences are mainly from learners' environment.

- The search for meaning occurs through 'patterning'. Effective teaching connects isolated ideas and information with global concepts and themes.
- Emotions are critical to patterning. Learning is influenced by emotions, feelings, and attitudes.
- The brain processes parts and whole simultaneously. Meaning requires understanding wholes as well as parts. Parts are understood in the context of the whole.
- Learning is influenced by the environment, culture, and climate.
- Learning always involves conscious and unconscious processes. Students need time to process 'how' as well as 'what' they've learned.
- There are at least two different types of memory: a spatial memory system, and a set of systems for rote learning. Teaching that heavily emphasises rote learning does not promote spatial, experienced learning and can inhibit understanding.
- We understand and remember best when facts and skills are embedded in natural, spatial memory thus, experiential learning is most effective.
- Learning is enhanced by challenge and inhibited by threat. The classroom climate should be challenging but not threatening to students.

The constructivist strategies discussed in this chapter are:

2.4.2 Integrative teaching

This is a teaching strategy which puts together the parts of a whole to arrive at a holistic, complete and more accurate view of reality (Corpus & Salandanan, 2003). Integrative teaching fuses multiple intelligences, varied learning styles and the daily experiences of the learners. It empowers learners to become lifelong learners and active makers of meaning (Corpus & Salandanan, 2003).

Integrative teaching strategy according to Corpus and Salandanan (2003) consisted of three levels namely: the facts level, the concept level and the values level. The fact and concept levels fall under the cognitive domain of Bloom's learning (Merrill, 2002). The fact level includes specific information on details, isolated facts, events, and the learning of very basic skills while the concept level explores the principles supporting the facts and generalisations made from the information gathered (Merrill, 2002). The concept level as stated by Merrill (2002) also involved the introduction and practice of more complex skills, if some basic skills were involved at the fact level. The teacher encourages the students to explore the principles behind the facts and to put pieces of different facts together so that generalizations can be made from the gathered data. Values level is under Bloom's affective domain which ensures the development of attitudes, values, and feelings towards particular issues and the environment (Merrill, 2002). Merrill (2002) argued that, the value level principally sees to the integration of the subject matter into students' lives, and to encourage students to think, feel, and act on their concerns, attitudes, and experiences to enable them relate the facts and concepts to their own lives

Indeed, it can be deduced from the discussion that integrative teaching approach offers the learner benefits such as, makes content more meaningful because the content is presented the way it is in the real world, student-centered, involves active learning with the teacher acting as facilitator of learning, allows learners to form their own representations of complex topics and issues, offers multiple ways for learners to demonstrate the knowledge, skills and attitudes learned, gives opportunities for students to work in a context where interdependence and cooperation are crucial for getting things done and helps learners develop a variety of social skills

2.4.3 Inquiry approach

The inquiry-based strategy is an approach that emphasizes the students' role in the learning process rather than the teacher telling students what they need to know. The approach perceives the teacher as a facilitator of learning. Khan, Hussain, Ali, Majoka, and Ramzan (2011) explained that teachers have the obligation to support students' learning. They proposed an inquiry-based learning curriculum which aimed to develop higher order thinking and practical skills by allowing students to act as problem solvers. This approach teaches students to handle situations they meet in the physical world.

A post class testing after a study conducted by Khan et al. (2011) to determine how an inquiry-based learning curriculum would affect students' academic achievements in chemistry at the high school level indicated that the students who were taught using inquiry based instruction reflected significantly higher academic achievement than those students who were taught using traditional. The study proved that the use of the inquiry-based strategy in teaching chemistry concepts has the potential to improve students' learning.

According to Bruner (2009) in using the inquiry approach in the teaching of Chemistry, the teacher must prepare activities that will allow students to develop the skill of recognising problems, asking questions, applying laboratory procedure and providing consistent descriptions, predictions and explanations.

Common features of the inquiry-based strategy include involving students in hands-on activities such as experiments and allowing students to focused on learning some analytical skills and applying the skills gained in the hands-on activities. The inquiry-based strategy according to Brunner (2009) follows the 5-E's principle: Engage, Explain, Explore, Elaborate and Evaluate.

2.4.4 Discovery approach

This approach like the inquiry-based approach takes place in problem solving situations. However, in the discovery approach the learner draws on his or her own experiences and existing knowledge to discover facts, relationships and new knowledge to be learned (Bruner, 2009). Students' motivation in lessons can be increased if they are to experience something different from their day to day activities. This implies that experiences leading to new discoveries make learning fun. The stages or levels involved in the discovery approach follows Bruner's levels of thought. (Bruner, 2009). The first, which is the enactive level, allows students to perform hands-on activities directly related to what is to be discovered. The next stage is the ikonic level. The teacher, at this level directs the thinking of the students using experiential situations to the mental images or models of the objects used upon which the discovery is to be based. This is why it is important for teachers to understand the mental models used by students to perceive the world and the assumptions they make to support those models. The ikonic level is followed by the symbolic level where the students are guided to replace mental images with symbols to increase generality and abstraction which eventually results in the discovery planned by the teacher in advance to help students construct their own learning.

2.4.5 Reflective teaching

Reflection as a proactive, on-going examination of beliefs and practices, their origin and impact. (Pollard, Anderson, Maddock, Swaffied, Warin &Warwick, 2008). Reflective practice hence, helps students to frame a problem, analyse it critically, bridge the gap between theory and practice, understand and influence their own thinking, recognise the depth and range of transferable skills learned and become life-long learners. Pollard et al (2008) suggested four ways by which students can be engaged in reflective teaching as journal writing, portfolio, self-analysis, and on-the-spot observation of students' response. According to Pollard et al (2008), journal writing allows the students to reflect and process their thoughts about chemistry concepts. Journals may be in the form of workbooks, diaries, logs, or progress profiles. The portfolio on the other hand is a personal record which includes an honest to goodness account of experiences, thoughts, behavior and reactions (Salandanan, 2000). Keeping portfolios helps students to relate past experiences to current learning situations to enable them construct their own meaning.

Self-analysis, also a type of reflective teaching, is a record of incidents, problems and issues that transpired during a science lesson. Self-analysis helps the student to remember to repeat the right thing and avoid the wrong in another situation. According to Pollard et al. (2008), questions such as; What went wrong? How could I have done this? and Is there room for improvement? Are asked during the self-analysis process. Finally, on the spot observation of the students' responses as a reflective teaching method, involves the teacher asking questions such as: Were the students motivated to participate in the activity? Did the students take part in the discussion? Did the students share their views animatedly? Were the students given equal opportunity during the discussion? Was the topic related to the world of the students? Would the students be able to apply the science concepts discussed to their everyday life? (Pollard et al., 2008).

2.4.6 Field trips

Sagor and Williams (2016) defined field trip as a trip arranged and undertaken by the school for educational purposes. Field trip sites are carefully chosen to enable students learn directly with the materials of instruction in their functional setting. Teaching and learning during field trips are valuable for cognitive and affective development of the students. According to Sagor and Williams (2016) field trips provides the opportunity for hands- on, real world experiences, improves quality of education, ensures motivation and development of positive attitude towards the subject. Further field trips result in improvement of the socialisation between students and develops a good rapport between teachers, students and the community. Additionally, field trips offer a change in the regular learning environment relieving students of the classroom associated boredom. The idea of the normal school norm is minimized thus students are free to express themselves about a particular activity thus fostering their engagement in the lesson. Learning in environments outside the school setting for example a visit to a local industry helps students in realising the relevance of concepts to their everyday life thereby developing their interest in the lesson.

2.4.7 Concept mapping

A concept map is a special form of a web diagram for exploring knowledge, gathering and sharing information and developing connections among concepts (Novak & Cañas, 2008). Concept mapping is one strategy to increase understanding of relationships among concepts by analysing smaller parts (Hinck et al., 2006). A concept map, Novak and Cañas (2008) explained, consists of nodes or cells and links. The nodes contain the concepts and are usually enclosed in a box or circle. The links are represented by arrows.

The labels in the links explain the relationship between the nodes. The arrow describes the direction of the relationship and is read like a sentence. Concept map serves as an assessment tool which provides information on how students identify and relate concepts from previous lessons to similar concepts in other learning situations, which gives an indication that the lesson was understood (Novak & Cañas, 2008). Children enjoy cartoons and love to play games hence, games, puzzles, cartoons, humor, and jokes can be used in the science classrooms to map concepts.

The application of these strategies are expected to make chemistry teaching interesting by demystifying the science. However, chemistry that is noted as challenging or abstract are being practiced with the environmental resources within the context of indigenous knowledge at different levels of human societies across the globe unknowingly. (Ugwu, & Diovu, 2016). This implies that chemistry concepts taught in the classroom are embedded in IK practices. Chemistry can therefore be made real and relevant to learners if the concepts are taught and learnt by integrating IK practices into these teaching strategies.

2.5 Performance in Chemistry

The West African Examinations Council has expressed concern over the decline in the performance of candidates in science. The performance in integrated science for example declined from 52.89% in 2017 to 50.48% in 2018. (WAEC, 2018). Specifically, WAEC results nationwide from 2016 to 2018 and of four Senior High Schools in the Agona Municipality from 2015 to 2018 was analysed for the performance trend of students in chemistry. The analysis revealed that 37.5%, 34.83% and 52.50% nationwide and 32.4%, 17.6%, 19.3%, and 30.2% of students who desired to offer any chemistry related course would not satisfy the minimum requirements to access tertiary education in the year under analysis. The result of the analysis indicated a general decline as shown in Table 1 and 2 in the previous chapter.

Indeed, the problem of poor performance in chemistry is a global one. According to research, regardless of the world-wide attention on improving students' learning outcomes, students in developing countries who register chemistry at the West African Secondary School Certificate Examinations (WASSCE) and Kenya Secondary Certificate Examinations (KSCE) perform poorly in the subject (Ogwe, Odhiambo & Kibe, 2008; Obamanu & Ekenobi, 2011). Analysis of results for six consecutive years in a publication by Opara (2013) revealed the performance of Kenyan and Nigerian students in chemistry. The mean achievement scores of students in chemistry from 2005 to 2010 in the Kenyan Secondary School Certificate Examination (KSCE) and WASSCE (Nigeria) were: 26.99, 24.78, 25.17, 22.50, 18.99 and 24.71 and 37.28%, 50.65%, 45.11%, 46.16%, 43.69% and 50.70% respectively (Opara, 2013). The trend in performance was presented in a graph as shown in Figures 3 and 4

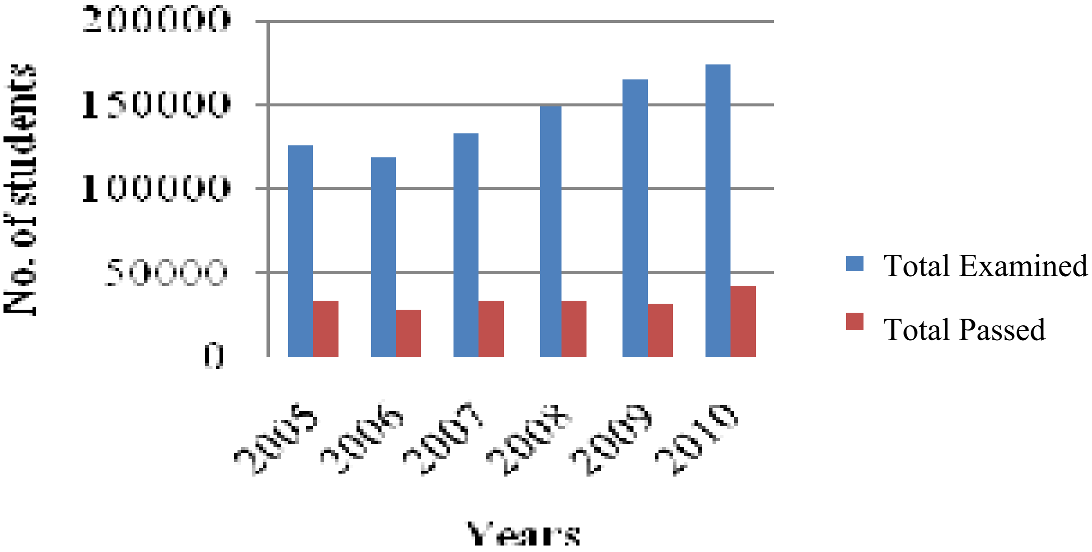


Figure 3: Trend of performance in chemistry in the KSCE
Source: Opara (2013)

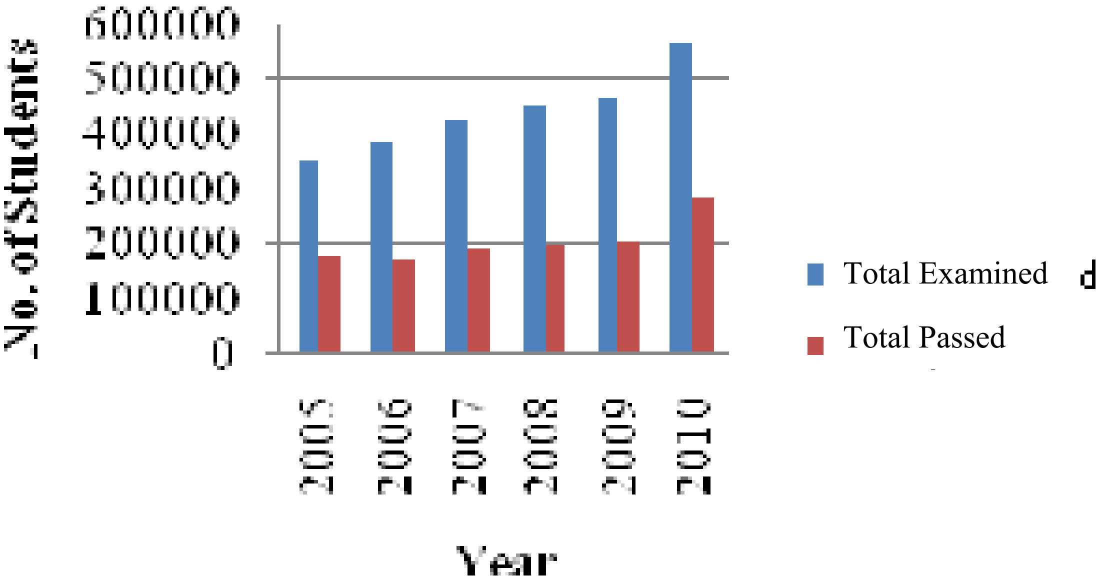


Figure 4: Trend of performance in chemistry in the WASSCE

Source: Opara (2013).

According to Opara (2013), this level of pass obstructs global competitiveness and hinders students' admission into the universities or higher institutions for science related subjects that need chemistry as a prerequisite.

In a related analysis by Sakiyo and Badau (2015), the results of students who took the WASSCE in chemistry from 2008 to 2012 revealed a mean pass rate of 46.30% which according to him, does not augur well for the development of any country. Studies conducted on the performance of students in chemistry have investigated and attributed the failure of the students to:

1.inadequate teaching resources (Asiyai, 2006; Arokoyu & Ugonwa, 2012)

2. students' attitude (Adesoji & Ogunniyi, 2012)

3. lack of interest and motivation (Ameyaw & Amankwah, 2014)

4. teaching methods (Bamidele & Oloyede, 2013)

5. inadequate trained teachers, large class size, inadequate infrastructure, poor working conditions of teachers and teachers' knowledge on subject matter (Hassan et al., 2015).

Indeed, concerns about the persistent poor performance in science in general and specifically in chemistry has led some countries into taking measures to curtail the problem. The Kenyan government mounted the SMASSE (Strengthening Mathematics and Sciences in Secondary School Education) project. The project was organized by the Ministry of Education Science and Technology (MOEST) in collaboration with the Government of Japan through Japan International Cooperation Agency (JICA). The aim of the project was to provide in-service training for mathematics and science teachers to help them improve on their pedagogical content knowledge (PCK) and teaching methodology.

Ghana alike, has taken some intervention measures to improve the teaching and learning of science throughout the country. This include the supply of modern science equipment and ICT-based science facilities, and training of science teachers and laboratory technicians in selected secondary schools (Bayali & Junko, 2015). Under the project, the government in 2011 rehabilitated and refurbished selected senior high schools in the country with science equipment installed and supplied by Philip Harris international. ((Bayali & Junko, 2015).

Of recent is the school education improvement program (SEIP) that has been constituted by the government to identify low performing schools and tackle challenges facing these schools in relation to infrastructure, equipment and learning resources (Brown, 2017).

The Government through the Ministry of Education aims at improving teacher quality in various schools in the country. Over the years, teacher education has seen many upgrading which are focused at producing well trained teachers who can teach effectively to improve the performance of students. The trend in the upgrading is as follows: award of Post Middle School Certificate ‘B’, 4-year Post Middle Certificate

'A' 3-year Post Secondary Certificate 'A' then finally to the award of Diploma in Basic Education. The University of Education, Winneba and University of Cape Coast were purposely built to train quality teachers to feed the various secondary schools.

In spite of all these efforts by the government to provide quality education, the performance of students in chemistry leaves a lot to be desired. According to Amedeker (2014), the expectation of excellent academic performance in the science subject due to the deployment of ICTs in instruction appears far from being achieved. Analysis of WASSCE chemistry results from 2016 to 2018 indicated that less than half (47.50%) of the population of students that took the examination in chemistry in 2018 and less than two-thirds of the science students who took the examination for the entire period 2016 to 2018 met the university entry requirement (Amedeker, 2014). This Amedeker (2014) explained, is contrary to the expectation of the Ministry of Education that not less than 85% of senior high school students will enter universities and other tertiary institutions.

The integration of indigenous knowledge into the teaching of chemistry has the potential of improving students' academic achievement, this is because IK has the ability to relate chemistry concepts to appropriate contexts in their environment to create in students the awareness of the relevance of the concepts to their everyday life experiences. Students' engagement in the lesson due to its relevance will help them construct understanding and be able to apply the concepts in relevant situation and for sustainable development.

2.6 Indigenous Knowledge

Studies conducted in the field of indigenous knowledge (IK) have provided various definitions for the concept. According to United Nations Forum on Indigenous Issues, Fact Sheet 1, lack of consensus in the definition of the term indigenous has led to a compilation of a list of descriptors that provide an inclusive understanding of the term. Kibirige and Van Rooyen (2007) defined IK as a legacy of knowledge and skills unique to a particular indigenous culture and consist of wisdom that has been produced and developed from an interface involving people and their environment, and passed on over generations. According to Kibirige and Van Rooyen (2007) IK is a locally based knowledge which is experience-driven, implicit, constantly changing, learned through repetition, transmitted orally and, in many cases, through imitation and demonstration. From the view of Onwu and Mosimege (2004) IK are local and community-based systems of knowledge which are unique to a given culture or society and have developed as that culture has evolved over many generations inhabiting particular ecosystems. Similarly, Grenier (1998) describes IK as a knowledge which is distinctive, traditional, confined, existing within, and developed around particular circumstances of people in a specific geographic area. Grenier (1998) added that IK is cumulative and representative of generations of experience acquired through trial-and-error, watchful observations and experiment. Stevenson (1996) describes IK as an outcome of years of shared experiences, customs and values, spiritual and cultural beliefs, as well as traditions of a given people which is passed on from generation to generation mainly by oral means, and in some cases through paintings, writing, and other artefacts.

IK is the product of human observation, inquiry, reflection, critical thinking, creativity, and resourcefulness. Ogunniyi (2013) stated that, IK in many cases, is the sum total of logical and well-organized human interactions with nature and is represented in various forms such as verbal, graphic or written. According to Ogunniyi (2011), IK embraced both testable and non-testable metaphysical phenomena that attempts to describe, explain, predict and control phenomena as well as harmonize with phenomena.

Indigenous Knowledge (IK) is a component of indigenous knowledge systems (IKS) (Onwu & Mosimege, 2004). Knowledge systems that existed in numerous parts of the non-Western world before the advent of colonialism are referred to as indigenous knowledge systems. (Hewson & Ogunniyi, 2011). According to Onwu and Mosimege (2004), IKS is a general term which refers broadly to the collective knowledge of indigenous people about relationships between people, habitat and nature. It encompasses knowledge commonly known within a community as well as knowledge which may be known only to a shaman, tribal elders, a lineage group, or a gender group (Onwu & Mosimege, 2004). IKS includes technologies and practices used both in the past and present by indigenous peoples for their survival in a variety of environments (Otulaja, Cameron & Msimanga, 2011). According to Onwu and Mosimege (2004) IK constitutes those aspects of IKS which are more likely to be identifiable in the field as part of the lifestyle of learners which could be used in the classroom.

In relation to IKS, Indigenous Knowledge (IK) refers to IKS that interprets how the world functions from the cultural perspective unique to a particular group of indigenous people. IK is the philosophy that gives rise to a diversity of indigenous technologies observed in preparation and preservation of food, manufacturing, agriculture, purification of water, healing and weather forecast among others, to ensure the sustainability of the environment Ankrah, Kwapong & Dankyi Boateng, 2021; Chikaire et al. 2012; Son, Kingsbury, & Hoa, 2021; Turner, 2014). In the United States of America (USA), technologies in IK has been incorporated into modern applied sciences such as ecology, engineering, medicine, architecture, pharmacology, metallurgy, navigation, agriculture and nautical science (Berkes, 2012; Turner, 2014). IK are therefore those aspects of IKS that can be integrated into the teaching of science to enhance the understanding of scientific concepts. The term local knowledge, traditional knowledge, indigenous knowledge, ethno science (Fasasi, 2017), indigenous science, informal knowledge, and folk knowledge are used as synonyms for IKS although each one has its own drawbacks (Nygren, 1999).

2.7 Relationships between IK and Western Scientific Knowledge

The Merriam-Webster online dictionary defines knowledge as a familiarity, awareness, or understanding of someone or something, such as facts, information, descriptions, or skills, which is acquired through experience or education by perceiving, discovering, or learning. Knowledge can refer to a theoretical or practical understanding of a subject which can be implicit or explicit and formal or systematic. Deducing from the definition it is clear that since indigenous knowledge and Western scientific knowledge are both forms of knowledge, the two may share some similarities. However, there may be differences owing to the fact that each represents a specific form of knowledge.

Studies conducted by Baker, Rayner and Wolowic, 2011; Medin and Bang, 2014; Ludwig and Poliseli, 2018; Tengö et al., 2021 presented many similarities as well as differences between IK and Western scientific knowledge (WSK). The similarities make it easier to see how the knowledge from both systems can be combined to create a better understanding of the natural world (Tsuji & Ho, 2002; Reid et al., 2021).

According to Emeagwali (2003) and Aikenhead (2006), IK and WSK are similar in that they rely on empirical evidence gathered by experimentation. Another similarity between indigenous knowledge and Western science is that “both IK and science are based fundamentally on observations of the outside world which are in principle accessible and communicable (Antweiler, 2004). From the view point of Baker, Rayner and Wolowic, (2011) IK and WSK are similar in that they both explain complex systems, seek to understand the physical world, are based on observation, bodies of knowledge change over time and are verified through repetition. Although similarities exist between these two knowledge forms, Antweiler (2004) argued that WSK is often portrayed as superior, universal, and as not having the 'cultural fingerprints' that appear to be much more conspicuous in other IK

Antweiler (2004) outlined the differences as follows:

WSK seeks information which is not context-bound, whilst indigenous knowledge seeks information which is context bound, IK proceeds from observations gained through trial-and-error, as opposed to controlled experiments in WSK, IK and WSK differ in their social goals as well as their means of gaining knowledge, and IK is acquired through observations and experiment based on natural occurrences whilst WSK is learnt in an abstract manner.

Furthermore, WSK presents science based on a mechanistic worldview, while IK on the other hand, presents essentially an anthropomorphic worldview (Ogunniyi, 2013). IK is holistic whilst WSK is reductionist (Ogunniyi, 2009; Mazzocchi, 2018). According to Horsthemke, (2021). WSK breaks down data into smaller elements to understand the whole and complex phenomena. WSK distinguishes science into zoology, botany, physics, chemistry while IK views ideas and practices as one. Another difference presented by Jegede (1997) and Semali (1999) is that learning in WSK is an individual enterprise whilst learning in IK is communal. IK and WSK also differ in their mode of transmission.

Another significant difference between IK and WSK is that IK embraces both testable and non-testable metaphysical phenomena" as it considers some aspects of the universe as mysterious whilst WSK is concerned with testable phenomena and considers the universe is knowable (Ogunniyi, 2011). While WSK attempts to describe, explain, predict and control phenomena, IK attempts to do the same as well as harmonize with phenomena and incorporates mystery in its explanation of the universe (Ogunniyi, 2011). The spiritual phenomena and explanations postulated by IK are rejected by mainstream science because they are empirically unobservable (Onwu & Mosimege, 2004). According to the Alaska Native Science Commission, the acquisition of IK is lengthy whilst WSK acquisition is rapid, classification of IK is based on a mix ecological use, non-hierarchical differentiation, includes everything natural and supernatural, contrarily, classification of WSK is based on phylogenetic relationship, hierarchical differentiation and excludes the supernatural and finally, IK explains phenomena based on examples, anecdotes and parables while WSK explains phenomena based on hypotheses, theories and laws. The differences between IK and Western scientific knowledge as argued by researchers in this section were presented in Table 5.

Table 5: Comparison between IK and Western scientific knowledge

Indigenous knowledge	Western scientific knowledge
Seeks information which is context bound	Seeks information which is not context-bound
Knowledge proceeds from observations gained through trial-and-error	Knowledge from observations gained from controlled experiments
Presents essentially an anthropomorphic worldview	Present science based on a mechanistic worldview
Holistic	Reductionist
Views ideas and practices as one.	Distinguishes science into zoology, botany, physics, chemistry, etc.
Learning is communal.	Learning is an individual enterprise
Basically transmitted through oral tradition	transmitted through written records.
Based on observations of the natural world coupled with direct experimentation in the natural setting	Experimentation in Western science is conducted in laboratories
Embraces both testable and non-testable metaphysical phenomena" as it considers some aspects of the universe as mysterious.	Concerned with testable phenomena and considers the universe as knowable.
Attempts to describe, explain, predict and control phenomena as well as harmonize with phenomena and incorporates mystery in its explanation of the universe.	Attempts to describe, explain, predict and control phenomena.
Explanation based on examples anecdotes and parables	Explanations based on hypothesis theories and laws.
Lengthy acquisition	Rapid acquisition
Classification based on a mixed ecological use, non-hierarchical differentiation, includes everything natural and supernatural	Classification based on phytogenic relationship, hierarchical differentiation and excludes the supernatural

Baker, Rayner and Wolowic, (2011) summarised the similarities and differences between Indigenous science and Western science as in Figure 5.

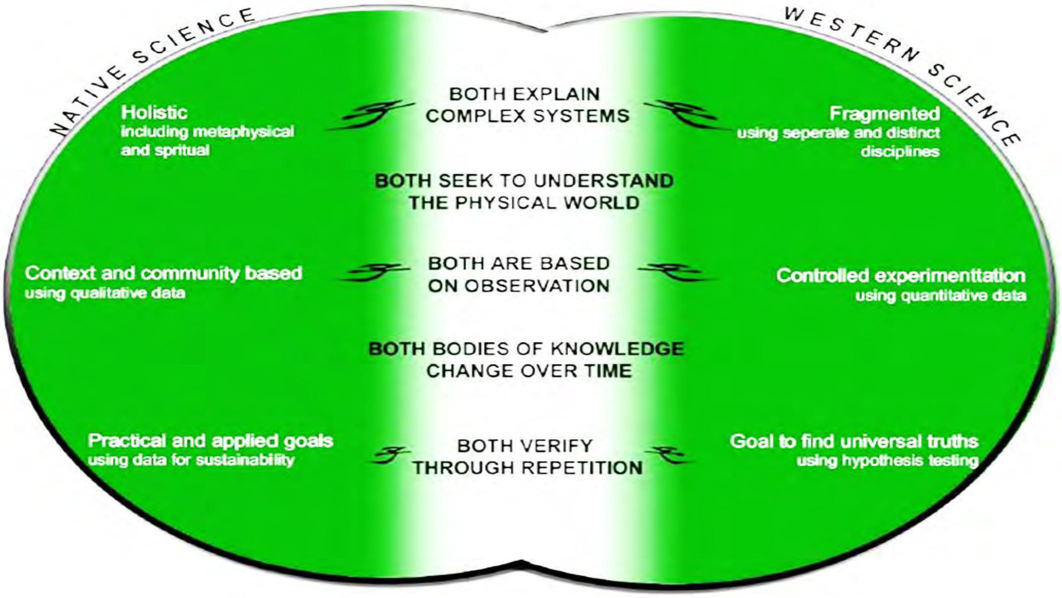


Figure 5: Similarities and differences between indigenous and Western science

Source: Baker, Rayner & Wolowic (2011)

2.8 Framework and Strategies for Integration of Indigenous Knowledge into the teaching of Science

The attempt to include IK practices into the teaching of school science has been made by some countries. These countries include the United States of America (USA), Canada, Australia, the Middle East, and Far East, Central and South American South Africa, Zimbabwe among others (Aikenhead, 1997; Jegede, 1997; Michie & Linkson, 1999; Snively & Corsiglia, 2001; Batiste, 2005). According to Hill (2004) and Scalfino (2005), there has been a strong call for values education in Australia because education that is founded on values, seeks to develop in the students a sense of responsibility and reinforce interrelationships and interdependence.

The Alaskan Native Knowledge Network in the United States, has successfully set standards that have been adopted by all relevant educational bodies in the Alaskan state (Battiste, 2002). Battiste (2002) noted that the Alaskan Standards for Culturally

Responsive Schools have received much attention among Aboriginal educators as democratic, inclusive, and comprehensive guidelines that articulate ways in which indigenous knowledge may be adapted to local needs. In the guideline, each school, community, and related organisation must review these standards to determine their appropriate application and to devise new standards to fit local circumstances (Battiste, 2002). According to Battiste, 2002) the newly devised standards are not an attempt to standardise or homogenise heritages, but a means to nurture and build upon rich and varied cultural traditions. Such standards operate as a starting point for communities and schools to achieve seven core purposes. These purposes are to:

1. review school or district-level goals, policies, and practices with regard to curriculum and pedagogy.
2. examine home environments and parenting support systems for the upbringing of the community's children.
3. devise locally appropriate ways to review student and teacher performances and how they relate to nurturing and practicing culturally healthy behaviour, including serving as potential graduation requirements for students.
4. strengthen the community's commitment to revitalising the local language and heritage and fostering the involvement of elders as an educational resource.
5. guide the preparation and orientation of teachers in ways that help them attend to the cultural well-being of their student.
6. guide the formation of state-level policies and regulations and the allocation of resources in support of equal educational opportunities.
7. evaluate educational programs intended to address the cultural needs of students (Battiste 2005).

Some provinces and territories in Canada have attempted to articulate standards for teaching Indigenous heritage in the classroom (Battiste, 2005).

In Canada, the provincial and territorial educational systems suggest that the integration of IK into the curriculum should involve three processes: First, is respecting the diversity of Indigenous knowledge's protocols, preparations, and purposes. Second, is understanding the multi-levels of preparation and purpose in transmitting Indigenous knowledge. Lastly is developing constitutional and ethical responsibilities for those researching Indigenous knowledge.

Battiste (2002) and Antoine, Mason, Mason, Palahicky, and Rodriguez de France (2018) added, in integrating both knowledge systems, it is important to note that Indigenisation does not mean changing something Western into something Indigenous. The goal, they added, is not to replace Western knowledge with Indigenous knowledge, neither is to merge the two into one. Rather, Indigenisation can be understood as weaving or braiding together two distinct knowledge systems so that learners can come to understand and appreciate both (Antoine et al., 2018). Thoughtfully interwoven Indigenous content and approaches must be informed by an understanding of Indigenous epistemologies and pedagogies (Antoine et al., 2018). Thus, according to Aikenhead (2001), the success of IK integration into WSK depends on careful planning and participative collaboration with knowledge holders in communities around schools. Indigenous pedagogy accepts students' cognitive search for learning processes they can internalise, and Aboriginal teachers allow for a lag period of watching before doing (Battiste, 2005) According to Antoine et al. (2018) interweaving Indigenous approaches should involve considering all the following aspects of your course design:

1. Goals: Does the course goal include holistic development of the learner? If applicable, does the course benefit Indigenous people or communities?

2. Learning outcomes: Do the learning outcomes emphasise cognitive, emotional, physical, and spiritual development? Is there room for personalisation, group and individual learning goals, and self-development?
3. Learning activities: Have you included learning activities that are hand-based, narrative, intergenerational, relational, experiential, and multimodal?
4. Assessment: Is the assessment holistic in nature? Are there opportunities for self-assessment that allow students to reflect on their own development?
5. Relationships: Are there opportunities for learning in community, intergenerational learning, and learning in relationship to the land?
6. Format: Does the course include learning beyond the classroom?

2.8.1 Strategies for Integration of Indigenous Knowledge into the teaching of Science

Studies have revealed some strategies used by researchers in integrating IK into the teaching of science. One of such is argumentation. Argumentation is the interdisciplinary study of how conclusions can be reached through logical reasoning that is claims based, soundly or not, on premises. It includes the arts and sciences of civil debate, dialogue, conversation, and persuasion. Rules of inference, logic, and procedural rules in both artificial and real-world settings relate to argumentation (Van Eemeren & Grootendost, 2003). Argumentation allows students to learn by arguing from available evidence thereby engaging them in the learning process (Van Eemeren & Grootendost, 2003).

Findings of a study carried out by Ogunniyi (2011) on the use of argumentation as a means of integrating IK into school science revealed that argumentation could be used to analyse and categorise different types of worldviews that are possessed by learners and teachers, which could have a positive or a negative impact on the success of IK and

WSK integration. An argument is taken simply as a conclusion that is arrived at based on reasons. A good argument is one whose conclusion follows from the given reasons, which are true (Bowell & Kemp, 2010; Jimenez-Aleixandre, & Erduran, 2008). According to Ogunniyi (2011) the effects of argumentation as a teaching tool for indigenous and scientific knowledge integration are very significant if epistemological differences between scientific and indigenous are very well considered.

Hewson (2015) noted that a successful integration will be possible if a thorough research is carried out to find out the content of IK and the processes by which indigenous people think. Again, Hewson (2015) reiterated that, the identification of similarities and differences between IK and WSK coupled with understanding of epistemological differences is essential in providing important indicators for integration. Hewson (2015) conducted a study to develop integrated Science-IK lessons. In the study, Hewson (2015) interviewed and allowed two groups of African traditional healers to demonstrate how they would teach some selected topics if given the opportunity. Hewson then developed the integrated Science-IK lesson based on the information received from the traditional leaders which he later applied in the classroom and realised it has a positive impact on students learning of science.

Similarly, Lee, Yen, and Aikenhead (2011) conducted a study on an indigenous clan in Taiwan. The study was focused on how indigenous wisdom could be included in school science teaching. Materials in science that described indigenous worldviews of time were written. Local tribal elders and knowledge keepers in the community were given specific topics and content to be vetted in order to gain a good understanding of the indigenous knowledge. These topics were then used to teach and develop Grade 4 (10 years old) students' conception of time in a science lesson. The findings from Lee et al. (2011) revealed that the learners become more informed and refined in conceptualising time through their engagement with an indigenous and science integration exercise and their interest in learning was increased. The researchers concluded that integrating both knowledge can help to improve learners' performance in science. Lee et al. (2011) noted that an adequate understanding of the students' worldviews helps the teacher to use these worldviews as a resource for improving their academic achievement.

A more recent study on the strategies of integrating indigenous knowledge into chemistry was by Zidny and Eilks (2020). The strategy consisted of a design framework which was used to introduce indigenous science as both content matter and context for science education using the education for sustainable development approach framework. The framework considered teachers' perspective, content structure, students' perspective, science content, western view on content, selection of relevant context, development of pedagogical structure, development of a lesson plan, implementation and evaluation. Zidny and Eilks (2020) explained that socio-cultural aspects of indigenous science can be used in education for sustainable development as potential contexts to achieve science learning. The conclusion made base on their study was that chemistry learning can be enriched by encouraging higher levels of student interest and increasing the personal perception of a topic's relevance.

The literature review provided a guide for the Researcher in the collection of the IK practice for use in designing the integrated indigenous knowledge-chemistry lessons for this study. The guiding principles adopted were respecting the diversity of Indigenous knowledge's protocols, preparations, and purposes, understanding the multi-levels of preparation and purpose in transmitting indigenous knowledge, recognising that integration is not a means of replacing western knowledge with indigenous knowledge but weaving or braiding together two distinct knowledge systems so that learners can come to understand and appreciate both, understanding of indigenous epistemologies and pedagogies, identification of the similarities and difference, the need to collaborate with holders of knowledge in the community, integration should aim at holistic development of the student and success of integration depends on careful planning.

2.9 Knowledge Gap

Several studies have been conducted in the field of Indigenous Knowledge and science education, and the integration of IK into the teaching of the subject. In fact, quite a number of such studies have been undertaken in the South African context. One of such studies was on the relevance of science to rural communities (Keane, 2006). Other publications on IK include those of Manzini (2000), Battiste (2005), Hewson and Ogunniyi (2011). The works of all these researchers established the importance of incorporating IK into the teaching and learning of science.

Some studies were found to have been carried out in the area of integration of Indigenous Knowledge into regular school curricula in Ghana. A research into science in indigenous industrial activities was carried out by Anamuah-Mensah *et* al. (2008), while a study into the perception of indigenous knowledge by teachers and students of science in senior high schools was carried out by Ameyaw and Amankwah (2014). Dei and Simmons, (2011) worked indigenous knowledge and the challenge for rethinking conventional educational philosophy. Owusu-Ansah and Mji (2014) also researched African indigenous knowledge. Nonetheless, there are still many unexplored IK practices that are of immense benefit to the teaching of science specifically, chemistry. This research work is to fill this gap by exploring and documenting some other IK practices.

Considerably, studies in IK in Ghana has not focused on the categorisation of IK under specific subject concepts with designed lesson plans This work targeted the categorisation of appropriate IK practices under selected chemistry concepts with designed lesson plans with integrated indigenous knowledge practices, named ‘integrated indigenous knowledge-chemistry lessons (‘IIK-CLs’) hence filling this gap.

2.10 Usefulness of ‘Indigenous Knowledge-Science lessons’

A study conducted by Ameyaw and Amankwah (2014) investigated teachers and students view on the effects of integrating IK into the teaching of science and came out with the following findings:

1. The use of IK will enhance students' knowledge and understanding of scientific concepts.
2. The use of indigenous materials in teaching will enhance students’ interest in science
3. Application of scientific concepts in the solution of problems will be enhanced when indigenous knowledge is integrated with science.
4. Science and technology will be greatly enhanced when indigenous knowledge is integrated in science teaching and learning
5. The use of indigenous knowledge in science will help students appreciate their culture.
6. The use of indigenous knowledge will help students to explore, know, understand and appreciate their immediate environment.
7. The use of indigenous knowledge will help promote education for sustainable development.

Other researchers have also considered the importance of IK in relation to the way students learn. These include

1. IK as prior knowledge. Students bring to the classroom ideas based on prior experiences, and children of different cultural backgrounds frequently interpret science concepts differently than the standard scientific view and teachers need to

begin instruction by determining the prior knowledge of the learners (Jegede & Okebukola, 1991; Snively & Corsiglia, 2001). Teachers need to probe for and incorporate the prior views of indigenous children (Snively & Corsiglia, 2001). Cobern (1996) asserts that science education as it is conceptualised frequently has little or no meaning for many students because it fails to teach scientific understanding within the actual environment of learners (Baker & Taylor, 1995; Cobern, 1996). For example, the Ghanaian students will find it difficult to understand science exactly the way students in western countries do. The Ghanaian student will construct a view of science based on their understanding of the human beings and the essence of the natural world (Cobern, 1996)

2. IK helps in restructuring learning. According to Cook et al. (2013) Learning occurs due to dissatisfaction with present knowledge. Hence, for meaningful learning to take place, learners must be put in situations that challenge their previous conceptions and create contradictions that will encourage discussion resulting in cognitive restructuring for new learning to occur. Integrating indigenous knowledge into the teaching of science, specifically chemistry will stimulate learning, promote discussion and the desire to clarify previously conceived ideas.
3. Learning has a social component. Learners construct knowledge not only by physically and mentally acting on objects but also through social interactions with others (Abah, Mashebe & Denuga, 2015). Ferguson (2007) argued that cognitive growth results from meaningful learner-learner and learner-teacher dialogue. Learning is facilitated by an environment devoid of domination but one that encouraged reciprocity, cooperative and collaborative involvement. The philosophy supporting social constructivism (Vygotsky, 1986; Solomon, 1987; Ferguson 2007) explains how these learners construct knowledge, how they add

new knowledge into existing cognitive structures through social interaction, and finally make sense of the outcome of the constructed knowledge (Tobin, 1990; Ferguson, 2007). According to Piaget (1977) learning takes place when the learner as an individual interacts with the environment. Learning is a complex process that takes place within a social context as social constructivists insist, but ultimately it is the individual who is responsible for and does the learning. Integration of indigenous knowledge practices will provide suitable context to engage students in the learning process to satisfy the social component of learning by making concepts relevant to students' life.

4. Learning requires application (Abah et al., 2015). According to the American Association for the Advancement of Science (1990) constant practice and application of knowledge acquired results in the mastery of the knowledge. The association added that students should be given the opportunity to construct their own meaning by relating new concepts to pre-existing ideas after which they should be encouraged to practice the new knowledge learned. Integration of IK into chemistry teaching and learning will assist students in construction of understanding and consequently apply the knowledge in solving problems. Based on the relevance of IK practices to the teaching and learning of science, Jegede and Okebukola (1991) suggested that the science curriculum must be structured to permit flexible understanding of the subject matter by integrating relevant IK from learner's immediate environment to help the learners appreciate and apply the new knowledge. Indeed, the integration of relevant IK practices into the teaching and learning of chemistry will positively affect students' engagement and learning outcome.

2.11 Challenges of Integrating IK with Western Scientific Knowledge

In spite of the numerous benefits of integrating indigenous knowledge practices into the teaching of school science, the integration process is confronted with some challenges. According to Diwu and Ogunniyi (2011), IK is neither documented nor readily available to teachers. Textbooks which are often the most important contributor to knowledge in science teaching, are not designed to include adequate Indigenous Knowledge materials. The textbooks designed for the National and International markets do not accommodate the diversity of environments in the African context, hence the absence of the appropriate IK practices to support teaching and learning (Lubben, 2011).

Lubben (2011) further added that, teachers' limited knowledge on what aspects to integrate and the diversity of cultures from one community to another, are other challenges of the integration process. This implies that the IK based teaching materials and strategies developed for one community may not be applicable to another community. The teaching and learning material must fit into the cultural context of the local community to make the IK material relevant to the chemistry concept being learnt. This diversity and complexity of indigenous knowledge practices according to Semali (1999), Mwenda (2003) and Mawere (2015) makes it difficult to identify the components to be integrated into the science curriculum.

The lack of trained indigenous educators and the absence of guidelines for the integration are further hindrances to the integration of IK into science, specifically chemistry. In fact, teachers and teacher educators are neither trained nor equipped to design and implement IK – chemistry teaching strategies (Dekkers, 2005). The situation is worsened by the absence of institutional guidelines for integration thus, schools, districts and the stakeholders in education are not obliged to design and implement IK-Chemistry teaching strategies. (Mushayikwa & Ogunniyi, 2011). According to Battiste (2005) and McKinley (2005), even in contexts where cross-cultural science teaching has been institutionalised, the integration of IK is sometimes ignored partly due to the pressure on the traditional curriculum.

Moreover, lack of consensus in recognising and validating the contribution of indigenous knowledge practices remains a challenge to achieving successful and practically oriented relevant educational changes that addresses the needs of learners and their indigenous environment. (Angioni, 2003; Dei, 2002; Semali; 1999). This lack of consensus may be due to the fact that, incorporating IK and its pedagogy into WSK involves confronting the power, authority and prestige of the existing western dominant culture, a situation that is likely to create dilemmas and challenges for teachers, educators, and curriculum developers due to their western oriented education background. (Angioni, 2003; Dei, 2002; Semali; 1999). Also, the dominating belief that prosperity means westernized development thus western education continues to undermine the authenticity and legitimization of indigenous knowledge practices (Mwenda, 2003). Additionally, inadequate evidence that such a curriculum can contribute significantly in addressing the socio-economic needs of the country (Dei, 2002; Gachanga, 2007; Mwenda, 2003; Semali, 1999). Finally, the source of funding for research in indigenous knowledge is limited. Attracting donor funding to support research in education that would provide adequate information for implementation of the integration of IK practices into formal education has suffered setbacks (Mwenda, 2003; Gachanga, 2007). In most cases donors are inclined toward the support of research in education that is based on their conception of what constitutes education or what they validate as important topics and approaches to education. (Mwenda, 2003; Gachanga, 2007). Findings from such research, according to (Mwenda, 2003;

Gachanga, 2007) are not likely to provide relevant information that would appropriately support the integration of IK into the formal school curriculum.

2.12 Indigenous Knowledge practices in the Agona Municipality

The United Nations Permanent Forum on Indigenous Issues presents the following list of characteristics that aids in identifying indigenous people and hence indigenous knowledge. These characteristics include self-identification as indigenous peoples at the individual level and accepted by the community as their member, historical continuity with pre-colonial and or pre-settler societies, strong link to territories and surrounding natural resources, distinct social, economic or political systems, distinct language, culture and beliefs, form non-dominant groups of society and resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities.

The people of the Agona Municipality share all the above listed characteristics and as such they can be classified as indigenous people. The Agona Municipality and its people therefore present a rich source of indigenous knowledge that can be integrated into the teaching of chemistry. Indeed, the unique culture of the people of the Agona Municipality, ways of knowing are passed on from generation to generation for sustainability and the continuance of life. These IK practices encompass the sophisticated arrays of information, understandings and interpretations that have guided the Agona communities in their innumerable interactions with the natural environment.

The Agona indigenous communities have survived till now by passing on sustainable way of living through local technologies employed in farming, fishing, brewing, blacksmithing, pottery, preparation and preservation of food, local soap manufacturing and oil and alcohol production. The cultural practices of the people of the Agona

Municipality like any Indigenous community are manifested in their way of life. These include marriage, parenthood, and customary rites and rituals. Indeed, any individual born into the Agona cultural setting is exposed to this traditional knowledge at a very tender age and hence becomes part of the individual.

As one of the primary sources of indigenous knowledge practices, elders bear the responsibility to share and pass on these IK practices in ways that are compatible with traditional teachings and practices (Ogunniyi, 2011). Every community in the Agona Municipality has people or elders who possess the ability to provide rich sources of indigenous knowledge practices in that community which could be helpful in the teaching of chemistry.

2.13 Conceptual Framework

A conceptual framework is a descriptive tool, which explains the main things to be studied, the main issues, constructs or variables and the supposed associations among them (Bell, 2005). Creswell (2018) and Loubser (2013) refer to conceptual framework as the concepts or worldviews based on philosophical assumptions that inform, and guide reasoning and thinking of a study.

The study was aimed at designing and evaluating the impact of integrated indigenous knowledge-chemistry lessons for teaching selected Chemistry concepts on students' engagement and construction of knowledge and its application. The conceptual framework, thus, considered activities that were found necessary to achieve the aims as spelt out under the research objectives in chapter one of this study. However, some aspects of the conceptual framework such as the most effective method for lesson presentation, the structure of the content and sequence of presentation were adopted from Bruner (2009) theory of instruction. Figure 6 presented the illustration to show the flow of events.

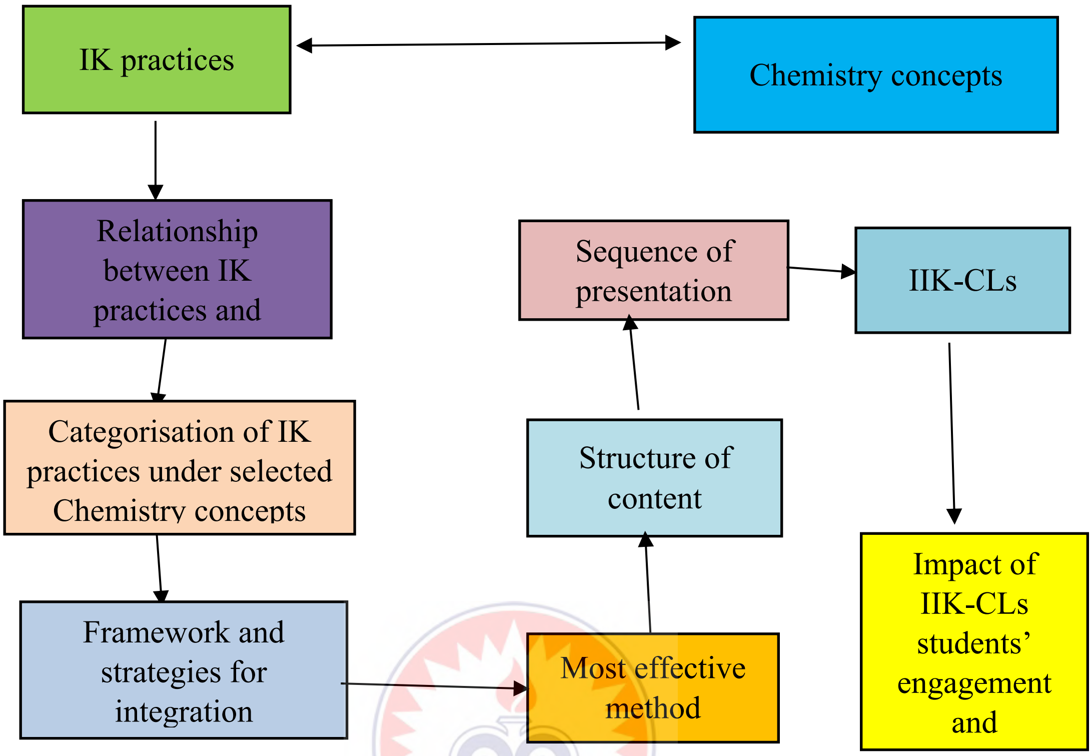


Figure 6: Conceptual framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

The methodology of this study provided a systematic and comprehensive plan for conducting the research. This was critically considered to enable the researcher to advance the research work in the right direction. The methodology is detailed in the methods or approaches that were used by the researcher to achieve the research objectives. This chapter, thus, presents a thorough description of the study area and the research method. The research method consisted of the research design, population and sampling techniques and research instrument. The chapter further considered the, validity and reliability of the research instruments data collection procedure, data analysis procedure as well as ethical considerations.

3.1 Study area

The study was conducted in the Agona Municipality of the Central Region of Ghana as presented in Figure 7. The Agona Municipality comprises Agona East and West with a total population of 275,358 and a total surface area of 1079.7km^2 (GSS HPC, 2012). The Agona Municipality is situated within latitudes $5^{0}30'$ and$5^{0}50'$N and longitudes $0^{0}35'$ and $0^{0}55'$W. (AWMA, 2016). The indigenous people of the Municipality are the ’Agonas’. Over the years, they have co-existed with other prominent minority migrants such as Gomoas, Ewes, Effutus, Ashantis, Fantis, Kwahus, Atakpames, Kotokolis and several other ethnic groupings from northern Ghana. According to the regional analytical report of the 2010 population and housing census, the Municipality is mainly made up of Akans constituting 87%, Ewes (5.2%), Gurmas (2.9%), Ga-Dangmes

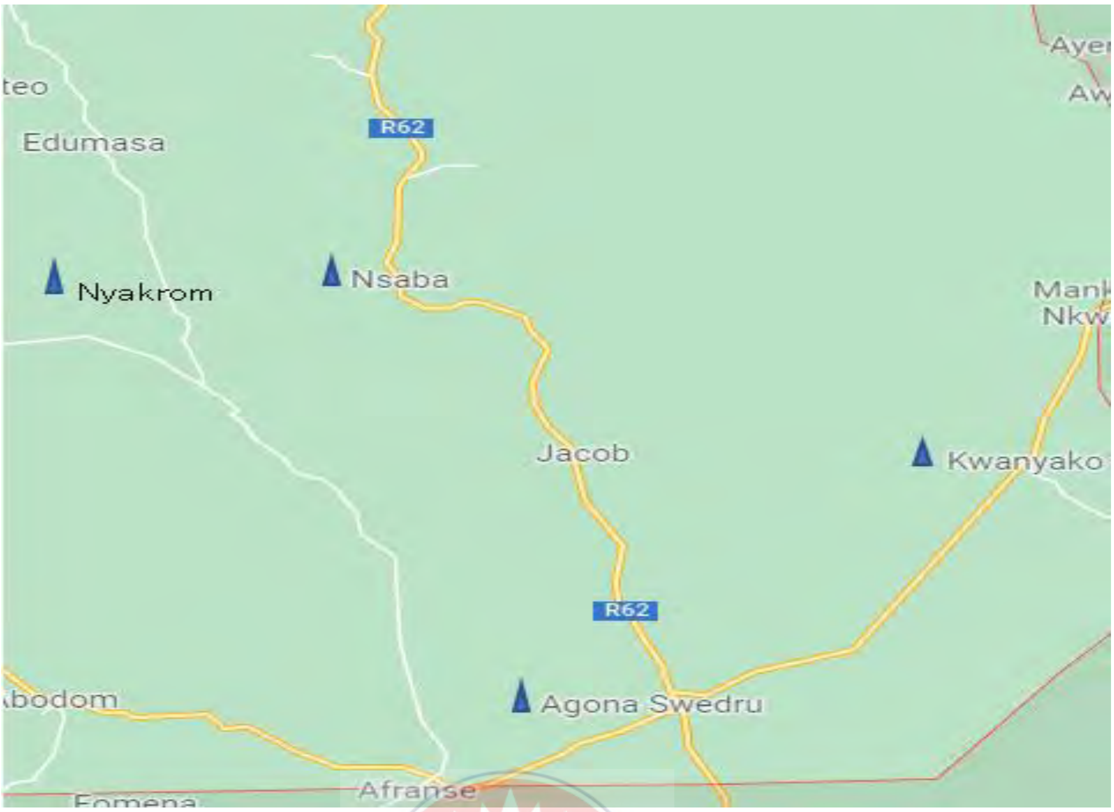
(1.2%), Guans (1.1%), Mole-Dagbons (0.8%), Mandes (0.5%) Grusi (0.3), and all other tribes constituting 0.9%.

The Municipalities are made up of two traditional councils: The Agona Nyakrom Traditional Area and Agona Nsaba Traditional Area. The key towns of the Agona Nyakrom Traditional Area are Nyakrom, Asafo, Duakwa and Kwanyako. Other communities that owe allegiance to the Agona Nyakrom Paramount Chief include Agona Mankrong, Agona Mensakrom and Mankrong Junction. The Agona Nsaba Traditional Area includes Lower Bobikuma, Teacher Okai and Agona Ninta.

Despite the diversity of different ethnic groups, the Agona Municipality has a strong social integration. The groups intermarry and participate in shared indigenous practices for peaceful coexistence. This has promoted solid social bonds and economic ties between migrants, tenants and their indigenous landlords (AWMA, 2016)

Generally, the Agona Municipality, according to the AWMA (2016) lies in the wet semi-equatorial climatic zone. It has two main crop growing seasons with a bio-modal pattern of rainfall occurring in May or June and the minor occurring in September or October. The annual rainfall figure lies within the range of 1000 mm to 1400 mm. The dry season starts in December and ends in March with the highest mean monthly temperature of 33.8 ^{0}C occurring between March and April and the lowest of about 29.4^{0}C in August. Agriculture is the main economic activity of the people of Agona Municipality. The major crops grown are food crops (cassava, plantain, maize) and cash crops (cocoa, oil palm) with some also engaging in forestry and fishing industries. The manufacturing industry constitutes a tenth (10%) of the employed population with the male dominance in physical jobs like construction and transportation. Industrial activities are largely on a small scale and characterized by reliance on indigenous knowledge (IK) and resources. Some of the small-scale industrial activities engaged in by the people include woodcarving, pottery, carpentry, bead craft, blacksmithing, cassava processing, coconut oil, palm oil and palm kernel extraction, “akpeteshie” distillery, tailoring, batik tie-dye making, local soap manufacturing and food processing (AWMA, 2016). Granite for the production of quarry stone for all types of construction abounds in the district. Mining of sand occurs in several parts of the district, particularly at Agona Asafo. Distillation of local gin is predominant in the Duakwa and Nsaba areas (A.W.M.A, 2016).

Festivals are important in the social life of the people. The "Akwambo" festival is the most important traditional festival instituted for the spiritual reunion of the people. Funeral rites that provide solemn occasions for sober reflection have also become occasions that bring people together. It is one single most important event that brings the youth home to mourn with their people. It also enables the youth who are not resident in the municipality to visit their home and learn more of their culture. The presence of almost all the ethnic groups in the Agona municipality provided a great opportunity to access diverse and credible forms of indigenous knowledge that can be integrated into the teaching and learning of chemistry concepts.



Source: Google map data, (2022).

Key: ▲Main sampling points

Figure 7: Map showing the study area

3.2 Research design

A research design describes a detailed plan for data collection and analysis depending on the research question(s) of a study (Saunders, Lewis & Thornhill, 2019; Sekaran & Bougie, 2013). A research design further refers to the framework used to conduct a research, within the context of a particular set of philosophical assumptions (Wahyuni, 2012). Enshrined in the research design are, research philosophy and research approach. A research philosophy refers to the belief of how data about a phenomenon should be collected, analysed, interpreted and used throughout the research process, and thus comprises positivism, interpretivism and pragmatism (Saunders, Lewis & Thornhill, 2019). As a philosophy, positivism adheres to the view that only factual knowledge gained through observation including measurement, is trustworthy. In positivism studies, the role of the researcher is limited to data collection and interpretation in an objective way. In these types of studies research findings are usually observable and quantifiable which allows for statistical analyses. It has been noted that as a philosophy, positivism is in accordance with the empiricist view that knowledge stems from human experience (Saunders, Lewis & Thornhill, 2019). King, Horrocks and Brooks (2018) argue that, as a general rule, positivist studies usually adopt deductive approach to research.

Diversely, interpretivist philosophy is a way to conduct research that includes the researcher's subjective analysis and interpretation of the elements of the study, thus, interpretivism integrates human interest into a study. Accordingly, interpretive researchers assume that access to reality is only through social constructions such as language, consciousness, shared meanings, and instruments (Saunders, Lewis & Thornhill, 2019). Development of interpretivist philosophy is based on the critique of positivism in social sciences which emphasises qualitative over quantitative analysis and thus adopts the inductive approach.

Indeed, recent studies have suggested the adoption of the pragmatic philosophy to scientific research (Sekaran & Bougie, 2013). The pragmatism significantly seeks to mitigate the limitations of using only one approach (Tashakkori & Teddlie, 2010). The pragmatist recognises that there are multiple traditions of describing the world as well as conducting the research, that no single point of view can ever give the entire picture since there may be multiple realities (Saunders, Lewis & Thornhill, 2019). The researcher can choose single or multiple methods that will facilitate the collection of reliable, well-founded and relevant data to conduct the study (Kelemen & Rumens, 2008). The advantages of the pragmatic philosophy include flexibility in investigation techniques, seeks to answer a wide range of research questions, and encourages collaboration among researchers having different philosophical orientations. (Onwuegbuize & Leech 2005; Robson, 2011).

Research approach on the other hand, is a plan and procedure that consists of the steps of broad assumptions to detailed method of data collection, analysis and interpretation (Saunders et al., 2019). The two distinct features of the research approach are data collection and data analysis (Bryman & Bell, 2015). Data collection and analysis approach comprise qualitative, quantitative and mixed approach which could be inductive, deductive and abductive respectively (Bryman & Bell, 2015). Inductive reasoning starts with specific observations where the researcher tries to detect patterns and regularities, makes hypotheses, explores them, and finally comes up with generalizations referred to as theories (Saunders et al, 2019). The deductive approach attempts to infer conclusions from an already existing theory and is applicable in situations where scientific hypotheses are verified (Cohen et al., 2018).

According to Bryman and Bell (2015) the inductive reasoning approach is most often employed in social science studies. However, Saunders et al. (2019) explained that, both approaches can be adopted in one study and used when appropriate. An earlier study by Greene et al. (1989) outlined the five broad purposes of combining both the inductive and deductive research approaches in a study which include triangulation (i.e., seeking convergence and validation of results from different methods studying the same phenomenon), complementarity (seeking elaboration, enhancement, illustration, clarification of the results from one method with results from the other method), development (using the results from one method to help inform the other method), initiation (i.e., discovering paradoxes and contradictions that lead to re-framing of the research question), and expansion (seeking to expand the breadth and range of inquiry by using different methods for different inquiry components).

Greene et al. (1989) explained that triangulation can help overcome the weaknesses and or inherent biases and problems that may result from the use of a single method. Figure 8, Figure 9 and Figure 10 are the illustrations of the research approach.

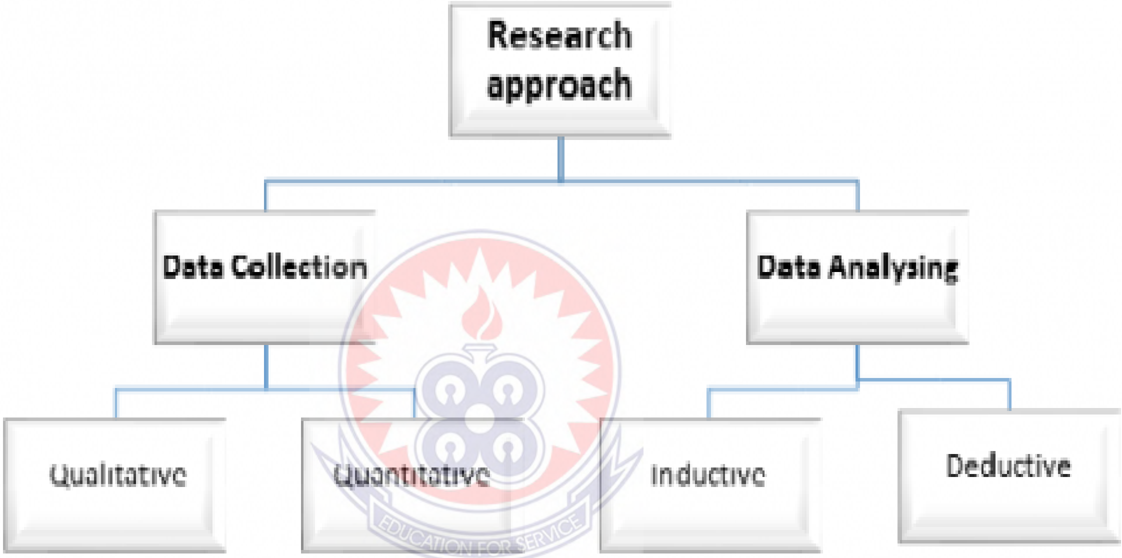


Figure 8: Components of research approach

The deductive research approach as proposed by Bryman and Bell (2015) presented in Figure 9 comprised choosing a research approach based on deduction from an existing theory formulating a hypothesis, collection of data, analysis of data to present findings to confirm hypothesis.

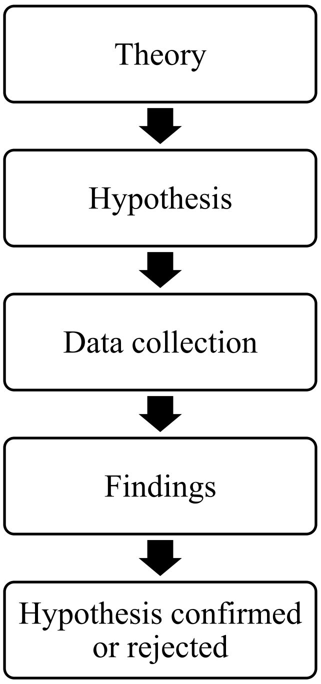


Figure 9: The deductive research approach process

As discussed earlier, unlike the deductive approach, the inductive consists of firstly making observations or tests for patterns to be detected leading the formulation of theories Figure 10 is a representation of the inductive approach process as proposed by Bryman & Bell, 2015.

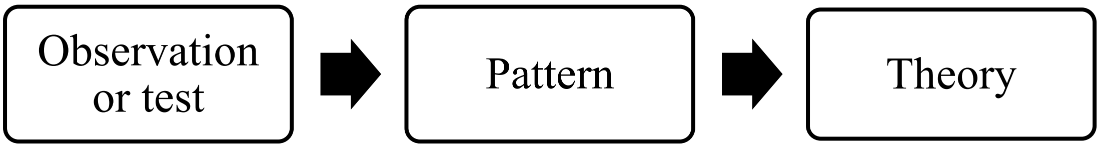


Figure 10: The inductive research approach process

Whichever research approach is selected guides the research design process. There are different types of research designs and the choice for any one in particular must depend on the objective of the research (Burns & Bush, 2000). Five different research designs including experimental, survey, longitudinal, comparative and case study have been identified (Bryman & Bell, 2015; Cohen, Manion & Morrison, 2018; Saunders et al., 2019). The utilisation of these research designs involves the use of either quantitative, qualitative and mixed approach (Creswell, 2018; Robson, 2011). The five principal methods of qualitative research design (Bryman & Bell, 2015; Cohen et al., 2018; Saunders et al., 2019) include:

1. case study (investigates an activity, an event, a process, one or several individuals in depth).
2. ethnography (Hammersley & Atkinson, 2019) (refer studies a cultural group in a common setting for a period).
3. grounded theory (derives a general abstract theory of an action, process or influence based on the views of participants).
4. narrative approaches (study the information that participants tell about their lives and experiences).
5. phenomenology (identifies the essence of human experiences).

Quantitative research approach consists of descriptive, correlational, quasi-experimental and experimental. The differences between these four types primarily relate to the degree the researcher designs for control of the variables in the experiment (Bryman & Bell 2015). According to Babbie (2013) descriptive design seeks to describe the current status of a variable or phenomenon. The researcher does not begin with a hypothesis, but typically develops one after the data is collected. Data collection is mostly observational in nature. A correlational design on the other hand explores the relationship between variables using statistical analyses (Babbie, 2013). Bryman and Bell (2015) however noted that the correlational design does not look for cause and effect and therefore, like descriptive it is also mostly observational in terms of data collection.

Experimental designs, often called true experimentation, make use of the scientific method to establish cause and effect relationship among a group of variables in a research study (Singh, 2007). All variables are controlled except the independent variable. The effects of the independent variable on the dependent variable are collected and analysed for a relationship (Bryman & Bell 2015).

Finally, the quasi-experimental design seeks to establish a cause and effect relationship between two or more variables (Saunders et al., 2019). Quasi-experiments are often conducted to evaluate the effectiveness of a treatment, usually perhaps a type of psychotherapy or an educational intervention (Bryman & Bell 2015). The kinds of quasi-experiments include the pre-test and post-test design, the nonequivalent group design, the interrupted time series design and the combination design (Posternak & Miller 2001).

In the pre-test post-test design, the dependent variable is measured once before the treatment is implemented, and once after its implementation (Posternak & Miller 2001). This design uses two groups, one group which is given the treatment and the results are gathered at the end and the control group which receives no treatment. Both groups however, over the same period of time, undergo exactly the same tests (Posternak & Miller 2001). Bryman and Bell (2015) are of the view that the treatment group and control group design is the simplest and most common of the pre-test and post-test designs and is a useful way of ensuring that an experiment has a strong level of internal validity.

A variant of the pre-test-post-test design is the interrupted time-series (ITS) design which is considered the most effective of the quasi-experimental design (Shadish, Cook & Campbell, 2002). A time series, according to Bernal et al. (2016) is a continuous sequence of observations on a population, taken repeatedly and normally at equal intervals such as weekly, monthly and yearly over a period of time. One important factor to consider when using the ITS design is knowing the exact time when an intervention occurs (Hudson et al., 2019). In an ITS study, a time series of a particular outcome of interest is used to establish an underlying trend, which is interrupted by an intervention at a known point in time (Polus `et al, 2017). Bernal et al. (2016) explained that, the hypothetical scenario under which the intervention had not taken place, and the trend continues unchanged is referred to as the counterfactual scenario which provides a comparison for the evaluation of the impact of the intervention by examining any change occurring in the post intervention period.

An interrupted time series design is in essence a single group pre-test and post-test model that has more than one pre and post measure. Bernal et al. (2016). In this design, all participants are administered the same treatment and assessment before and after a manipulation of the independent variable (Hudson et al., 2019). This design according to Bernal et al. (2016), is most effective when the treatment variable is anticipated to have a quick and substantial effect on the group and more appropriate when participants are most likely to have cognition upon one-time application of the treatment.

According to Hudson et al. (2019), the main objective of an interrupted time series design is to examine whether the data pattern observed in the post-intervention is different to that observed in the pre-intervention. When designing an ITS and analyzing the data there are important characteristics that need to be considered, these include autocorrelation, whereby a data collected closely together are correlated with each other, nonstationary or secular trend, which is where the data are increasing or decreasing over time irrespective of any intervention, seasonality (yearly) or cyclic (shorter or longer than one year calendar) patterns, outliers which is when an observation lies at an abnormal distance from other values in the sample and other interruptions occurring in the data series and sample size (Hudson et al., 2019).

Considering the main objective, this study adopted the quantitative research approach from a pragmatic point of view designing and evaluating the impact of 'integrated indigenous knowledge-chemistry lessons' (IIK-CLs) on students' engagement and academic performance. However, the researcher used the protocol approach to collect qualitative data which was needed to establish a baseline for the collection of quantitative data. Therefore, an ethnographic case study (Hammersley & Atkinson, 2019) within an interpretive paradigm (Creswell, 2018; Merriam, 2009) was used to address the collection and categorisation of IK practices. Merriam (2009) added that the interpretive paradigm is context bound, and relies on human interpretations of reality as basis for understanding the world. The interpretive paradigm offered the researcher the opportunity to describe, comprehend and interpret the observable fact under investigation (Merriam, 2009). The interpretive paradigm also called the humanistic paradigm provided a holistic understanding of patterns, behavior and emergent designs in the natural setting (Creswell, 2018; Merriam 2009). This helped the researcher to discover the underlying meaning of events and activities during the data collection stage. Research instruments were then selected and used for the data collection process.

3.3.1 Research phases

This study was carried out in three phases. Phase one was based on an ethnographic case study of the indigenous people in the Agona East and West municipalities. The semi-structured interview schedule was developed and used for the collection of IK practices in the Municipality (Appendix D). In phase two, 8 chemistry teachers who were selected from participating schools in the municipalities, were involved by means of a questionnaire in the analysis and categorisation of the IK practices collected under chemistry concepts for the design of ‘Integrated indigenous knowledge-chemistry’ lessons (IIK-CLs). Phase three was centered on using the designed lessons to engage students in the learning of selected chemistry concepts such factors affecting chemical reactions, properties of metal and liquids and distillation to evaluate its effect on students’ engagement and their overall learning outcome. Questionnaires and observational schedule were used for data collection on students’ engagement and the interrupted time series (ITS) design used to collect quantitative data from pre-test and post-test results. The research instruments were trial tested prior to their use in the study to determine the reliability and validity of the research instruments, as well as aspects of practicability of administering the instrument. The research phases are presented in Figure 11.

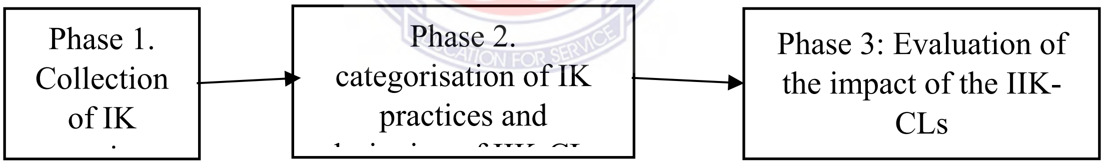


Figure 11: Phases of the research

3.4 Population, Sample and Sampling Procedures

The population of a study is the universe of units from which a sample is to be selected (Bryman & Bell, 2015). The population of this study comprised all IK experts in 3 selected towns in the Agona East and West municipalities (Swedru, Asafo Kwanyako) were placed under seven categories of indigenous practices namely cassava dough production, palm oil production, blacksmithing, akpeteshie distillation, everyday practices, farming and local soap (‘alata samina’) production. Also, all chemistry students in Swedru SHS and all chemistry teachers from 4 senior high schools in the municipality namely Swedru SHS, Nyakrom SHTS, Kwanyako SHTS and Nsaba SHS. Based on the nature of the study, appropriate sampling techniques were used in selecting the samples. A sample according to Bryman and Bell (2015) is a selected portion of a population purposely for investigation. The sample size and sampling procedure adopted for each phase of this study involved the purposive sampling procedure (Cohen et al., 2018) for phase one. The technique was used to select 20 people who were immersed in IK practices in the Agona municipality to participate in this study. The indigenous people were selected according to pre-selected criteria relevant to the study research questions (Nieuwenhuis, 2016). The purposive sampling technique was used to enable the Researcher to acquire a sample that matches the established criteria (Merriam, 2009).

In ensuring the suitable sample of indigenous experts, elders in the community were consulted to assist in identifying individuals or groups engrossed in IK practices, particularly in the field of agriculture, local technology, cultural and everyday practices. The purpose of the study and the expected roles of the identified persons were communicated to them. Pictures of them could only be used after permission had been obtained and participation was on a voluntary basis. Volunteers were requested to participate in the interviews and answer questionnaires to collect qualitative data (Appendix D). The 20 volunteers selected for the case study were considered to reflect most closely the interests of the research in terms of knowledge and expertise.

The researcher again adopted purposive sampling technique to select 8 chemistry teachers and an intact class of 26 chemistry students. This sampling technique according to Singh, (2007) provides the researcher the opportunity to draw the sample from experts in the field of chemistry teaching. The expert sampling technique thus enabled the Researcher to acquire a sample of chemistry teachers with a high degree of knowledge about the subject matter and pedagogy. The 8 chemistry teachers selected have 10 and above years of teaching experience. The intact class of 26 students were observed to be comparatively weaker in chemistry than the others.

3.5 Research Instrument

A Research Instrument is a tool used to collect, measure, and analyse data (Creswell, 2014). These tools are most commonly used in health sciences, social sciences, and education (Creswell, 2018) to assess study samples such as patients, clients, students and teachers for a conclusion to be made regarding research objectives. Research instruments most often include interviews, tests, surveys, questionnaires or checklists (Cohen et al., 2018). The researcher is solely responsible for the choice of the specific research instrument to be used by considering the research approach. To enable the effective efficient and reliable data collection from indigenous knowledge expert an interview schedule was designed (Appendix D). An interview is a conversation for gathering information. A research interview involves an interviewer, who coordinates the process of the conversation and asks questions, and an interviewee, who responds to those questions (Cohen et al., 2018). Interviews are an appropriate method when there is a need to collect in-depth information on people's opinions, thoughts, experiences, and feelings. Interviews are useful when the topic of inquiry relates to issues that require complex questioning and considerable probing (Creswell, 2018). There are three types of interviews namely: unstructured, semi-structured, and structured (Bell, 2014).

Unstructured interviews are interviews that take place with few, if any, interview questions. They often progress in the manner a normal conversation would, however it concerns the research topic under review. It is a relatively formless interview style that researchers use to establish rapport and comfort with the participant, and is extremely helpful when researchers are discussing sensitive topics (Bell, 2014). The researcher is expected to probe participants in order to obtain the relevant and in-depth information possible. The researcher, having selected this interview style, may have to conduct several rounds of interviews with participants in order to gather all the information needed. Due to the absence of the use of a standard interview protocol in unstructured interviews, participants may sometimes maneuver the conversation away from other aspects of the research topic to be explored (Creswell, 2018).

Semi-structured interviews on the other hand, are interviews that use an interview protocol to help guide the researcher through the interview process (Cohen, Manion & Morrison, 2018). While this can incorporate conversational aspects, it is mostly a guided conversation between the researcher and participant. It does maintain some structure hence the name semi-structured, but it also provides the researcher with the ability to probe the participant for additional details. This style avoids the need to conduct several rounds of interviews because the interview protocol keeps the researcher focused on gathering all the information needed to answer the research questions. The semi-structured interview style also offers the flexibility to probe to get more details about participants' thoughts, feelings, and opinions (Laksov et al. 2017).

Structured interviews, according to Creswell (2018) are interviews that strictly adhere to the use of an interview protocol to guide the researcher. It is a more rigid interview style, in that only the questions on the interview protocol are asked. As a result, there are not a lot of opportunities to probe and further explore topics that participants bring up when answering the interview questions. This method can be advantageous when researchers have a comprehensive list of interview questions, since it helps target the specific phenomenon or experience that the researcher is investigating. It makes for expedient interviewing and will gather the correct information needed, hence there is no need for follow-up interviews for missed or forgotten questions (Bell, 2014).

According to Creswell (2018) whether research interviews are structured, semi-structured or unstructured, the procedure can be carried out using either personal interviews, telephonic interviews and email or web page interviews. Each of these methods is peculiar in its application and can be used according to the research study requirement.

Personal interviews are one of the most used types of interviews, where the questions are asked personally and directly to the respondent (McGrath et al., 2019). For this, a researcher can have a guide to take note of the answers. A researcher can design his or her survey in such a way that notes can be taken of the comments or points of view that stands out from the interviewee (McGrath et al., 2019)

To enable the collection of reliable and in-depth qualitative data, the semi-structure style of interview schedule was adopted for data collection from IK experts. This guided the researcher in preparing and analysing the questions before the scheduled interview. The style also offered the opportunity to probe respondents for more details pertaining to the study while maintaining the research guidelines. Additionally, questionnaire and observational schedule were designed and used to assess students' engagement in the 'IIK-CLs.

3.6 Validity and Reliability of the research instruments

To assess the stability of students' scores after the series of pre-tests and post-tests, the test-retest reliability was used to determine the reliability of the test items for data collection from students. In order to measure the test-retest reliability, the same test items were given to 20 respondents who were not part of the study group on two separate occasions. The scores recorded for the first test was denoted test 1(T1) and the second denoted test 2 (T2). The scores, T1 and T2 were then correlated (Appendix I) to determine the test-retest-reliability coefficient of stability. The paired samples test analysis recorded 0.966 correlation at a significance of 0.00 which indicated that the test items are reliable. The Cronbach's alpha also gave internal consistencies, 0.87, 0.88 and 0.91 as reliability coefficients for responses to questionnaires on behavioural, emotional and cognitive engagement respectively.

3.7 Data collection Procedure

The study used the semi-structured interview protocol (Appendix E) to conduct personal interview for the collection of relevant data on various IK practices from the 20 IK experts who form the study sample. Personal interview was necessary due to the objective 1 of the study which intended to identify the IK practices in the municipalities, how they were practiced and the science involved in the practice.

Before the interview, the objectives were defined, the type of interview was chosen, appropriate respondents were selected, the interview method was chosen and finally, a decision on how the interview will be recorded was made.

During the interview, a self-introduction to initiate a friendly but professional conversation was done, the purpose of the project, the importance of their participation, and the expected duration of the interview was explained, the format of the interview was explained, respondents were informed on how the interview will be recorded and how the collected information will be used, a written consent was obtained to participate, tone of voice and language was controlled, focus was kept on the topic of inquiry and the interview was completed within the agreed time limit, notes and recordings were checked regularly and respondents thanked .

After the interview, check the researcher conducted a check to see if the interview was properly recorded and additional notes made. The number of respondents interviewed ensure data saturation. Peer debriefing and member checks were conducted to ensure that the right information was recorded. Prolong engagement with the interview responses further increased the credibility of the transcribed data

Additionally, questionnaire (Appendix F) was designed and used for the collection of data from 8 chemistry teachers to investigate their use of IK in the teaching and learning of chemistry which is to answer research question 2. The teachers were informed of the study and what they were expected to do as participants.

Questionnaires on engagement (Appendix F) and an observational schedule (Appendix G) were designed based on the various types of engagement proposed by Fredricks et al. (2004) to obtain comparable information about students' engagement. The observational schedule had indicators on students' behavioural, emotional and cognitive engagement was used by an interrater to rate students' engagement in the 'IIK-CLs. The students were also required to respond to the items on the questionnaire. Further, the study adopted the interrupted time series (ITS) design of the quasi-experimental method for the quantitative research within a positive paradigm to collect quantitative data. Similar to the pre-test-post-test design, the quantitative data were before and after the implementation of the instructional. However, the ITS design includes multiple pre-test and post-test measurements and without any control group. The principle therefore involved the administration of the treatment on the study group.

The researcher taught all three chemistry concepts before and during the intervention. The group was pre-tested and post-tested twice with a one-month interval. The design enabled the analysis of the performance trend from pre-test to post-test and to evaluate the overall effectiveness of the intervention with regards to knowledge retention and application.

3.8 Data Analysis Procedure

The data analyses consisted of categorising collected IK practices under selected chemistry concepts. The scale by Likert (1932) was employed for all close ended items used for the qualitative data collection. A 2-point, 4-point 5-point and 7-point Likert scale ratings were used to score questionnaires for ‘Yes’ and ‘No”, ‘Strongly Disagree’ through to ‘Strongly agree 'and ‘Never’ through to ‘Always’. Depending on the question, responses were rated as either positive or negative. The results were tabulated and discussed. Additionally, data from pre-test and post-test scores were analysed using the paired samples test to evaluate the improvement in the learning outcome of students. The independent samples test was also used to determine the effect of gender on ‘IIK-CLs’. Results were represented and interpreted using tables, graphs and percentages.

3.9 Ethical consideration

This study was conducted by ensuring voluntary participation, safety, anonymity, confidentiality and compliance with other codes of ethics. Additionally, informed consent of respondents was sought before the questionnaires and interview schedules were administered. Anonymity and confidentiality were complied with by assuring respondents that their identities would not be revealed unless with their explicit consent.

Other codes of ethics regarding accuracy of research design, data collection and processing, as well as acknowledging sources of information were duly adhered to.

The researcher applied for and obtained ethical permission from the University of Education, Winneba before data collection commenced (Appendix A). Once the study was completed, a clearance was given as confirmation that the study was conducted in line with all expectations.

In phases 1 and 2 of the study, the twenty Indigenous experts and 8 chemistry teachers who had volunteered for the project were informed of the purpose of the study, their expected role, the way in which confidentiality would be assured, and of their right to participate or withdraw voluntarily at any time. Formal consent was obtained from the IK experts and the chemistry teachers (Appendices B and C respectively) Participants were assured that permission to use quotations, pictures, artefacts and video recording in the thesis statements would be obtained from them. To maintain anonymity, the indigenous people were labelled Indigenous Person 1 (IKP1) to Indigenous Person 20 (IKP20) while the chemistry teachers were coded CT1-CT8.

In Phase three of the study, permission was obtained from the headmistress of Swedru SHS to enable access to the schools with the assurance that the research would be conducted by observing all the code of ethics. The study group and individual students were labelled S1- S26 (Student 1 to Student 26). The researcher explained to the participants that their identities would be treated confidentially and would not be disclosed to the public.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

Chapter four presents the results and discussions of the findings of the study. The results of the study were outlined in the order in which the research questions were stated in section 1.4 of the study.

4.1 Results and Discussions

The Indigenous Knowledge practices collected from the Agona East and West municipalities were grouped under industrial, agricultural, cultural and everyday practices. These IK experts have been involved in the practice for at least 10 years. The responses to Indigenous Knowledge Persons (IKPs) Interview item 1: Which IK practices are present in your locality? were presented in Table 6.

Answers to IKPs interview question1 are presented in Table 6.

Table 6: Indigenous Knowledge Practice in the Agona Municipality

Industrial	Agricultural	Cultural	Everyday
Local soap manufacturing	Crop farming (staple crops, cash crops and vegetable)	Naming ceremonies	Food preservation
Akpeteshie distillation	Animal farming	Traditional marriage ceremonies	Food preparation
			Cleaning
Oil production (palm, coconut, palm kernel)	Fishing	Festivals	
Cassava dough production		Funeral rites	Stain and odour removal
Gari processing			Duties and responsibilities of parents and children
Batik, Tie and Dye making			
Local beverages brewing (‘asaana’ and ‘ahe’)			
Blacksmithing			
’Fante’ kenkey production			

The answers provided to interview questions 2-4 by the IKPs are presented below.

Responses from IKPs group 1.

2. Which of the IK practices in Table 6 do you often use?

Cassava dough production

3. How is the IK you mentioned practised

Method (Figure 12):

a. Peeling and washing of the cassava tubers.
b. Grating or milling the fresh cassava with a few of cassava that has been soaked for three days,
c. Bagging the milled or grated cassava
d. Compressing and tying up the sack
e. Leaving sack and content in an open space, preferable in the sun.
f. Sieving dough and dry frying (for gari processing)

4. What are some of the benefits derived from use of the IK?
'Peeling removes waste, washing makes the cassava clean, you cannot make a dough without milling or grating the cassava. People do not even want a dough that is rough in texture and therefore the soaked cassava is added to make it smoother. The bagging compressing and tying of the sack helps to remove water from the dough'.

For efficient extraction of the juice from the cassava in cassava dough processing, the IK knowledge experts peel and mill the cassava to increase the surface area, which is what the increase in surface in chemistry refers to. When the dough is bagged, pressure is exerted on the content by to press the particles of the cassava dough against each other, first by using the hand and a heavy object thereafter. This allows the dough to be adequately drained to give the desired product. The scientific knowledge applied here in terms of the factors affecting rate of chemical reaction are increasing surface area, pressure and concentration. Additionally, the cassava which is soaked for three days serves as a starter for fermentation involving microorganisms and enzymatic activities.

The various stages involved in the production of cassava dough is shown in Figure 12

Source: IKPs involved in cassava dough production

Figure 12: Plate showing the various stages involved in cassava dough production

Responses from IKPs group 2

2. Which of the IK practices in Table 6 do you often use?

Response: ‘For me, I am a housewife though I help my husband at the farm, my main duty is to take care of my children and the home’. (The response was classified under everyday indigenous knowledge practices).

3. How do you perform your daily chores?

Response: ‘My husband is a farmer and he makes sure he provides for the family. I cook and take care of the cleaning of the home. In feeding, apart from my husband the younger ones are always considered first. For example, my one-year old daughter can eat as much as four times a day but the older ones can be satisfied with two meals a day. As you can see, she is young so I carry her wherever I go’.

The nuclear atom can be taught with the structure of the nuclear family and the shielding effect of the nuclear can be described using how new born are always protected by the parents sometimes at the expense of the older ones.

4a. How important is wood ash, lemon and charcoal to you?

Response: ‘I use lemon and wood ash to scrub my utensils, I smear wood ash on cut yam or water yam and sometimes pour wood ash in the pit latrine, I usually use wood ash mixed with water and salt to treat stomach ache and diarrhea. The wood ash combined with lime or lemon can be used in the armpit before taking your bath. Apart from firewood, I use charcoal for cooking. I put some charcoal in my soup, mostly groundnut soup, when I want to keep it overnight. We even use it to whiten our teeth’.

4b. What are some of the benefits derived from use of the IK?

Response: ‘I feel very happy taking care of my family and children. I don’t have to send them to the hospital for every little problem. As for the wood ash it is very good, besides making the utensil to shine, it also prevents bad odour and prevents the latrine from getting full up early. The charcoal also keeps my soup from spoiling. If you put some wood ash on lime or lemon and rub in your armpit and leave it a few minutes before taking your bath, it will keep you fresh all day and takes away any form of body odour'.

Wood ash refers to potash is alkaline in nature and application of its use by IK experts can be applied when teaching properties of bases. Aluminum hydroxide (base) is used to relief stomach ache which is why the wood ash probably works when being by IK experts in treating same. Further call is effecting against odour due to its adsorbent properties. Indeed, this is science specifically chemistry in action.

Responses from IKPs Group 3

2. Which of the IK practices I Table 6 do you often use?

   Response: 'Palm oil production'

3. How is the IK you mentioned practised?

   a. Storing the palm spikelet for about two weeks
   b. Removing the fruitlets from the spikelet
   c. Using a wide spaced sieve to separate the palm fruit from the chaff
   d. Drying the fruit in the sun for about three days
   e. Boiling the palm fruit
   f. Pounding or milling the boiled palm fruit when hot
   g. First compression of the pounded palm fruit is done to drain the oil from the chaff
   h. The palm kernel is now handpicked from the chaff
   i. Second compression of only the chaff now to drain all the oil from it

j. Boiling of oil

k. Allowing to cool, bottle or store in a clean and dry container

l. If the apparatus used in the compression is not available, the pounded palm fruit is mashed with cold water.

m. The oil which is lighter than water rises above the water and it is scooped and boiled for all the water to evaporate from the oil.

Figure 13 shows the entire palm oil production process

Figure 13: Plate showing the various stages in palm oil production

Source: IKPs involved in palm oil production at Agona Swedru

4. What are some of the benefits derived from use of the IK?

Response: ‘Storing for two weeks allows easy removal of fruits and for them to rot, sieving of fruits to remove dirt, drying in the sun to get water out of the fruits, boiling to soften the fruits, pounding or milling when hot makes it easier to separate the flesh from the kernel and to help extract the oil, first compression is done together with the kernel and the second is done after separating the kernel from the chaff to help extract all the oil from the chaff, the boiling of the oil is done to remove water from the oil’.

In the production of palm oil, the various separation techniques are observed which can be used to teach types of mixtures and separation of mixtures. In this practice, solid-solid mixture is observed (the palm kernel and the fleshy pulp), solid-liquid mixture (the pulp which contains the oil and the chaff) and liquid-liquid mixture (oil and water). the various separation techniques include hand picking, filtration and evaporation.

Responses from IKPs Group 4

2. Which of the IK practices in Table 6 do you often use?

Response: Blacksmithing

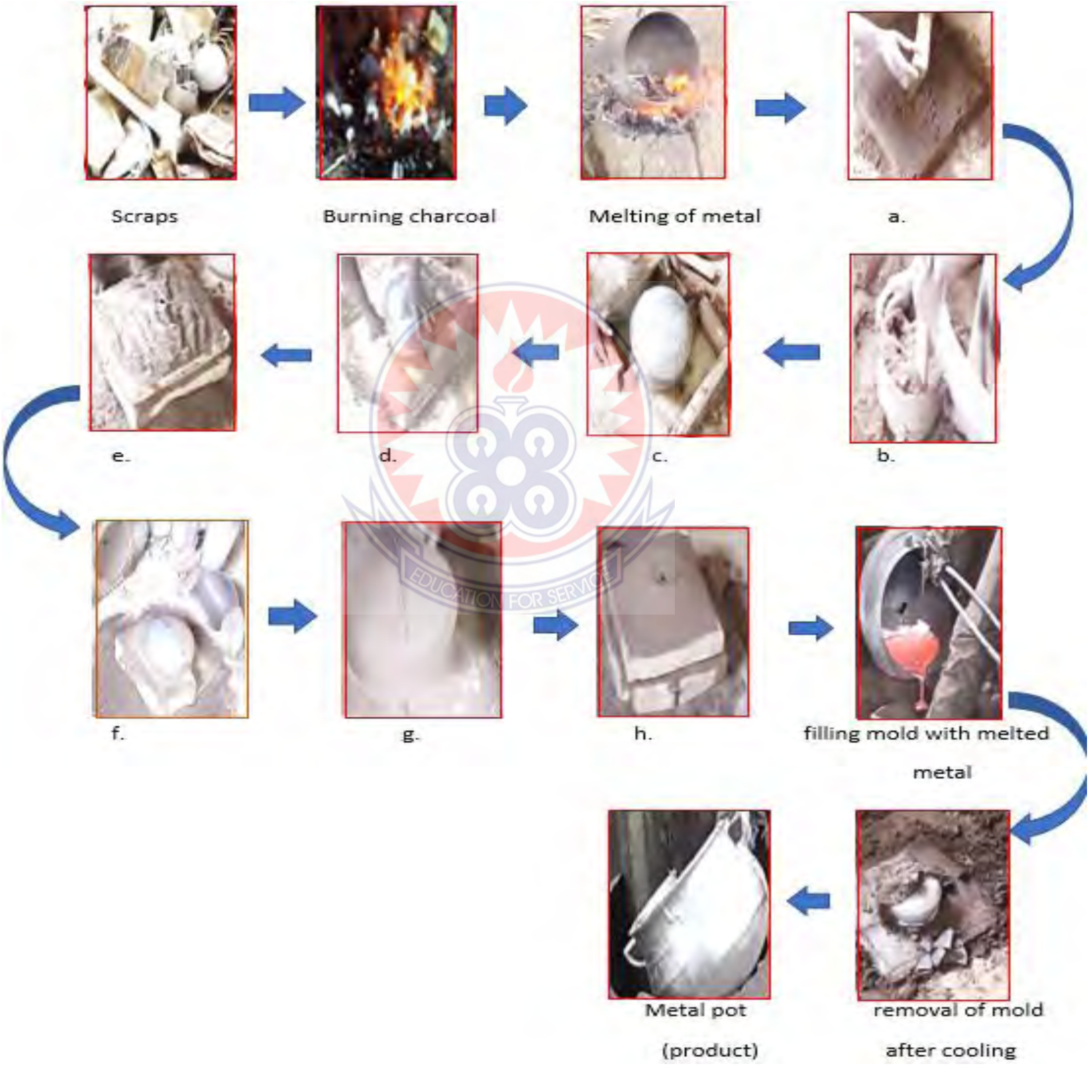
3. How is the IK you mentioned practised? Responses:

a. Acquire your aluminum (from scraps)
b. Make a furnace from charcoal
c. Heat or melt the metal
d. Shape heated metal using hammer, an anvil and a chisel and cooling in water
e. Pour out melted metal into molds and allow to cool and solidify.

4. What are some of the benefits derived from use of the IK?

Response: 'The charcoal provides a very high heat that is needed to heat or melt the metal. The hammer, the chisel and the anvil are used to shape the metal to materials such as knives, cutlass, planting rods and hoe. Then I cool to harden the produce using water. With the molds, I can make pots, coal pots, pans, spoons, ladles, and many more. I sell all these for income.'

The processes involved in the blacksmithing are illustrated in Figure 14.



Key: a-h - mould making process. Source: IKPs involved in blacksmithing

Figure 14: The various stages employed by the blacksmith in making a pot

The processes involved in blacksmithing can be used to help learners construct knowledge and understanding of the concept of properties of metals. For example, the intense heat used to convert the metal to molten state in an indication that metals have a high melting point. This activity can also educate students on environmental sustainability through recycling.

Below are the responses from IKPs Group 5

2. Which of the IK practices in Table 6 do you often use?

Response: Akpeteshie distillation

3. How is the IK you mentioned practised? Responses:
    a. Store the palm wine for about a week after harvesting
    b. Put the palm wine in tanks connected with tubes (the tubes made of copper and plastic are connected to the tank and passed through water to the container in which the distillate will be collected
    c. Apply intense heat and allow to boil
    d. The vapour passes through the copper tubes
    e. The vapour is cooled and the liquid (Akpeteshie) is collected
4. What are some of the benefits derived from use of the IK?

Response: 'Storing the palm wine for a week is for it to ferment to produce the alcohol, the mixture contains water and the alcohol so, the intense heat allows the mixture to boil faster for the alcohol to be collected. Copper tubes are used to prevent melting, so they are connected to the boiling tank. The end of the copper tube is connected to the plastic tube and placed in water to cool the hot vapour and into liquid (Akpeteshie)'.

The akpeteshie distillation process is illustrated in Figure 15.

Figure 15: The processes involved in the distillation of akpeteshie

Source: IKPs in the field of akpeteshie production at Agona Kwanyako

Akpeteshie distillation can be used in teaching the concept of distillation in chemistry. The function of the various parts of the distillation apparatus including the various stages of the distillation process can also be studied. Further the concept of separation of mixture using their boiling points can also be explained.

Responses from IKPs Group 6

2. Which of the IK practices in Table 6 do you often use?

Response: Farming

3. How is the IK you mentioned practised?

a. Clearing the land mostly by burning

b. Tilling the land

c. Mixing the soil with animal manure (poultry droppings)

d. Planting of seeds, stems, tubers and seedlings

e. Caring for the crops till you harvest them

4. What are some of the benefits derived from use of the IK?

Clearing the land by burning makes it more fertile, the tilling is done to loosen the soil particles, mixing the soil with the poultry droppings makes the crops grow well to give you a good yield.

Below are the responses from IKPs Group 7

2. Which of the IK practices mentioned in Table 6 do you often use?

Response: Local soap preparation

3. How is the IK you mentioned practised? Responses:

a. The palm kernel oil or any oil of choice is poured into a metal pot or tank and placed on fire

b. The powdered roasted cocoa pod or plantain pod (Gyenkisi) is dissolved in water to make a lye and poured into the hot oil on fire

c. The mixture is allowed to boil for about 30-45 minutes while stirring and adding the ‘Gyenkisi’

d. The resulting dough is then molded while hot (this gives the white colour local soap)

e. To get the black local soap, the resulting dough is pounded till it gets sticky

f. A hot shovel is used to scoop the dough from the mortar and molded in ash

g. The molded soap is placed back on fire and allowed to darken

h. The darkened soap is now taken from the fire, broken up into smaller pieces and dried

i. The local black soap ('Alata samina') is ready for use.

4. What are some of the benefits derived from use of the IK?

Soap has many uses such as for washing, cleaning and bathing so we cannot do without it. Besides, local soap is made from natural material and solves many skin problems. A lot of people patronise the local soap so we sell it for income. One has to continue stirring the mixture while on fire to prevent it from boiling over as it adds air to the mixture. The white 'alata samina' is to cater for those with sensitive skin. If the white soap is not molded while hot, it hardens and becomes very difficult to mold. The 'alata samina' production process is illustrated in Figure 16.

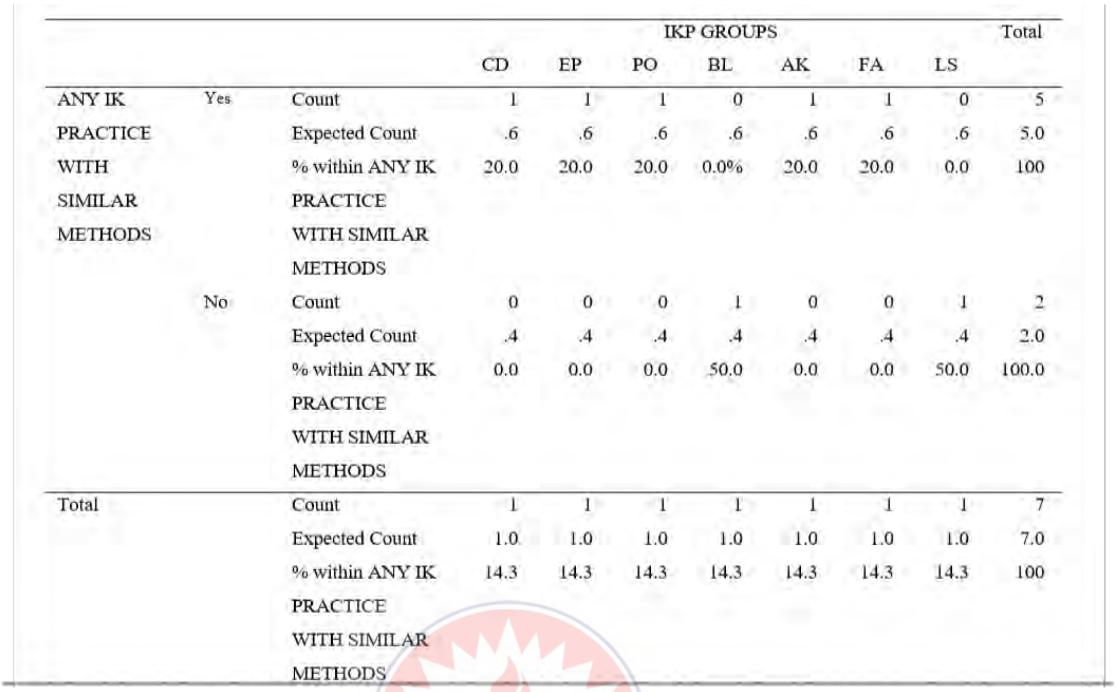
Figure 16: The various stages in the production of Local Soap

Source: IKPs involved in local soap production at Agona Kwanyako

The process of local soap production can be used to teach the concept of saponification and further, the use of bases.

Answers to IKPs interview item 5: Are you aware of any other IK practices that use similar methods? This question was intended to help state various examples of indigenous knowledge processes that could be used in teaching a particular concept since students could have at least one IK practiced in their communities. The responses are presented in Table 7.

Table 7: Responses from IKPs to whether they are aware of other IK practices that use similar methods as theirs



			IKP GROUPS							Total
			CD	EP	PO	BL	AK	FA	LS	
ANY IK PRACTICE WITH SIMILAR METHODS	Yes	Count	1	1	1	0	1	1	0	5
		Expected Count	.6	.6	.6	.6	.6	.6	.6	5.0
		% within ANY IK PRACTICE WITH SIMILAR METHODS	20.0	20.0	20.0	0.0%	20.0	20.0	0.0	100
	No	Count	0	0	0	1	0	0	1	2
		Expected Count	.4	.4	.4	.4	.4	.4	.4	2.0
		% within ANY IK PRACTICE WITH SIMILAR METHODS	0.0	0.0	0.0	50.0	0.0	0.0	50.0	100.0
Total		Count	1	1	1	1	1	1	1	7
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.0
		% within ANY IK PRACTICE WITH SIMILAR METHODS	14.3	14.3	14.3	14.3	14.3	14.3	14.3	100

Key: CD- cassava dough, EP- everyday practices, PO- palm oil, BL- blacksmithing, AK- akpeteshie, FA- farming, LS- local soap.

The responses analysed in Table 8 revealed that four indigenous knowledge practice (IKP) groups comprising cassava dough and gari processing, everyday practice, palm oil production farming and akpeteshie distillation groups responded that there were other indigenous knowledge practices that made use of similar methods of production, while the blacksmithing, and local soap (Alata samina) groups said otherwise. A total of 5 out of 7 groups responded ‘YES’ to the question and three responded ‘NO’. This implied that, of the seven Indigenous Knowledge practices surveyed, 71% of them have other IK practices that employ similar methods. Pearson's Chi-square result in Table 8 showed that there was no significant difference ($p > 0.05$) in the true values which meant that the values were not statistically significant. This implied that chemistry teachers who desire to adopt some particular IK practice in teaching and learning of a concept have the opportunity to give other examples to the benefit of the individual student.

Table 8: Pearson's Chi-square result of IKP responses to IK practices with similar operational methods

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.000[a]	6	.321
Likelihood Ratio	9.561	6	.144
Linear-by-Linear Association	3.125	1	.077
N of Valid Cases	7		

$p > .05$

Indigenous Knowledge Persons who responded 'YES' to IKPs item 5: Are you aware of any other IK practice(s) that use similar methods? were required to mention the IK practice with the similar method in Question 6 and this was presented in Table 9.

Table 9 IK Practiced and other IK Practices that Adopts Similar Methods of Practice

IKPs Group	IK practices	Other IK that adopts similar practice
CD	Cassava dough production	Cassava flour and gari processing
EP	Everyday activities employed in taking care of the home	Farming
PO	Palm oil production	Coconut oil or palm kernel oil production
BL	Blacksmithing	None
AK	Akpeteshie distillation (from palm wine)	Akpeteshie distillation(from sugarcane)
FA	Farming	Care for children
LS	Local soap preparation	None

IKPs Interview item 7: Do you think your IK of practice has any link with classroom science? This was to inquire from the indigenous knowledge persons their level of agreement to the integration of IK practices into the teaching of science. Table 10 presented the IKPs views on the possible integration of the Ik they practice into the teaching of Science.

Table 10: Level of agreement by IKPs that their IK of practice has a link with classroom science.

			GROUPS							Total
			CD	EP	PO	BL	AK	FA	LS	
IK practices can be integrated into the teaching of science	Strongly Disagree	Count	0	0	0	0	0	0	0	0
		Expected Count	.1	.1	.1	.1	.1	.1	.1	.1
		% within GROUPS	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Disagree	Count	1	0	0	0	0	0	0	1
		Expected Count	.1	.1	.1	.1	.1	.1	.1	1.0
		% within GROUPS	0.0	0.0	0.0	100.0	0.0	0.0	0.0	14.3
	Agree	Count	0	0	0	1	1	1	0	3
		Expected Count	.3	.3	.3	.3	.3	.3	.3	3.0
		% within GROUPS	0.0	0.0	0.0	100.0	100.0	100	0.0	42.9
	Strongly Agree	Count	0	1	1	0	0	0	1	3
		Expected Count	.4	.4	.4	.4	.4	.4	.4	3.0
		% within GROUPS	0.0	100.0	100	0.0	0.0	0.0	100	42.9
Total		Count	1	1	1	1	1	1	1	7
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.0
		% within GROUPS	100	100	100	100	100	100	100	100

From Table 10, the group of Indigenous Knowledge Persons (IKPs) involved in cassava dough production disagree that, their IK practice has a link with teaching of science in the classroom, However, IKPs in blacksmithing, akpeteshie distillation and farming groups agreed that their IK practice could be linked to classroom science while IKPs in the everyday practices, palm oil and local soap groups also strongly agreed that, a link exist between the IK practiced and science.

The responses to the interview question in Table 10 were rated either positive or negative and the results presented in Table 11. Responses 1, and 2 representing strongly

disagree and disagree respectively were rated negative while responses 3 and 4 representing agree and strongly agree respectively were rated positive.

Analysis of the response ratings presented in Table 11 showed that six Indigenous Knowledge Persons groups representing 85.7% responses were rated positive. This meant that 85.7% of IKPs believe that the indigenous knowledge practice they are involved in can be linked to teaching of science concepts and can be integrated into the teaching of science whereas 14.3% representing 1 IKPs group had the response rated negative because, they disagree the IK practice has a link with classroom science.

Table 11: Response rating of IKPs agreement

			GROUPS							Total
			CD	EP	PO	BL	AK	FA	LS	
RESPONSE RATING	NEGATI-VE	Count	1	0	0	0	0	0	0	1
		Expected Count	.3	.3	.3	.3	.3	.3	.3	1.0
		% within GROUPS	100	0.0	0.0	100	0.0	0.0	0.0	14.3
	POSITI-VE	Count	0	1	1	1	1	1	1	6
		Expected Count	.7	.7	.7	.7	.7	.7	.7	6.0
		% within GROUPS	0.0	100	100	100	100	100	100	85.7
Total		Count	1	1	1	1	1	1	1	7
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	7.0
		% within GROUPS	100	100	100	100	100	100	100	100

Pearson's Chi-square analysis in Table 12 also showed that there was no significant difference ($p>0.05$) in the values which implied that the values were not statistically significant. Hence a deduction can be made that the IKPs interviewed believe that IK practices in the environment can be integrated into the teaching of science, specifically chemistry.

Table 12: The Pearson's Chi-square analysis of IKPs who agree that their IK of practices has a link with classroom science

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.000[a]	6	0.321
Likelihood Ratio	8.376	6	0.212
Linear-by-Linear Association	1.350	1	0.245
N of Valid Cases	7		

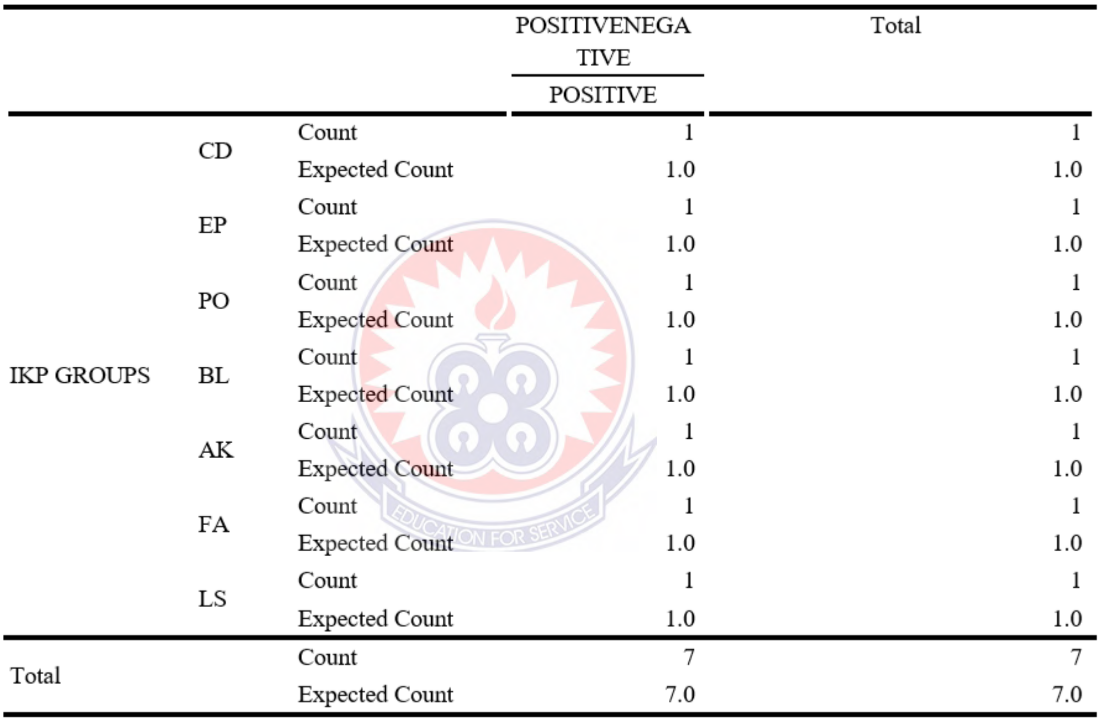
p> .05

IKP item 8: Will the integration of IK practice into the teaching of science have a positive effect on the teaching and learning of science? If YES, why?

This focused on IPKs view on the effect of the integration of IK practices into the teaching and learning of science. Indigenous Knowledge Persons were to respond 'YES' or 'NO' to the question after which their responses were cross tabulated in Table 13

Responses from all the Indigenous Knowledge Persons involved in the study as shown in Table 13, indicated that a possible integration of Indigenous Knowledge practices into the teaching of science will have a positive impact on the teaching and learning of the subject. Using a 2-point Likert scale, response 1 was rated positive while response 2 rated negative. All the responses from the IKPs responses were rated positive since they all responded 'YES' to the question. The reasons given by IKPs who responded yes indicated that the integration of IK into the teaching of science will help students connect their learning to the concepts in the classroom that will enable them to use the knowledge to improve their way of life. Thus, the integration of Indigenous Knowledge practices into the teaching of science, specifically chemistry offers students the opportunity to learn from known to unknown by relating concepts to real life experiences in the students' environment thus demystifying chemistry concepts and concretising students' learning (Chang & Overby, 2019).

Table 13: Responses by IKPs of the effect IK integration on teaching and learning of science



			POSITIVENEGATIVE	Total
			POSITIVE	
IKP GROUPS	CD	Count	1	1
		Expected Count	1.0	1.0
	EP	Count	1	1
		Expected Count	1.0	1.0
	PO	Count	1	1
		Expected Count	1.0	1.0
	BL	Count	1	1
		Expected Count	1.0	1.0
	AK	Count	1	1
		Expected Count	1.0	1.0
	FA	Count	1	1
		Expected Count	1.0	1.0
	LS	Count	1	1
		Expected Count	1.0	1.0
Total		Count	7	7
		Expected Count	7.0	7.0

4.2 Research Questions 2

What IK practices are used by chemistry teachers in the Agona East and West municipalities in teaching and learning chemistry?

Several questions were asked to investigate the use of IK practices by teachers in teaching and learning chemistry including; What is the level of students' interest in chemistry lessons learnt using IK practices? and Which concepts in chemistry can the IK practices identified in the Agona municipality be used to teach? The aim besides investigating the use of IK practice by teachers, was to explore the chemistry teacher's knowledge on IK practices that could be integrated into chemistry teaching, to find out the attitude of students to chemistry lessons integrated with IK and to seek the views of the chemistry teachers on specific IK practices that could be integrated into teaching specific chemistry topics. This Phase was divided into Part 1 and Part 2.

4.2.1 Responses to Questionnaire by Chemistry Teachers (Part I of Phase Two)

Chemistry teachers question 1a. Do you relate concepts in chemistry to IK practices during chemistry lessons? This question demanded YES or NO answer. The responses were presented in Table 15. The analysis in Table 14 showed that all the Chemistry teachers used in the study related concepts in chemistry to Indigenous Knowledge (IK) practices during chemistry lessons. The study has thus confirmed the use of IK practices in the teaching of chemistry.

Table 14: Chemistry teachers response to whether concepts taught are related to IK practices or not

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
Relates concepts in Chemistry to IK practices during Chemistry lessons	YES	Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0
Total		Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0

The issue was now to find out the extent of use. Thus chemistry teachers question 1b required that the CTs state the frequency of use of IK in teaching chemistry concepts. Question 1b. If yes, how often? The responses provided were presented in Table 15. A

5-point Likert scale of: 1 - never, 2 - rarely, 3 - sometimes, 4 - most times and 5 - always was used for the analysis of the responses. Responses 1 and 2 were rated negative while responses 3, 4 and 5 rated positive. From Table 15, 1 teacher rarely relates concepts in chemistry to IK during chemistry lessons, 2 teachers sometimes and 5 teachers most of the time relate concepts in chemistry to IK during chemistry lessons. There were however no recorded responses for 'never' and 'always'. Deductions from the response ratings were that, the chemistry teachers who chose option 1 and 2 (never and rarely) as the frequency of use might have realised the importance of IK practices to the teaching of chemistry (since they both responded 'YES' in Table 19 but have limited knowledge on the specific IK to use in teaching most concepts. The five other teachers that most of the time relate chemistry concepts to IK might have also realised the benefit of the use of IK in teaching and might also have quite a good knowledge of IK that could be integrated into the teaching of chemistry. The analysis rated the frequency of use of IK practice by the Chemistry teachers in teaching at 75%.

Table 15: Frequency of use of IK in the teaching of chemistry concepts

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
FREQUENCY OF USE OF IK IN TEACHING CHEMISTRY	RARELY	Count	0	1	0	0	0	0	0	0	1
		Expected Count	.1	.1	.1	.1	.1	.1	.1	.1	1.0
	SOMETI-MES	Count	0	0	1	0	0	0	0	1	2
		Expected Count	.3	.3	.3	.3	.3	.3	.3	.3	2.0
	MOST TIMES	Count	1	0	0	1	1	1	1	0	5
		Expected Count	.6	.6	.6	.6	.6	.6	.6	.6	5.0
Total		Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0

The Pearson's Chi-square result (Table 16) confirmed this when it showed that there was no significant difference in the true values implying that the values were not statistically significant.

Table 16 Chi-square Test for CTs, frequency of use of IK practices in teaching

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000^{a}	7	.333
Likelihood Ratio	6.028	7	.536
Linear-by-Linear Association	1.190	1	.275
N of Valid Cases	8		

$p > .05$

Source: Field Data

Students' familiarity with IK practices used in teaching and learning is essential in improving learning outcome hence CTs question 1c sought to find out students' familiarity with the IK practices used by the chemistry teachers. Question 1c. What is the extent of students' familiarity with these IK practices? This question was also intended to help the Researcher to determine how conversant students are with the IK practices in their environment. The CTs were therefore to rate their students' familiarity with the IK practices they often adopt in explaining chemistry concepts to them. The responses of the CTs were detailed in Table 17.

Table 17: Chemistry teachers assessment of students' familiarity with IK practices

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
STUDENTS FAMILIARITY WITH IK PRACTICES	Some times	Count	1	0	0	0	0	0	0	1	2
		Expected Count	.3	.3	.3	.3	.3	.3	.3	.3	2.0
		% within STUDENTS FAMILIARITY WITH IK PRACTICES	50	0.0	0.0		0.0	0.0	0.0	50	100
	Most times	Count	0	1	1	0	0	1	0	0	3
		Expected Count	.4	.4	.4	.4	.4	.4	.4	.4	3.0
		% within STUDENTS FAMILIARITY WITH IK PRACTICES	0.0	33.3	33.3	0.0	0.0	33.3	0.0	0.0	100
	Always	Count	0	0	0	1	1	0	1	0	3
		Expected Count	.4	.4	.4	.4	.4	.4	.4	.4	3.0
		% within STUDENTS FAMILIARITY WITH IK PRACTICES	0.0	0.0	0.0	33.3	33.3	0.0	33.3	0.0	100
Total		Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0
		% within STUDENTS FAMILIARITY WITH IK PRACTICES	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	100

The chemistry teachers' responses were rated 'Negative' or 'Positive' cross tabulated and presented in Table 19. A 5-point Likert scale consisting of: 1- never, 2 - rarely, 3 - sometimes, 4- most times and 5- always was again used, for the analysis of the responses of chemistry teachers to students' familiarity with IK practices often used in teaching of chemistry concepts. Responses 1 and 2 were rated negative while responses 3, 4 and 5 rated positive. From table 17, 2 chemistry teachers chose option 3 while 3 CTs each, chose option 4 and 5 representing the frequency of familiarity as sometimes, most times and always respectively. From Table 18 all the responses from the teachers were rated positive since no chemistry teacher selected option 1 and 2. Though the familiarities vary from one chemistry teacher to the other, the researcher's conclusion on students' familiarity to indigenous knowledge practices in the environment based on the opinion rating was that students are familiar with IK practices in their environment, therefore careful integration of the two strengths, indigenous knowledge and classroom science, may have the possibility of improving students' learning outcome learning outcomes (Hewson & Ogunniyi, 2011).

Table 18: Response rating for students' familiarity with IK practices

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
OPINION RATING	POSITIVE	Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0
		% within OPINION RATING	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	100
Total		Count	1	1	1	1	1	1	1	1	8
		Expected Count	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.0
		% within OPINION RATING	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	100

Chemistry teachers' item 1d required that they give examples of the chemistry concepts and the corresponding IK practices that they normally use in their teaching. 1d. Give at least five examples of some of these chemistry concepts and the IK practice that was used. The examples of chemistry concepts and the corresponding IK practices provided by CTs are presented in Tables 20, 21, 22, 23, 24, 25, 26 and 27.

From Table 19, Chemistry teacher one (CT1) provided three chemistry concepts with their corresponding Indigenous Knowledge practices. These included local soap preparation for teaching the concept of esterification and food preparation for both diffusion and separation of mixtures.

Table 19*: *Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Esterification (alkaline hydrolysis of esters)	Local preparation of soap
Diffusion gases	Aroma from food preparation and perfumes
Separation of mixtures	Preparation of palm nut soup

Source: Chemistry teacher 1

Chemistry teacher 2 (CT2) also like CT1, provided three IK practices and their corresponding Chemistry concept. From Table 20, shapes of objects in the indigenous setting were used to teach the concept of hybridisation, whereas preparation of palm nut soup and aroma of dishes and perfumes were used to teach separation of mixtures and diffusion of gases respectively.

Table 20: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Diffusion gases	Aroma from food preparation and perfumes
Separation of mixtures	Preparation of palm nut soup
Hybridization	Shapes of objects

Source: Chemistry teacher 2

A total of 4 chemistry concepts and their corresponding Indigenous Knowledge practices stated by chemistry teacher 3 (CT3). The responses provided in Table 21 suggested that, preparation of local soap, oiling of metal parts of tools and the use of lemon to prevent rust, distillation of alcohol and the use of salt to preserve food were used to teach saponification, rusting, separation of mixtures and acids bases and salts respectively.

Table 21: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Saponification	preparation of local soap
Metals (rusting)	Application of oil in metal part of tools, using lemon to remove rust
Separation of mixtures	Distillation of alcohol
Acids, bases and salts	Using salts to preserve food such as fish

Source: Chemistry teacher 3

From Table 22, CT4 noted that, preparation of beverage for breakfast, the use of sucrose and fructose in the preparation of drinks, picking up stones from beans, arrangement of items at home and naming of people were used to teach preparation of solutions, carbohydrates, separation of mixtures and naming of compounds respectively.

Table 22: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Mole concept (preparation of solutions)	Preparing a beverage for breakfast
Organic chemistry (carbohydrates	Use of Sucrose and fructose as sweeteners in the preparation of drinks
Matter (Separation of mixtures)	Picking stones in beans before cooking,
Periodic chemistry	Arrangement of things in a room , place or house
Matter (naming of compounds)	The day you are born, family name, ancestry name, characteristics of ancestors, and may be the circumstances surrounding your birth gives you your name

Source: Chemistry teacher 4

The indigenous knowledge practices, cloth filtration for enema, making of soup and eating fufu with limited soup in Table 23 were adopted by CT5 in teaching specific chemistry concepts such as Buchner funnel filtration, mixtures and limiting and excess reagents respectively.

Table 23: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Buchner funnel filtration	Cloth filtration for enema
Mixtures	Making soup
Limiting and excess reagents	Eating fufu with limited soup

Source: Chemistry teacher 5

Chemistry teacher 6 (CT6) noted in Table 24 that 4 Indigenous Knowledge practices were employed in the teaching of solubility, separation of mixtures, acids, bases, and salts and qualitative analysis.

The corresponding Indigenous Knowledge practices were, preparation of food, removal of chaff from maize, preservation of fish using salt and the use of smell and change in colour of food to determine if the food is cooked.

Table 24: Chemistry Concepts and their Corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Solubility	During cooking or preparation of beverages
Separation of mixtures	Removal of chaff from maize
Acids, bases and salts	Using salts to preserve food such as fish
Qualitative analysis	During cooking (for example, the colour and smell of food can tell if the food is ready)

Source: Chemistry teacher 6

The responses provided in Table 25 indicated that CT7 used food items in the home, smoke from burning and straining of mashed corn dough to teach acids, bases and salts, diffusion and separation of mixtures.

Table 25: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Acids Bases and salts	Food items used in the home
Diffusion	Smoke from burning
Separation of mixtures	Straining mashed corn dough

Source: Chemistry teacher 7

Chemistry teacher 8 (CT8) in Table 26 used examples of all mixture separation measures adopted in the home for the teaching of the concept of separation of mixtures. Preparation of local soap and akpeteshie distillation to teach the concept of saponification and distillation.

Table 26: Chemistry concepts and their corresponding IK

CHEMISTRY CONCEPT	IK PRACTICE
Separation of mixtures	All practices adopted in the home for separating mixtures
Saponification	Preparation of local soap
Distillation	Akpeteshie distillation

Source: Chemistry teacher 8

Analysis of responses provided in Tables 20 to 27 indicated that only 1 chemistry teacher (CT4) was able to provide the required number of Indigenous Knowledge practices. However, 2 chemistry teachers provided 4 IK practices with remaining 5 CTs providing 3 IK practices each. It was also noted that, 7 out of the 8 chemistry teachers employed various separation techniques used in the home to teach the concept of separation of mixtures, 5 of them adopted the materials and processes used in local soap preparation to teach saponification. Again, 3 and 2 CTs provided IK practices for teaching acids, bases and salts and solubility respectively. There were however concepts such as hybridisation, rusting, naming of compounds and qualitative analysis that was stated by individual chemistry teachers. The inability of the majority of the teachers to state the required number of IK practices may be as a result of limited knowledge on which IK practices could be used in the teaching of specific chemistry concepts.

Chemistry teachers item 1e: Do students show interest in lessons involving IK practices? This was asked to investigate the attitude of students to chemistry lessons when integrated with the appropriate IK. Thus, Table 26 presented chemistry teachers' views on whether students are interested in IK-chemistry lessons or not. A cross tabulation of CTs responses from Table 27, gave the percentage count for each chemistry teacher as 12.5% which summed up to 100% for all eight teachers. This was an indication that students have interest in lessons when chemistry concepts are related to indigenous knowledge practices during the teaching and learning of chemistry, hence integrated IK-chemistry lessons will indeed impact positively on students' learning outcome.

Table 27: Chemistry teachers response to students' interest in IK lessons

			TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	6CT	CT7	CT8	
STUDENTS HAVE INTEREST IN LESSONS INVOLVING IK	Yes	Count	1	1	1	1	1	1	1	1	8
		% within STUDENTS HAVE INTEREST IN LESSONS INVOLVING IK	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	100
Total		Count	1	1	1	1	1	1	1	1	8
		% within STUDENTS HAVE INTEREST IN LESSONS INVOLVING IK	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	100

The Chemistry teachers who responded 'YES' to question 1e, were further asked in question to state the extent of students' interest in integrated IK-chemistry lessons by choosing from a range of responses provided. Question 1f. To what extent do students show interest?

The extent of students' interest as specified by each chemistry teacher is presented in Table 30. A 5-point Likert scale consisting of: 1- never, 2 - rarely, 3 - sometimes, 4 - most times and 5- always, was used to analyse the response of chemistry teachers pertaining to the extent of students' interest in IK- chemistry lessons. Table 28 showed that, 12.5%, 62.5%, and 25.0% representing 1, 5 and 2 chemistry teachers agreed that students are sometimes, most times and always, respectively interested in chemistry concepts taught using indigenous knowledge practices.

Table 28: Chemistry Teachers response to the extent of students' interest in IK lessons

			EXTENT OF STUDENTS' INTEREST IN CHEMISTRY LESSONS INVOLVING IK			Total
			SOMETIMES	MOST TIMES	ALWAYS	
Teachers	CT1	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT2	Count	1	0	0	1
		% within teachers	100	0.0	0.0	100
	CT3	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT4	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT5	Count	0	0	1	1
		% within teachers	0.0	0.0	100	100
	CT6	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT7	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT8	Count	0	0	1	1
		% within teachers	0.0	0.0	100	100
Total		Count	1	5	2	8
		% within teachers	12.5	62.5	25.0	100

Studies conducted on the performance of students in chemistry have investigated and attributed the failure of the students to students' attitude (Adesoji & Ogunniyi, 2012). In a similar development, Ameyaw and Amankwah 2014, stated that students' poor performance was due to lack of interest and motivation in lessons. Hence, the deduction from the chemistry teachers' responses was that, the integration of indigenous knowledge practices into the teaching of chemistry will improve the learning outcome of the students in the subject. The opinions provided by the chemistry teachers were rated 'Negative' or 'Positive' and cross tabulated in Table 29. Options 1, 2, and 3 representing never, rarely and sometimes were rated negative while most times and always were rated positive. From Table 20, 12.5% (1) and 87.5% (7) chemistry teachers' responses were rated negative and positive respectively.

Table 29: Opinion ratings for extent of students' interest

			OPINION RATING		Total
			NEGATIVE	POSITIVE	
Teachers	CT1	Count	0	1	1
		% within teachers	0.0	100	100
	CT2	Count	1	0	1
		% within teachers	100	0.0	100
	CT3	Count	0	1	1
		% within teachers	0.0	100	100
	CT4	Count	0	1	1
		% within teachers	0.0	100	100
	CT5	Count	0	1	1
		% within teachers	0.0	100	100
	CT6	Count	0	1	1
		% within teachers	0.0	100	100
	CT7	Count	0	1	1
		% within teachers	0.0	100	100
	CT8	Count	0	1	1
		% within teachers	0.0	100	100
Total		Count	1	7	8
		% within teachers	12.5	87.5	100

However, the Chi-square result in Table 30 showed that there was no significant difference ($p>0.05$) in the true values implying that the values were not statistically significant and hence can be deduced that students are motivated to learn chemistry integrated with indigenous knowledge practices from their environment.

Table 30: Chi-square test for opinion ratings for extent of students' interest

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000[a]	7	0.333
Likelihood Ratio	6.028	7	0.536
Linear-by-Linear Association	1.190	1	0.275
N of Valid Cases	8		

$p > .05$

4.2.2 Response to Questionnaire by Chemistry Teachers (Part II of Phase Two)

The part two of phase two consisted of five questions: 2a-2e (Appendix E). The first question (question 2a) demanded that the chemistry teachers suggest concepts that could be taught using some specific IK practices. The researcher thus listed various IK practices and chemistry teachers were to suggest chemistry concepts that they can be used to teach. The suggestions of the teachers were presented in Table 31. The broken lines in the boxes represented the response, 'No particular concept in mind'.

Table 31: Chemistry teachers CT1, CT2 and CT3 suggestion of chemistry concepts that can be taught using IK practices

IK PRACTICE	CT1	CT2	CT3
i. Cassava dough production	Indigenous technology, fermentation process for alcohol production, preservation of food	Biotechnology, food processing	Fermentation
Gari processing	Indigenous technology	Biotechnology, food processing	Fermentation
Farming	Pollution, the nitrogen cycle, indigenous technology (CO passes through to kill pests). Temperature as increasing rate of reaction	Food production	Pollution, preservation of food
Palm oil production	Separation mixtures, Breaking bond of organic components from inorganic components (Bonding)	Palm oil production	Hydrolysis, oxidation, separation of mixtures
Food preparation and preservation	Extraction of iron using coke catalyst, water purification	Solubility, Analytical chemistry	Absorption, Adsorption and Bonding
Cleaning	Alkaline hydrolysis (saponification) The action soaps. Uses of bases	Removal of stains	Breaking of bonds
Medication	Neutralization (process dipping hog plum or yellow mombin in ash before eating)	Uses of bases as drugs	Neutralization
Distillation of akpeteshie	Distillation (separation of mixtures)	Distillation	Distillation (separation of mixtures)
Marriage and Structure of the family	Structure of the atom, Ionic bonding, Electron affinity, ionization, hybridization	-----------	………….
Blacksmithing	Metals	Metals	Metals
Brewing of beverages	Fermentation process	Distillation	

Enzymatic digestion , Fermentation

Source: Chemistry teachers (1-3)

In Table 31, CT1 suggested concepts for all eleven Indigenous Knowledge practices listed. chemistry teachers 2 and 3 (CT2 and CT3) however could not suggest any chemistry concept for the IK practices in marriage and structure of the family. The suggestions of chemistry teachers 4, 5 and 6 are presented in Table 32.

Table 32: Chemistry teachers CT4, CT5 and CT6 suggestion of the chemistry concepts

IK PRACTICE	CT4	CT5	CT6
Cassava dough production	………..	Chemistry and industry	Biotechnology, Factors affecting rates of reaction
Gari processing	…………	Chemistry and industry	Biotechnology, Factors affecting rates of reaction
Farming	Organic chemistry	Chemicals, Pollution	Environmental pollution, analytical chemistry
Palm oil production	Chemical and physical changes, separation of mixtures, basic biochemistry (fats and oils)	Chemistry and industry	Separation of mixtures, bonding
Food preparation and preservation	Solubility uses of bases and alkanes, Basic biochemistry (fats and oils, proteins and carbohydrates)	Chemistry and industry	Uses of bases, mole concept, rates of reaction
Cleaning	Organic and inorganic solvents (uses of solvents)	Chemicals	Properties of acids and bases
Medication	Acids, bases and salts (uses of bases)	chemicals	Acids bases and salts
Distillation of Akpeteshie	separation of mixtures	Mixtures	Separation of mixtures)
Marriage and Structure of the family	Atomic structure	Organic chemistry and classification Metals	Structure of the atom, Periodicity.
Blacksmithing	Metals		Metals
Brewing of beverages	Fermentation	Chemistry and industry	Chemical industry

Source: chemistry teachers (4, 5 and 6)

Chemistry teachers 5 and 6 in Table 32 were able to suggest chemistry concepts for all indigenous knowledge practices provided. However, CT4 could not suggest any concept for the IK practices, cassava dough production and gari processing. Table 33 detailed the suggestions made by CT7 and CT8.

Table 33: Chemistry teachers CT7 and CT8 suggestion of chemistry concepts that can be taught using IK practices

IK PRACTICE	CT7	CT8
Cassava dough production	Chemistry and industry	Chemistry and industry
Gari processing	Biotechnology	Chemistry and industry
Farming	---------	Air pollution
Palm oil production	Separation of mixtures	Chemistry and industry
Food preparation and preservation	Biotechnology	Solubility
Cleaning	Neutralization	Chemical industry
Medication	Acids and bases	Neutralization
Distillation of Akpeteshie	Distillation	Separation of mixtures
Marriage and Structure of the family	---------	The Nuclear Atom
Blacksmithing	Metal	Metals
Brewing of beverages	Biotechnology	Fermentation

Source: chemistry teachers (7 and 8)

It was noted in Table 33 that CT7 could not suggest any chemistry concept for gari processing, marriage and family structure. However, CT8 provided responses for all the IK processes listed by the researcher.

Generally, although the IK practices listed, provided all the CTs the opportunity to brainstorm and suggest appropriate chemistry concepts, there were however some chemistry concepts that could have been aligned with the IK practices but failed to be noticed by the teachers. Also, most of the chemistry teachers thought that the indigenous technologies listed such as gari processing could only be applicable to the teaching concept of biotechnology.

In question 2b, the chemistry teachers were to share their views on whether all the IK practices listed by the researcher would be useful for the teaching of chemistry. The responses of the chemistry teachers are detailed in Table 34.

Table 34: Relevance of IK practices listed to the teaching of chemistry concepts

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
All the IK practices listed above are useful for the teaching of chemistry	Disagree	Count	0	0	0	1	0	0	0	0	1
		% within teachers	0.0	0.0	0.0	100	0.0		0.0	0.0	12.5
	Agree	Count	0	1	1	0	1	1	0	1	5
		% within teachers	0.0	100	100	0.0	100	100	0.0	100	62.5
	Strongly Agree	Count	1	0	0	0	0	0	1	0	2
		% within teachers	100	0.0	0.0	0.0	0.0	0.0	100	0.0	25
Total		Count	1	1	1	1	1	1	1	1	8

% within teachers	100	100	100	100	100	100	100	100	100

The chemistry teachers were to select a response from a 4-point Likert scale (strongly disagree, disagree, agree and strongly agree) provided. From Table 35, 1 chemistry teacher representing 12.5% disagreed that all the IK practices listed by the researcher would be useful in the teaching and learning of chemistry concepts whereas 5 teachers representing 62.5% and 2, representing 25.0% agreed and strongly agreed respectively that all the IK practices would be useful. The opinions of the chemistry teachers were rated either 'Negative' or 'Positive' as presented in Table 35.

Table 35: Opinion ratings of chemistry teachers' responses to relevance of IK practices to chemistry concepts

			Teachers								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
OPINION RATING	Negative	Count	0	0	0	1	0	0	0	0	1
		% within teachers	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	12.5
	Positive	Count	1	1	1	0	1	1	1	1	7
		% within teachers	100	100	100	0.0	100	100	100	100	87.5
Total		Count	1	1	1	1	1	1	1	1	8
		% within teachers	100	100	100	100	100	100	100	100	100

Options 1 and 2 (strongly disagree and disagree) were rated negative while options three and four (agree and strongly agree) were rated positive. The opinion ratings of the chemistry teachers in Table 37, recorded 12.5% negative and 87.5% positive responses respectively. The 12.5% negative response recorded, might be as a result of the inability of the chemistry teacher to carefully analyse the processes involved in the IK practices provided hence was unable to suggest a chemistry concept. However, the Chi-square result in Table 36 showed that there was no significant difference ($p>0.05$) in the true values implying that the values were not statistically significant.

Table 36: Pearson Chi-square result of CTs response to relevance of IK practices to chemistry concepts

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000[a]	7	0.333
Likelihood Ratio	6.028	7	0.536
Linear-by-Linear Association	.048	1	0.827
N of Valid Cases	8		

$p> .05$

Furthermore, CTs question 2c demanded that they express their views on the development of ‘integrated indigenous knowledge-chemistry lessons’ (IIK-CLs) from the IK practices listed by the researcher. Table 37 thus presented the responses of the chemistry teachers.

Table 37: Response of chemistry teachers to whether a teaching IIK-CLS can be developed from the IK practices.

			A TEACHING MANUAL CAN BE DEVELOPED FROM THE IK PRACTICES			Total
			DISAGREE	AGREE	STRONGLY AGREE	
Teachers	CT1	Count	0	0	1	1
		% within teachers	0.0	0.0	100.0	100
	CT2	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT3	Count	0	0	1	1
		% within teachers	0.0	0.0	100	100
	CT4	Count	1	0	0	1
		% within teachers	100	0.0	0.0	100
	CT5	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT6	Count	0	0	1	1
		% within teachers	0.0	0.0	100	100
	CT7	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
	CT8	Count	0	1	0	1
		% within teachers	0.0	100	0.0	100
Total		Count	1	4	3	8
		% within teachers	12.5	50.0	37.5	100

From Table 37, 1, 4, and 3 chemistry teachers, representing 12.5%, 50%, and 37.5% disagreed, agreed and strongly agreed respectively that a ‘IIK-CLs’ could possibly be developed from the IK practices listed by the researcher. The opinions expressed by the chemistry teachers were rated and presented in Table 38. The opinion rating of the chemistry teachers’ responses in Table 39 revealed that 87.5% (CTs who selected agree and strongly agree) believe in the possibility of designing an ‘IIK-CLs whereas 12.5% (CTs who selected disagree and strongly disagree) of the teachers thought otherwise

Table 38: Opinion ratings of chemistry teachers’ responses to the possibility of developing a chemistry teaching manual using the IK practices

			OPINION RATING		Total
			NEGATIVE	POSITIVE	
Teachers	CT1	Count	0	1	1
		% within teachers	0.0	100	100.
	CT2	Count	0	1	1
		% within teachers	0.0	100	100
	CT3	Count	0	1	1
		% within teachers	0.0	100	100
	CT4	Count	1	0	1
		% within teachers	100	0.0	100
	CT5	Count	0	1	1
		% within teachers	0.0	100	100
	CT6	Count	0	1	1
		% within teachers	0.0	100	100
	CT7	Count	0	1	1
		% within teachers	0.0	100	100
	CT8	Count	0	1	1

	% within teachers	0.0	100	100
Total	Count	1	7	8
	% within teachers	12.5	87.5	100

The Pearson's Chi-square result in Table 39 showed that there was no significant difference (p>0.05) in the true values implying that the values were not statistically significant. This implied that IIK-CLs could be designed using the indigenous knowledge provided.

Table 39: The Pearson Chi-square result of CTs responses to the possibility of designing IIK-CLS using the IK practices

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000[a]	7	0.333
Likelihood Ratio	6.028	7	0.536
Linear-by-Linear Association	.048	1	0.827
N of Valid Cases	8		

p> .05

Again, the chemistry teachers were required in question 2d to express their opinions on whether the designed 'IIK-CLs will have a positive impact on the teaching and learning of chemistry. Table 40 showed the response of the chemistry teachers. Table 40 showed that 12.5%, 25% and 62.5% representing 1, 2 and 5 chemistry teachers disagree, agree and strongly agree respectively that 'integrated indigenous knowledge-chemistry lessons will have a positive impact on the teaching and learning of chemistry concepts.

Table 40: Chemistry teachers' response to the impact of IIK-CLs on teaching and learning of chemistry

			CHEMISTRY TEACHERS								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
teaching manual will have a positive impact on the teaching of Chemistry	Disagree	Count	0	0	0	1	0	0	0	0	1
		% within Chemistry teachers	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	12.5
	Agree	Count	0	0	0	0	1	0	1	0	2
		% within Chemistry teachers	0.0	0.0	0.0	0.0	100	0.0	100	0.0	25.
	Strongly Agree	Count	1	1	1	0	0	1	0	1	5
		% within Chemistry teachers	100	100	100	0.0	0.0	100	0.0	100	62.5
Total		Count	1	1	1	1	1	1	1	1	8
		% within Chemistry teachers	100	100	100	100	100	100	100	100	100

The opinion rating of the chemistry teachers' responses in Table 41 indicated that 87.5% responded positively while 12.5% responded negatively.

Table 41: Opinion rating of chemistry teachers' response on the impact of IK-manual on teaching and learning of chemistry

			CHEMISTRY Teachers								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
OPINION RATING	Negative	Count	0	0	0	1	0	0	0	0	1
		% within chemistry teachers	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	12.5
	Positive	Count	1	1	1	0	1	1	1	1	7
		% within chemistry teachers	100	100	100	0.0	100	100	100	100	87.5
Total		Count	1	1	1	1	1	1	1	1	8
		% within chemistry teachers	100	100	100	100	100	100	100	100	100

The Pearson's Chi-square result in Table 42 showed that there was no significant difference in the true values implying that the values were not statistically significant.

Table 42: The Pearson's Chi-square result of CTs' response on the impact of IK-manual on teaching and learning of Chemistry

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000^a	7	0.333
Likelihood Ratio	6.028	7	0.536
Linear-by-Linear Association	.048	1	0.827
N of Valid Cases	8		

p> .05

In question 2e, the chemistry teachers were to state the extent to which they think that 'IIK-CLs' will have a positive impact on students' performance.

The answers to the impact of the IK-chemistry teaching manual is presented in Table 43. The analysis showed that 12.5% of the chemistry teachers disagree that IK-CLs will have a positive impact on the performance of students in chemistry whereas 37.5% and 50% agree and strongly agree respectively.

Table 43: Chemistry teachers' response on the impact of IK-CLs on students' performance in chemistry

			Chemistry teachers								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
The teaching manual will have a positive impact on students' performance	Disagree	Count	0	0	0	1	0	0	0	0	1
		% within Chemistry teachers	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	12.5
	Agree	Count	0	1	0	0	1	0	1	0	3
		% within Chemistry teachers	0.0	100	0.0	0.0	100	0.0	100	0.0	37.5
		Count	1	0	1	0	0	1	0	1	4

	Strongly agree	% within Chemistry teachers	100	0.0	100	0.0	0.0	100	0.0	100	50.
Total		Count	1	1	1	1	1	1	1	1	8
		% within Chemistry teachers	100	100	100	100	100	100	100	100	100

The opinion ratings of answers provided by the chemistry teachers are shown in Table 44. A 4-point Likert scale was used for the analysis. Responses 1, and 2 representing strongly disagree and disagree respectively were rated negative while responses 3 and 4 representing agree and strongly agree respectively were rated positive. The opinion rating of the chemistry teachers' responses in Table 44 indicated that 87.5% responded positively while 12.5% responded negatively. The 12.5% negative response might be due to the fact that the chemistry teacher might have considered the impact of IK practices on students' performance anytime IK practices were integrated into the teaching of chemistry concepts.

Table 44: Opinion rating of chemistry teachers' response on the impact of IK-CLS on the performance of students' in chemistry.

			Chemistry teachers								Total
			CT1	CT2	CT3	CT4	CT5	CT6	CT7	CT8	
OPINION RATING	Negative	Count	0	0	0	1	0	0	0	0	1
		% within Chemistry teachers	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	12.5

Positive	Count	1	1	1	0	1	1	1	1	7
	% within Chemistry teachers	100	100	100	0.0	100	100	100	100	87.5
Total	Count	1	1	1	1	1	1	1	1	8
	% within Chemistry teachers	100	100	100	100	100	100	100	100	100

However, Pearson's Chi-square result in Table 45 showed that there was no significant difference ($p>0.05$) in the true values implying that the values were not statistically significant hence teaching and learning chemistry concepts using IIK-CLs is believed to have a positive impact on the learning outcome of students.

Table 45: Pearson Chi-square result of chemistry teachers' response on the impact of IIK-CLs on the performance of students' in chemistry

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000^a	7	0.333
Likelihood Ratio	6.028	7	0.536
Linear-by-Linear Association	.048	1	0.827
N of Valid Cases	8		

$p> .05$

The researcher, after considering all questionnaires, provided a categorisation of indigenous knowledge practices and their related chemistry concepts are presented in Tables 47 to 49.

Table 46: Categorisation of IK practices under selected chemistry concepts

CHEMISTRY CONCEPTS	INDIGENOUS KNOWLEDGE PRACTICES
Chemistry as a discipline	Description of a particular indigenous group
Measurement of Physical Quantities	Everyday life activities mostly practiced in the market
Basic Safety Laboratory Practices	Safety measures observed by indigenous people during work
Particulate Nature of Matter	Things in the environment
Structure of the Atom	Structure of the family
Periodicity	Structure of the family, naming a new born
Interatomic Bonding	Family structure, relationships and marriage
Intermolecular Bonding	Family and relationships and marriage
Hybridization and Shapes of Molecules	Structure of the family and marriage

Table 47 shows a continuation of the categorisation of Indigenous Knowledge practices under specific Chemistry concepts.

Table 47: Categorisation of IK practices under selected chemistry concepts

CHEMISTRY CONCEPTS	INDIGENOUS KNOWLEDGE PRACTICES
Carbon-12 Scale	Marketing practices for example: One 'olonka' of any substance contains six margarine tins of that substance.
Solutions	Food preparation
Stoichiometry and Chemical Equations, naming of compounds	Naming a new born, food preparation
Solids and Liquids	Through everyday interactions, food preparation
Gases and their properties	Food preparation
Kinetic model of matter	Food preparation
Energy changes in Physical and Chemical Processes	Food preparation
Rates of reactions	Gari and cassava dough and flour production, food preparation

Properties of Acid, Bases and acid-base Indicators	Medication, cleaning, preparation and preservation of food
Classification of acids and bases	Cleaning
Solubility of Substances	Food preparations
Salt and Chemicals from Salt	Food preparations
Oxidation – reduction processes and oxidizing – reducing agents	Cleaning, for example the use of lemon to remove rust from surfaces

Further Chemistry concepts that could be taught using specific Indigenous Knowledge practices are presented in Table 48

Table 48: Categorisation of IK practices under selected chemistry concepts

CHEMISTRY CONCEPTS	INDIGENOUS KNOWLEDGE PRACTICES
Corrosion of Metals	Cleaning
Bonding in Carbon	Marriage
Separation and purification of Organic Compounds	Distillation of akpeteshie, salt production
Alkanes	Preparation of food
Alkenes	Farming
Alkanols	Distillation of akpeteshie, brewing of local beverages and food preparation
Alkanoic Acids	Food preparations, tire and dye industry
Alkanoic Acids derivatives: Alkylalkanoate(esters)	Pleasant smell of fruits, scented plants around homes, preparation of local soap
Chemical Industry	Local soap production, Batik tie and dye

Extraction of metals and properties of metals.	Extraction of salt, gold, diamond and bauxite. Blacksmithing and Goldsmithing.
Environmental pollution	Farming, everyday practices
Biotechnology	Food preparations, palm oil production, gari and cassava dough processing, distillation of akpeteshie
Cement and its uses	Mining, pottery, building and construction
Fats and oils	Food preparation, local soap manufacturing, medication
Proteins	Food preparation
Carbohydrates	Food preparation

It was discovered from the categorisation in Table 46 to 48 that some chemistry concepts in the senior high school chemistry syllabus could be taught using indigenous knowledge practices.

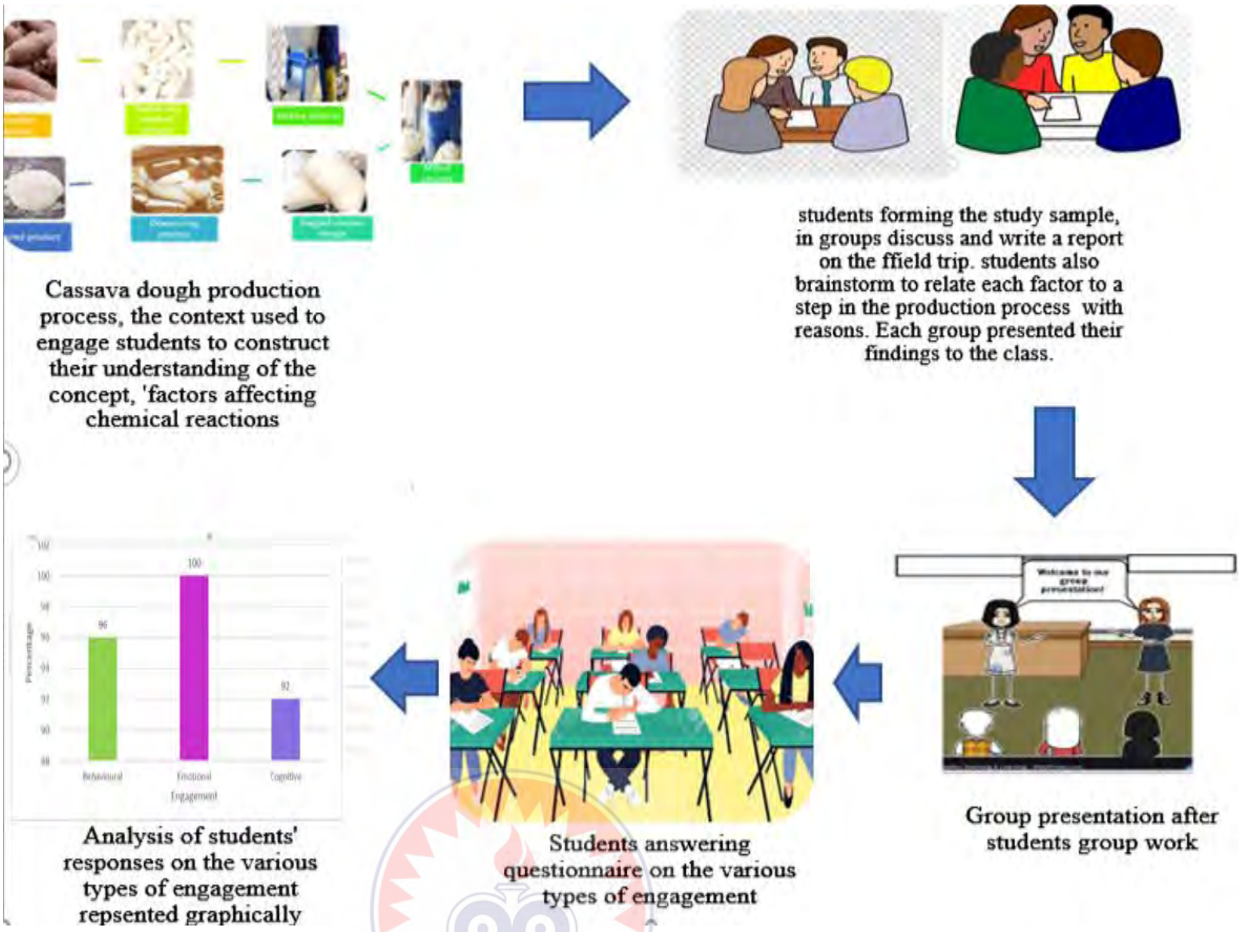
4.3 Research Question 3,

3. What is the level of students' behavioural, emotional and cognitive engagement in 'IIK-CLs

Based on the data collected from the indigenous knowledge people and the chemistry teachers, and having considered strategies for IK integration into the teaching of science, (Hewson, 2013; Lee, Yen & Aikenhead, 2011; Zidny & Eilks, 2020), an 'indigenous knowledge-chemistry' teaching manual (Appendix J) was designed from the categorisation which included planned 'integrated indigenous knowledge-chemistry lessons' (IIK-CLs). Students' engagement in an 'IIK-CL was assessed through the teaching and learning of factors affecting chemical reaction in the context of cassava dough production. An 'Integrated Indigenous Knowledge-Chemistry lesson' (IK-CL) plan was designed which included a field trip to a cassava dough production site around the school. The purpose of the trip was communicated to the students and they were asked to engage in the activity with the concept (factors affecting chemical reaction) in mind. Students participated in the production process with the indigenes and were free to interact and ask questions for clarification. Students were occasionally prompted to observe critically, focusing on the chemistry concept and to take note of every step and its relevance to the production process. After the field trip, students in groups of 4 were to write a report on the trip, stating and describing the various stages of the cassava dough production process and their importance.

Students were to prepare two sets of cards, one set with the main stages of cassava dough production processes and the other set with the factors affecting the rates of chemical reaction. They were to match the cards and give reason(s) for the order.

Each group presented their ideas to the class which also engaged the class in a discussion. Figure 17 describes the activities students were engaged in.


Cassava dough production process, the context used to engage students to construct their understanding of the concept, 'factors affecting chemical reactions

students forming the study sample, in groups discuss and write a report on the ffield trip. students also brainstorm to relate each factor to a step in the production process with reasons. Each group presented their findings to the class.

Group presentation after students group work

Students answering questionnaire on the various types of engagement

Analysis of students' responses on the various types of engagement repsented graphically

Figure 17: A summary of students' engagement activities used

The students were expected to relate the factors affecting chemical reaction as stated in their syllabus to the main stages involved in the cassava dough production process as shown in Figure 18 and explain their choices during the discussion period.

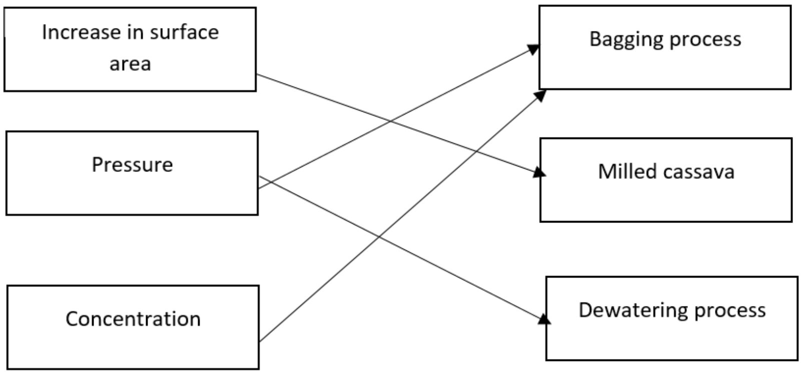


Figure 18: Relating the factors affecting chemical reaction to the stages involved in cassava dough production

The researcher designed and used questionnaires and observational schedule based on behavioural, emotional and cognitive. engagement proposed by Fredricks et al. (2004) to obtain comparable information about students' engagement. The students were provided with the questionnaire with a 6-Likert scale response, ranging from 'strongly disagree to strongly agree (Appendix F). The students were to choose the response they deem appropriate and deposit the completed questionnaire in a pin hole provided. The observational schedule (Appendix G) was also used by an interrater during the lesson to rate students behavioural, emotional and cognitive engagement. Questionnaire responses were analysed presented in Table 49 and Figures 20, 21, 22 and 23

Table 49: Data from students' responses to statements on engagement

OPTIONS	STATEMENTS						
	ST1	ST2	ST3	ST4	ST5	ST6	ST7
SD	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-
SLD	-	2	-	-	-	-	4
SLA	4	4	3	-	1	6	2

A	10	11	11	12	9	8	11
SA	12	9	12	14	16	12	9
TOTAL	26	26	26	26	26	26	26

Key: ST- STATEMENT

The students' engagement questions were in the form of statements as follows:

Statement 1. It was easy to follow the instructions during the lesson

Statement 2. I understood what is expected from me during the lesson

The above statements were to assess behavioural engagement. As suggested by Fredricks et al. (2004) statement 1 specifically measured conduct in terms of ability to follow instructions while statement 2 focused on the effort made by the student to understand what was expected from him or her during the lesson. Out of a total of 26 students, 4, 10, and 12 slightly agree (SLA), agree (A) and strongly agree (SA) that it was easy to follow the instructions during the lesson. No student however, strongly disagrees (SD), disagrees (D) nor slightly disagrees (SLD) with the statement. Hence, considering the response ratings, all 26 students representing 100% responded positively. However, in statement 2, 24 (92%) students compared to 2 (8%) understood what was expected from them during the lesson. Combining the response ratings from the two statements it was realised that students' engagement in the integrated indigenous knowledge-chemistry lesson achieved 96% (25 students) compared to 4% (1 student) in the context of behavioural engagement in the lesson. Figure 19 is a graphical representation of students' behavioural achievement illustrating responses from students including the total percentage of students who were engaged behaviourally (TEB) and total percentage of students who were not behaviourally engaged (TNEB)

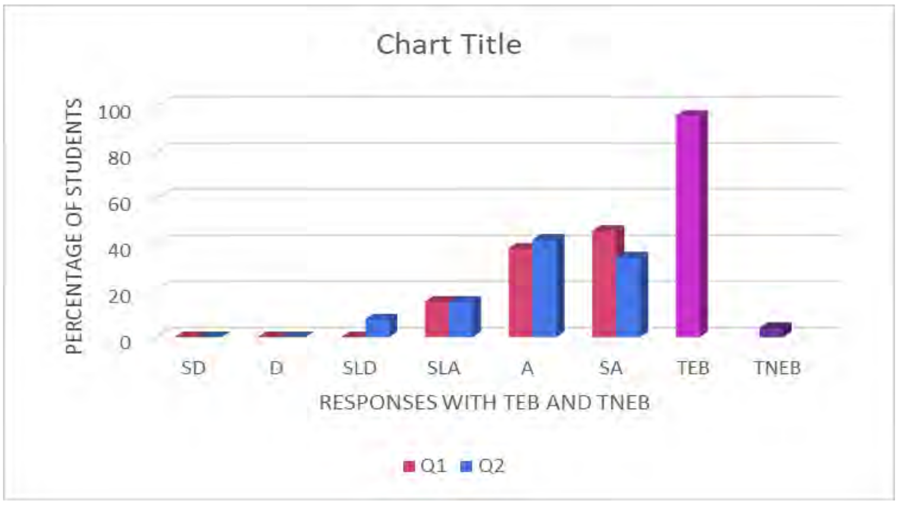


Figure 19**:** Multiple bar charts of students' responses with their behavioural engagement

Statement 3. The lesson felt meaningful for me

Statement 4a. I enjoyed the lesson

Statement 4b. why?...........

Statement 5. I want more of such lessons

Statements 3, 4 and 5 were used to assess emotional engagement of the students. As discussed by Fredricks et al. (2004), emotional engagement measures students' feelings about the lesson which are expressed in terms of relevance or meaningfulness of the activity to their daily lives, and enjoyment of the lesson that will make the students ask for more lessons to be conducted in like manner. Students were therefore required to rate how meaningful they felt the lesson was in statement 3, how much they enjoyed the lesson in statement 4 and how much they desire to have more lessons taught with such strategy. From Table 50, 3 (12%), 11(42) and 12(46) students slightly agree, agree and strongly agree respectively that they felt the lesson was meaningful. No student however, chose the options strongly disagree, disagree and slightly disagree. Statement 4 recorded 12(46%) and 14(54%) of students who agree and strongly agree respectively that they enjoyed the lesson. All the other options recorded zero. Again, 1(4%), 9(35%) and 16(61%) of students slightly agree, agree and strongly agree that they desire the use of the strategy further in their lessons. Considering the response ratings, and combining all three questions, the integrated indigenous knowledge-chemistry lesson achieved 100% of students' emotional engagement in the lesson. Figure 20 is a graphical representation of students' responses including total percentage of students engaged emotionally (TEE) and total percentage of students not engaged emotionally (TNEE) in the lesson.

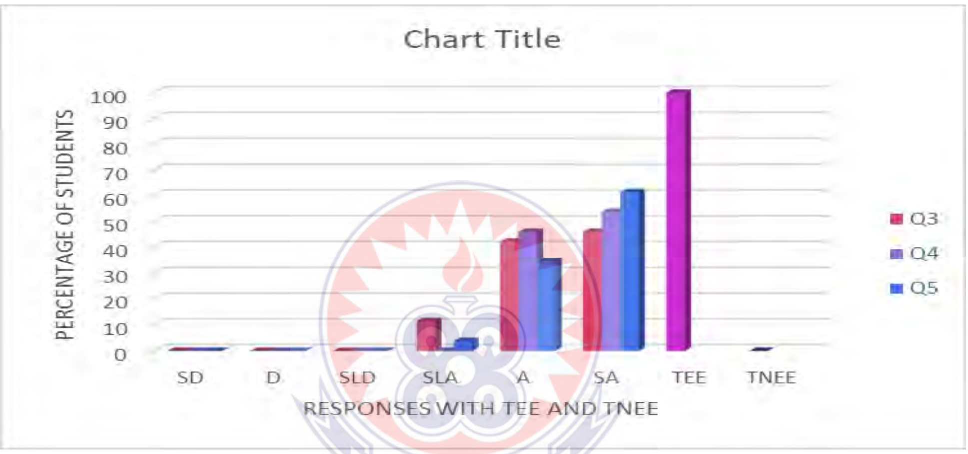


Figure 20: Multiple bar charts of students' responses with their emotional engagement

A follow up on Question 4a requested that the students express their views on the option selected. Hence students were asked to state why they enjoyed or did not enjoy the lesson. The result from Question 4a revealed that all the students enjoyed the lesson. The responses from the students to Question 4b was summarised into 7 main points;

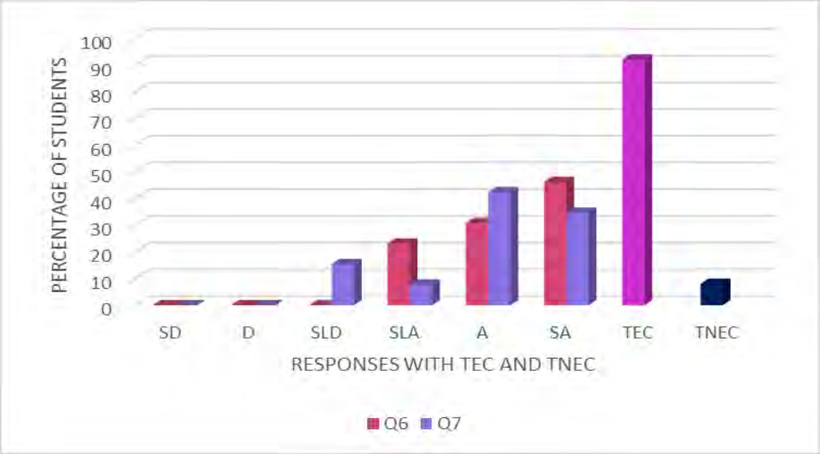
- 'I was happy to see chemistry in something so relevant in my environment'. (S2)

- ‘The lesson really was meaningful to me, I can remember, explain and apply this knowledge’. (S4)
- ‘The lesson was so real’. (S9)
- ‘I have engaged in cassava dough production before but never thought it can be related to this concept’. (S12)
- ‘The lesson was so amazing; I did every learning by myself’. (S15)
- ‘I could see the importance of each of the factors on cassava dough’ production and ways the production can be improve’. (17)
- ‘I can transfer this understanding to other areas where applicable’. (S22)
- ‘This lesson cannot be forgotten’. (S26)

Statement 6. I understand the concept learnt

Statement 7. I am able to apply the concept learnt in relevant situations

The cognitive engagement of the students was assessed using statements 6 and 7. These questions sought to measure cognitive engagement students’ comprehension of the concept and their ability to apply it in relevant situations as suggested by Fredricks et al. (2004). From the data presented in Table 1, 6 (23%), 8 (31%), and 12 (46%) students slightly agree, agree and strongly agree respectively that the lesson was understood. However, 4 (15%), 2 (8%), 11 (42%) and 9 (35%) students slightly disagree, slightly agree, agree and strongly agree respectively that they can apply the concept learnt in relevant situations. A reference to the response ratings implied that all 26 (100%) feel they understood the concept while 22 (85%) compared to 4 (5%) students think they can apply the concepts in relevant everyday life situations. Thus, the integrated indigenous knowledge-chemistry lesson caused 24 (92%) compared to 2(8%) students to be cognitively engaged in the lesson. This implied that 92% of students did not only think they understood the lesson but could also make use of the knowledge in relevant situations. Figure 21 is a representation of students' responses and their cognitive engagement.



Key: TEC- total number of students engaged cognitively, TNEC- total number of students not engaged cognitively

Figure 21: Multiple bar charts of students' responses with their cognitive engagement

Figure 22 is a comparison between the various types of engagement assessed using the questionnaire and the observational schedule. The analysis showed that emotional engagement recorded a percentage of 100% each when both instruments used. Behavioural engagement recorded 96% and 94% while cognitive engagement 92% and 91% when both the questionnaire responses and the observational schedule ratings were analysed respectively.

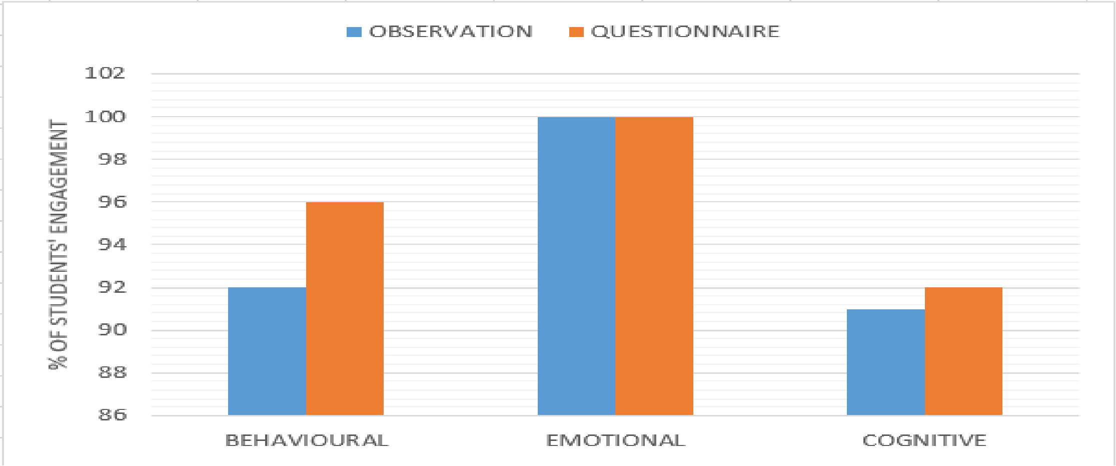


Figure 22: Multiple bar charts showing comparison between engagement observational schedule ratings and questionnaire responses

4.4 Research Questions 4

Research question 4: What is the impact of the IIK-CLs on students' learning outcome? For evidence that IIK-CLs lessons can improve students' performance in chemistry the researcher taught three chemistry concepts namely, factors affecting rate of chemical reaction (surface area, pressure and concentration), properties of metals and distillation. The ITS design was used to collect pre-test and post-test data before and after use the 'integrated indigenous knowledge-chemistry lessons. The pre-test scores of students in the first chemistry concept, factors affecting chemical reaction is presented in Figure 23. The graph depicted that 7, 7 and 6 students scored 0, 1.5 and 3.5 while 1, 2, 2 and 1 students also scored 5, 6.5, 8.5 and 10 respectively as mean marks out of a total mean mark of 12.5 in the pre-test. It was also noted that 21 students (81%) out of a total of the 26 students assessed had a mean mark below the average with only 5 students (19%) scoring above the average mark.

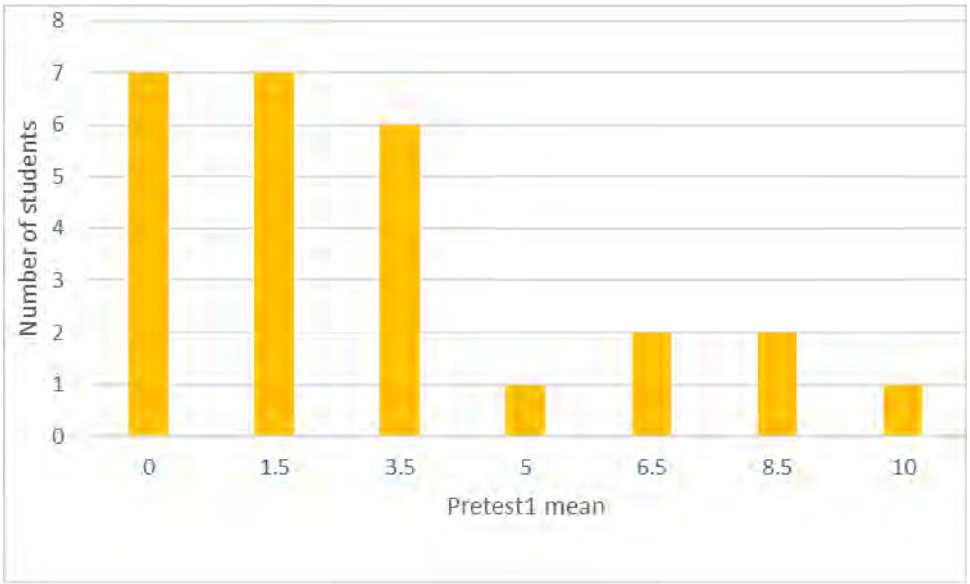


Figure 23: Bar charts showing mean marks compared to number of students in pre-test 1

After the 'integrated indigenous knowledge-chemistry lesson 1, described during the students' engagement assessment stage, the students' cognition of the concept was evaluated using the interrupted time series and the result presented in Figure 24

The analysis in Figure 24 showed that a total of 2 students scored 3.5 as mean mark in the post-test 1 while a total of 24 students scored 6.5 (2 student), 7.5 (2 student), 8.5 (4 students), 11.5 (8 students) and 12.5 (8 student) respectively in the post-test 1. It can be noticed that the majority of students (92%) scored above the average mean mark of 12.5 with only 8% students scoring below the average mark. The improvement in students' performance in post-test one was evidenced in the difference in Students response to questions in the pre-test and post-test 1 (Appendix H) For example, question 2 of pre-test 1 required that the Student explain the effect of pressure and surface area on the rate of chemical reaction. Samples of Students responses are detailed below:

Student five's (S_5) pre-test 1 response to the effect of concentration on reaction rate: 'When pressure is increased the rate of reaction is increased'.

Student nineteen's (S_{19}) pre-test response to the effect of surface area on the rate of chemical reaction: 'An increase in surface area increases the rate of chemical reaction because the reactants occupy a larger space'.

Analysis of the responses provided by both students indicated that they both had the initial statement right but could not offer any explanation to that effect. In the post-test however, the Students were able to offer the correct explanations of the effect of pressure and surface area on the rate of chemical reaction as follows:

Student five's (S_5) post-test 1 response to the effect of pressure on reaction rate: An increasing pressure increases the rate of chemical reaction. The reason is that, increasing the pressure reduces the volume of the reaction vessel thereby reducing the distance between reactant molecules resulting in higher number of collisions per second (when one particle collides with the other). Hence, the faster the reactants are converted to products'.

Student nineteen's (S_{19}) post-test 1 response to the effect of surface area on the rate of chemical reaction: The larger the surface area, the faster the reaction rate. Reason: A large surface area provides a large number of particles. The higher the number of particles, meant that more particles will come into contact with one another which will result in a large number of collisions per second and the faster the reactants are changed to products'

It was noted from the responses in the post-test that the communication of the concept of the factors affecting chemical reaction to the students through the use of the processes involved in cassava dough production was effective since students provided vivid explanation to the effect of the factors on the rate of chemical reaction as compared to the answers given in the pre-test.

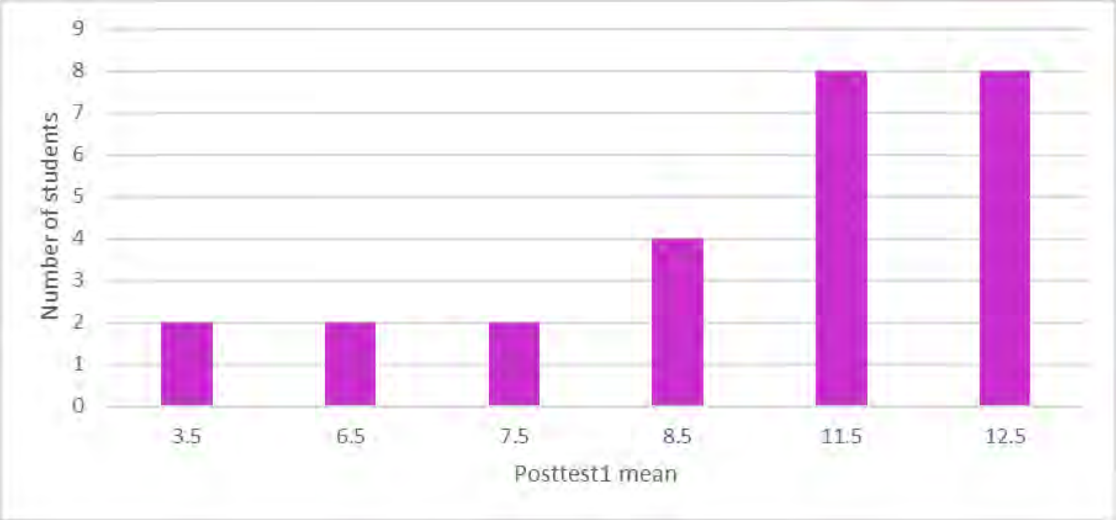


Figure. 24: Bar charts showing students' performance in post-test 1

Figure 25 clearly depicted the improvement in the learning outcome of the individual student in the pre-test and series of tests conducted in pre-test and post-test 1. Figure 25 showed that every individual students' learning outcome in the post-test was better compared to that of the pre-test. This was an indication that the use of the 'integrated indigenous knowledge-chemistry lesson' was effective in communicating the concept of factors affecting chemical reaction to learners.

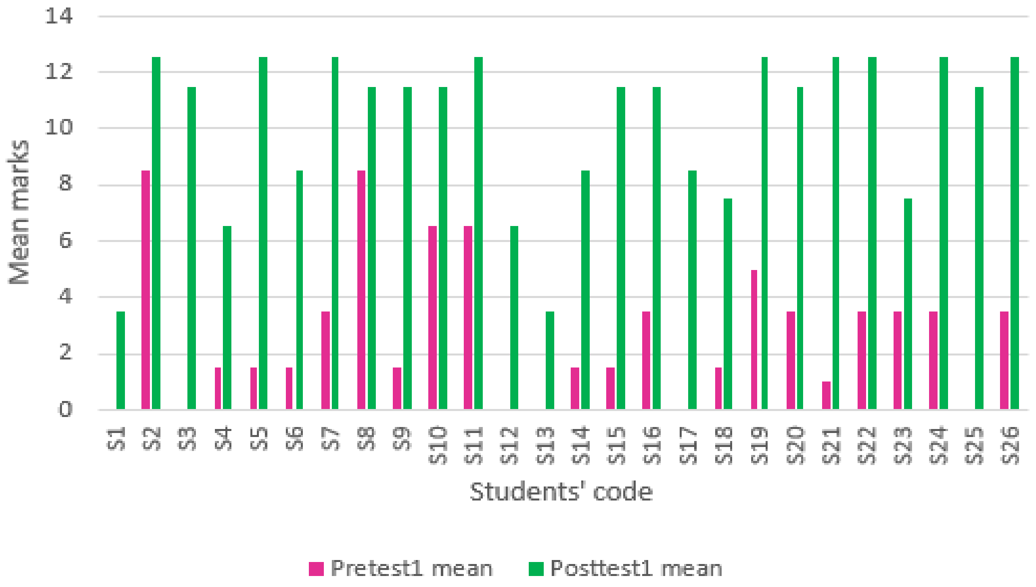


Figure 25: Students' performance in pre-test and post-test 1

The improvement in performance was again confirmed by the paired samples test analysis in Table 50 which recorded a mean difference -7.462, a standard deviation of 2.672 and a t-value of -14.240. The p-value of 0.00 recorded showed that there was significant difference between ($p<0.05$) the mean achievement scores in the pre-test and post-test1.

Table 50: Paired sample test for students' performance in pre-test and post-test 1

Pair	Mean difference	Std. deviation	T	df	Sig. (2-tailed)
Pre-test 1- post-test 1	-7.462	2.672	-14.240	25	0.000

The second chemistry concept, 'Properties of metals and liquids' was taught using the indigenous knowledge practices involved in blacksmithing.

The blacksmithing process was well described by the students.

a. *'Acquire your aluminium (from scraps)*
b. *Make a fire from charcoal*
c. *Heat or melt the metal*
d. *Shape heated metal using hammer, an anvil and a chisel and cooling in water*
e. *To make items such as pots, coal pots ladles and knives, pour out melted metal into moulds and allow to cool and solidify'.*

Some answers to test 2 assessment questions by students are presented in Table 51

Table 51: Ideas expressed in the pre-test 2 and post-test 2

Pre-test	Post-test
Properties of metal stated by the students ● Metals are hard ● Metals are shiny ● Metals are strong ● Metal are ductile ● Metals are malleable	Properties of metal stated by the students ● Metals have high melting point ● Metals are good conductors of heat ● Metals are good conductors of electricity ● Metals are malleable ● Metals are ductile
	High melting point means that metals require a great amount of heat to break it the bonds between the metal atoms (S21)
	Metals have a high melting point means metal can only change from solid to molten state when a very high heat is applied enabling the bonds between the atoms to be broken'. (S22)
	'High melting point means that a very high temperature is needed to break the bonds between the atoms'. (S11, S15)
'The metal can be hammered to change its shape' (96% of the students gave this answer including S4, S6 and S10)	'Malleability means that metals can be hammered to change their shape. This is possible because of the arrangement of the atoms in the metal'. (S4, S6, S10)
'Metals conduct good conductors because electricity passes through metal easily'. (This explanation was given by 81% of the students. The remaining 19% just stated the property without any explanation.	Metals are good conductors of heat because of the presence of the delocalized electrons in the lattice structure. Charged particles conduct electricity and the electrons are charged particles. the movement of the electrons when a voltage is applied creates electric current (S2 S19,)
Heat is a form of energy so the metal is able to transfer the energy from one point to the other	'Good conductor of heat. Metal easily get heated when heat is applied. When metals are heated, the molecules gain energy and vibrate and transfer the heat throughout the metal'. (S15, S24)
Metals are ductile means they can be drawn into wires. All the students gave this explanation	Metals are ductile means that they can be drawn into wires. The arrangement of the atoms makes the metals slide over each layer. (S7, S26)

Question: With the properties of metals in mind explain how you can help a friend open a very tightly closed glass bottle with a metal lid.

‘Metals expand when they are heated so a gentle heat can be applied around the lid so that the lid can be opened’. (S1)

‘My friend should simply apply heat but must take care the bottle does not break’. (S3)

‘I will tell my friend to heat the bottle in water and try to open it again, now it will be easy to open because the metal has expanded and so will not be tight again’. (S5)

‘My friend can just pour hot water continuously around the lid to make it loose, because when metal gains heat they expand’. (S8)

‘I will tell my friend to put the lid area of the bottle in very hot water, this will cause the metal lid to expand and the bottle can be opened’. (S9)

‘Metals are good conductors of heat so to be able to open the bottle, heat must be applied. If the bottle is put directly on the naked fire it will break so the bottle should be heated in water. If it is heated the meat lid will gain heat and expand so it can easily be opened’ (S12)

‘When heat is applied the metal will expand and will lose hold of the glass, so the solution is to warm the area where the lid is to be able to open it’. (S13)

‘The metal is a better conductor of heat than the glass so the bottle can be heated in water. If this happens the metal will easily conduct heat and will expand faster than the glass so that it can lose hold of the glass’. (S14)

‘When you use a cotton napkin around it and try to turn it several times, heat will be generated around the lid and it will open. If it still cannot be opened, then you need a stronger heat so you could put in hot water to make the metal lid expand so that you can open it'. (S14).

'Heat will help open the bottle because when the metal lid comes into contact with the heat it will cause it to expand and will be loosened around the glass. This is because metals are good conductors of heat'. (S17).

Content analysis was conducted to assess the students' performance in the pre-test and post-test and presented in Table 52. This was done to determine the actual improvement made by the students in the various concept areas.

Table 52: Content analysis of items in the pre-test 2 and post-test2

		PRETEST		
Item	Point			
1	3	Grouping of item under concepts assessed	Items that assessed concept	No. of students
2	4	Energy	3 and 6	0
3	2	Heat	3 and 6	2 (item 3), 1(item 6)
4	2	Metal properties	1, 2 and 5	25 (1 and 5) 3(2)
5	3	Structure	4 and 7	4 (item 4), 0 (item7)
6	3			
7	3			
		POSTTEST		
Item	Point			
1	3	grouping of item under concepts assessed	Items that examined concept	No. of students
2	4	Energy	3 and 6	26 (item3), 25 (item 6)
3	2	Heat	3 and 6	26
4	2	Metal properties	1, 2 and 5	26
5	3	Structure	4 and 7	24(item 4), 20 (item7)
6	3			
7	3			

In the pre-test 2 and post-test 2, all 26 students stated at least 3 of the points in Table 51. However, in the pre-test students' answers reflected only the macro domain of thinking. The explanations given to the properties stated was inadequate and also based on the same level. Students' answers in the post-test however revealed a significant improvement in their learning as students progressed from the macro domain to the micro domain as shown in the content analysis. Students' construction of the concept after the intervention is a prove of the cognitive engagement of the learners in the lesson. The performance of each student in the pre-test 2 is graphically presented in Figure 26.

The graph in Figure 26 revealed that a total of 22 (85%) students scored below the average mark of 10 in the pre-test while 4 (15%) students, two each, scored the average and above the average mark. It was also noted that no students scored the total mark of 20 in pre-test.

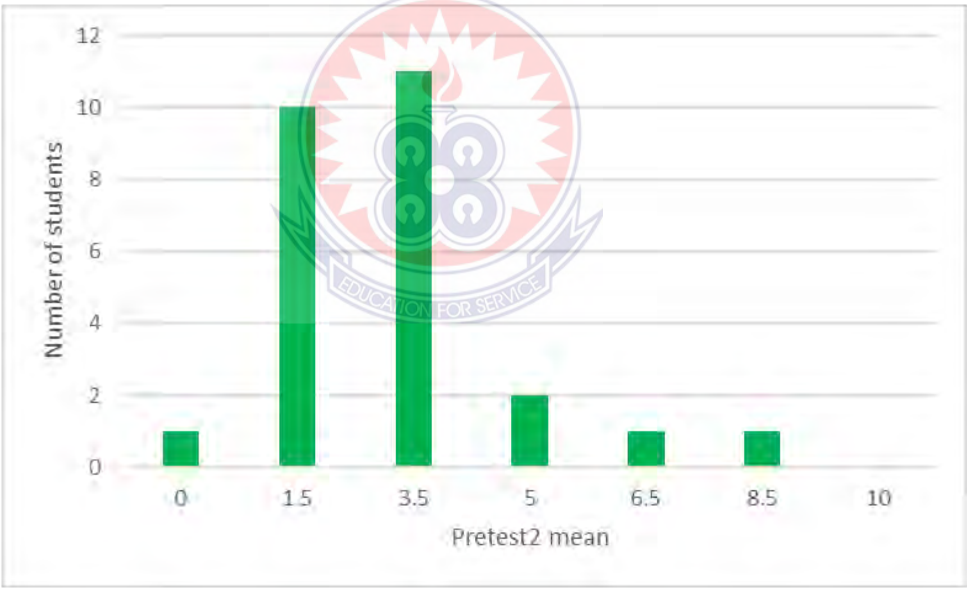


Figure 26: Bar chart showing students' performance in pre-test 2

The analysis of students' performance in post-test 2 (Figure 27) revealed that only 1 student scored a mean mark of 4 which is below the average and 1 other student scored the average mark of 5. However, 1, 4, 6, 6, and 7 students scored 6, 7, 8.8, 9.5 and 10 marks respectively which summed up to a total of 24 (92%) students who scored above the average mean mark. The analysis depicted the progress in learning made by the learners which is a reflection of their knowledge and understanding of the concept. Figure 27 is a graphical representation of students in post-test 2

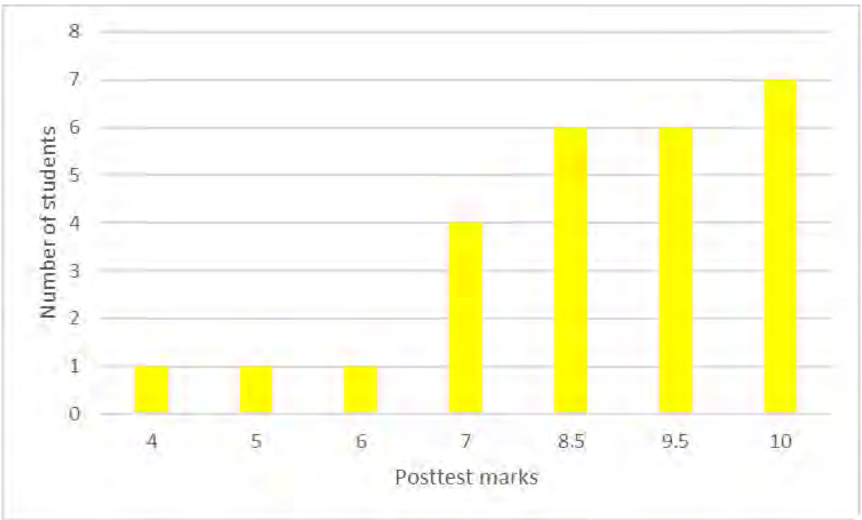


Figure 27: Bar charts showing students' performance in post-test 2

The performance of each student in the pre-test 2 and post-test 2 was compared and presented in Figure 28. From Figure 28, each student reflected an improvement in the post-test.

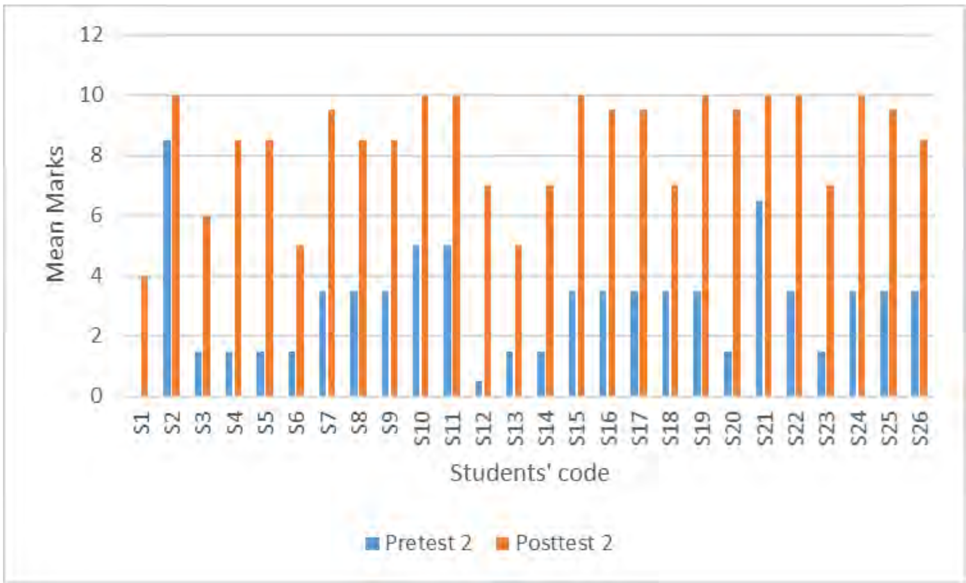


Figure 28: Multiple bar charts comparing students' performance in pre-test and post-test 2

The paired samples test in Table 53, recorded a high negative t-value of -18.749 a p-value of 0.00 showed that there was significant difference ($p<0.05$) between the achievement scores in the pre-test and post-test 2.

Table 53: Paired samples test of students' performance in pre-test and post-test 2

Pair	Mean difference	Std. deviation	t	df	Sig. (2-tailed)
Pre-test 2- post-test 2	-5.3269	1.4487	-18.749	25	0.000

Students' in groups of four and five (6 groups in total) presented their views on environmental sustainability based on Blacksmithing.

Group 1: ‘Blacksmithing helps to manage waste in the environment’.

Group 2: ‘Promotes recycling of metals and helps save energy’

Group 3: ‘Recycling metals prevents more mining and protects the environment’

Group 4: ‘Promotes resource management and protect natural habitats’

Group 5: ‘Maximises the use of already mined metals’

Group 6: ‘Metals left in the environment occupy space and pollute it’.

The ‘integrated indigenous knowledge-chemistry lesson’ 3 was the concept of distillation using the indigenous knowledge in ‘akpeteshie’ (local gin) distillation was taught and post-tests conducted. Performances of students in the pre-tests and post-tests were analysed and results presented. Figure 29 is a graphical representation mean marks compared to the number of students in pre-test 3. Figure 29 revealed that 2, 6, 7, 3, 8 and 1 students scored 0, 1, 2, 3, 4 and 6 respectively as mean marks in pre-test 3. This meant that, from a total mean mark of 10, 96% and 4% of the students performed below and above average respectively.

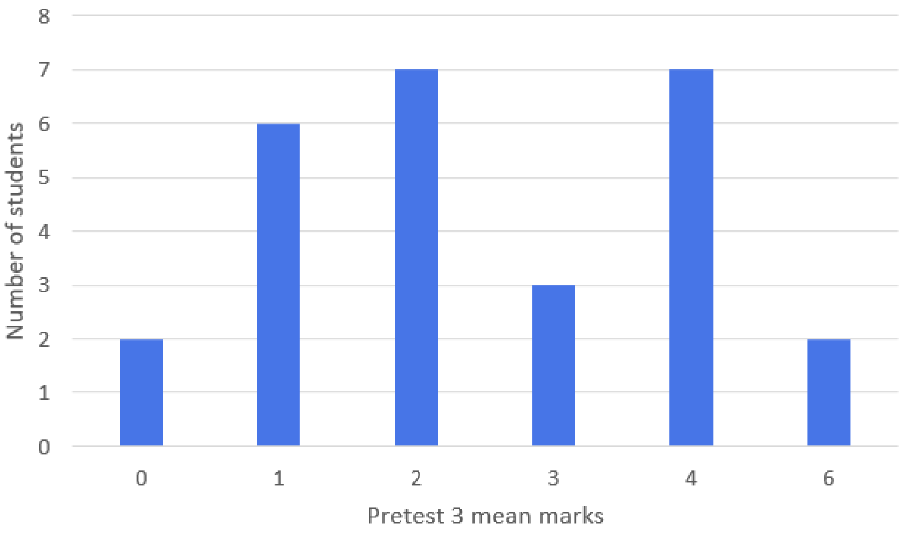


Figure 29: Bar chart showing students’ performance in pre-test 3

The analysis presented in Figure 30 showed that 1, 3, 5, 6, 5 and 6 students scored 5, 6, 7, 8, 9 and 10 respectively out of a total mean mark of 10 in the post-test. This meant that all the students (96%) except 1 (4%) scored marks above the average. Figure 30 presented the performance of students in post-test 3.

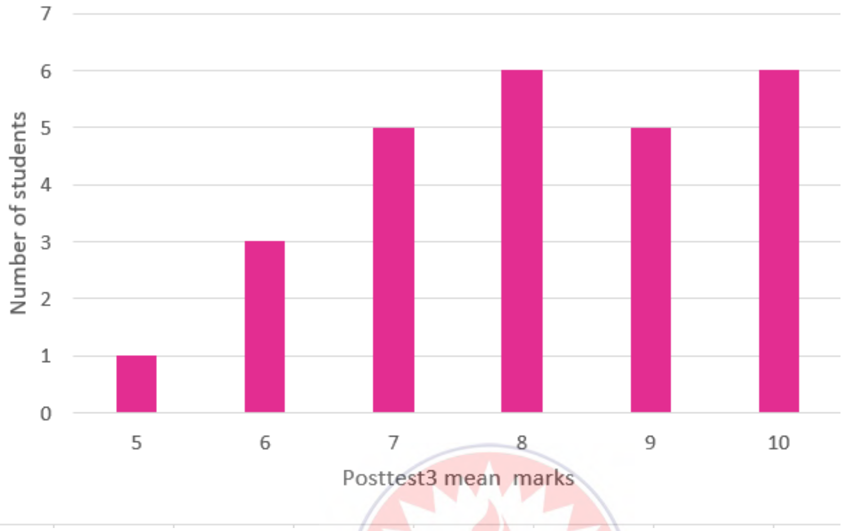


Figure 30: Bar charts showing students' performance in post-test 3

The improvement in the performance of the students in the post-test 3 is evident in the answers provided by some of the students' questions on distillation. Question 1. What is distillation? 2. Describe the process of distillation using local production as an example.

S19 (pre-test answer): 'Distillation is the process of separating two liquids using heat'

S19 (post-test answer): 'Distillation is the process of separation of two liquids of different boiling points. The difference in boiling points must be large enough, example a mixture of water and alcohol, water has a boiling point of 100ºC whereas alcohol has a boiling point of 78ºC. The alcohol will boil before the water and so the vapour of the alcohol can be collected and cooled and it will condense into liquid'

S21 (pre-test answer to question 2): ‘In distillation, the liquid is heated and the vapour is cooled and collected’.

S21 (post-test answer to question 2): ‘Materials needed include: Palm wine, petroleum drum, copper tube water and source of heat’.

‘Local gin called ‘akpeteshie’ is prepared mostly from palm wine using the process of distillation. The palm wine is fermented for about one week. The fermented palm wine is a mixture of alcohol and water. It is then poured into a metal drum connected with a copper tube. The tube is passed through water. Heat is applied to bring the fermented palm wine to boil. The vapour passes through the copper tube and is cooled in the water. The condensed liquid called the distillate is collected. The distillate is the alcohol and the water remains in the petroleum drum.’

The performance of the students improved significantly as they were able to explain the concept of distillation and described stepwise the production of alcohol which undoubtedly was due to the indigenous knowledge from their environment and the visuals of the production process shown to them during the lesson.

Figure 31 illustrated the progress made by each individual student when pre-test post-test 3 were compared.

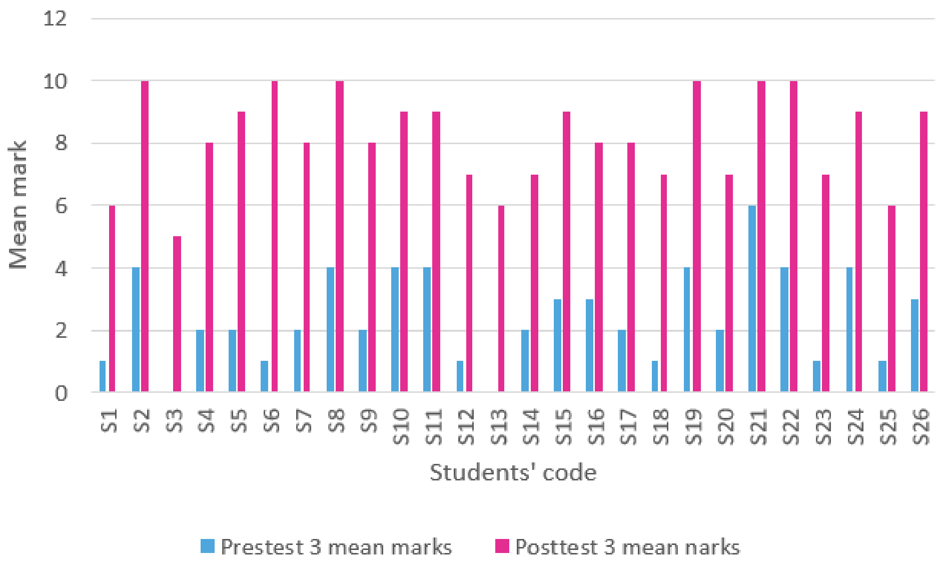


Figure 31: Multiple bar charts showing students' performance in pre-test and post-test 3

The paired samples test analysis in Table54, recorded a mean difference of -5.653 between the pre-test and post-test at significance of 0.00 which implied that there was significant difference between the mean achievement scores in the pre-test and post-test 3.

Table 54: Paired sample test for students' performance in pre-test and post-test 3

Pair	Mean difference	Std. deviation	t	df	Sig. (2-tailed)
Pre-test 3- post-test 3	-5.653	1.809	-15.929	25	0.000

4.5 Research Questions 5

Research question 5: What is the effect of gender on the 'IIK-CLs'?

Since boys and girls learn differently, the study sought to determine the effect of the gender on 'IIK-CLs'. The post-test performance of males and females in the three chemistry concepts taught by the researcher were compared. The performance in the first chemistry concept was compared and the result presented in Figure 32.

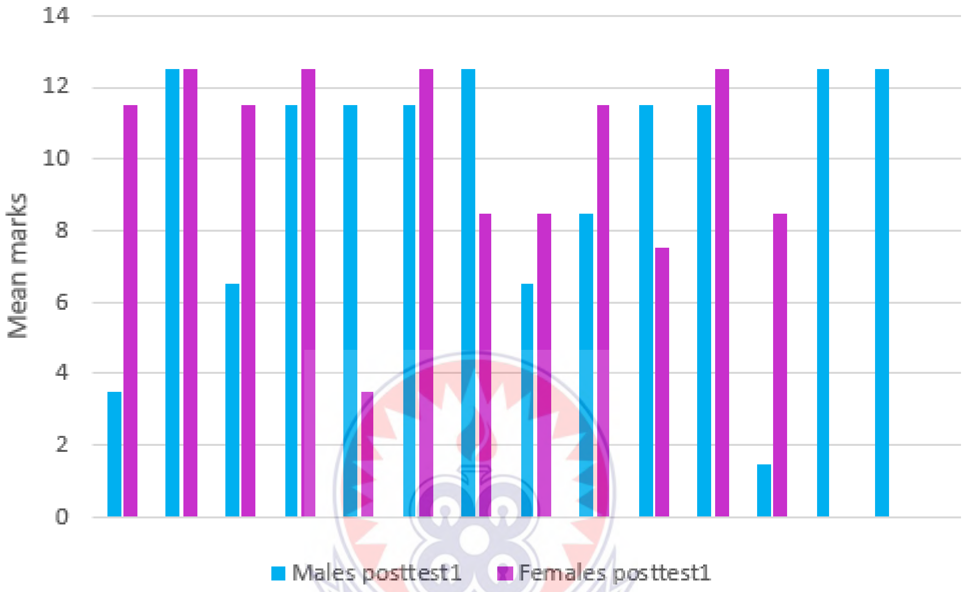


Figure 32: Multiple bar charts comparing the performances of females and males in the post-test 1.

Table 55 presented the independent samples analysis of males and females performances in the post-test1 to determine the significance. The analysis recorded a significant figure of 0.697 which indicated that there was no significant difference ($p>0.05$) in the learning outcome of male and female students in post-test1. It was therefore concluded that the 'IIK-CL' on the factors affecting chemical reactions impacted positively on both male and female students.

Table 55: independent samples test for males and females post-test 1 scores

Post-test 1 pair	Mean difference	df	t	Sig. (2-tailed)	Equal variances assumed. Sig.
Males/ females	-51190	24	-0.394	0.697	0.277

$p > 0.05$

Source: field data

The performance of male and female students in the second chemistry concept taught was compared using the independent samples test (Table 56). The comparison assumed an equal variance of 0.277 which implied that the mean scores of both male and female students can be said to be equal. The test further in recorded a significant figure of 0.445 which implied that there was no significant difference ($p>0.05$) in the true average performance of males and females in post-test 2. The comparison confirmed that the 'IIK-CL on properties of metals and liquids, favoured both genders.

Table 56: Independent samples test of males and females in post-test 2

Post-test 2 pair	Mean difference	df	t	Sig. (2-tailed)	Equal variances assumed. Sig.
Males/ females	0.559	24	0.776	0.445	0.196

$p > 0.05$

Source: Field data

The performance of males as well as females improved in the post-test 3 as depicted by a p-value of 0.783 recorded by the paired sample test analysis in Table 57 when the performance of males was compared to the females. The mean score of both males and females also assumed equal variance of 0.559 which implied that both mean score could be said to be the same.

Table 57: Independent samples test for males and females in post-test 3

Post-test 3 pair	Mean difference	df	t	Sig. (2-tailed)	Equal variances assumed. Sig.
Males/ females	-0.167	24	-0.278	0.783	0.559

P< 0.05 Source: Field data

The analysis of results presented to enable the researcher answer the research questions revealed interesting findings worthy of discussing. Indigenous Knowledge practices, Howden (2001) explained, are better understood as practical, personal and contextual units which cannot be detached from the individual, the community and the environment (both physical and spiritual). Again, indigenous knowledge practices constitute the core of community development processes such as; agriculture, indigenous technologies, preparation and preservation of food, the collection, storage and purification of water, and ethnic veterinary medicine (Ankrah et al., 2021; Chikaire et al. 2012; Son et al., 2021; Tuner, 2014; Zidny & Eilks 2020).

Indeed, researchers have argued that, the problems currently confronting Africans can be resolved by initially understanding the dynamics within the local context (Angioni, 2003; Ankrah et al., 2021; Chikaire et al., 2012; Dei, 2002; Son et al., 2021; Tuner, 2014; Zidny & Eilks 2020) which include the integration of indigenous knowledge practices in to the teaching and learning process. Applicable to chemistry education is the adoption of an indigenous approach to the teaching and learning of the subject to help students relate chemistry to their environment and to give them practical evidence of the existence of the subject. Against this background, and to answer research question 1, a questionnaire was designed and used to collect relevant indigenous knowledge practices, using an ethnographic case study of indigenous experts in the students' environment, for the purpose of integrating these indigenous knowledge (IK) practices into the teaching of the concepts. The study successfully collected IK practices including palm oil, coconut and palm kernel oil production, cassava dough, cassava flour, gari production, akpeteshie distillation, local drinks (asaana and pito) brewing, blacksmithing, local soap preparation, kenkey preparation, food preparation and preservation, farming, pottery, bead making, and batik tie and dye. In addition, other customary practices such as marriage, naming ceremonies, festivals and funerals were assessed. Others included the use of proverbs, wise sayings, folklore, folktales, superstitions and everyday practices. All these IK practices were discovered to have significant relevance to the teaching of science, specifically chemistry.

The study also involved chemistry teachers to investigate their knowledge and use of indigenous knowledge practices during the teaching and learning process to enable research question 2 to be answered, and to assist in the categorisation of the various IK practices under appropriate scientific concepts. Teachers attested to the importance of integrating indigenous knowledge into the teaching and learning of chemistry which included making the lesson interesting and encourages students' participation and its ability to improve students learning outcome Angioni, 2003; Chikaire et al. 2012; Dei, 2002; Hewson, 2013; Zidny & Eilks 2020) as evidenced in Table 45. However, the study revealed that the chemistry teachers have limited knowledge of the applicability of most IK practices to various chemistry concepts. Having considered the strategies involved in integrating IK into western knowledge (Aikenhead 2001; Antoine et al., 2018; Battiste, 2005; Hewson & Ogunniyi, 2011; Lee, Yen & Aikenhead, 2011; Zidny & Eilks, 2020) and with the constructivists perspective of learning and structuring learning (Bruner 2009; Vygotsky 1986) the study strategically and thoughtfully designed integrated indigenous knowledge-chemistry lessons with the data collected from the indigenous knowledge experts and the chemistry teachers. The main teaching strategies (Eilks & Leerhoof, 2001; Feierabend & Eilks 2011; 1994; Lyman, 1981) adopted were based on the principles of students' engagement (Fredricks, et al., 2004) which focused at giving students the opportunity to construct their own understanding and knowledge of the chemistry concepts.

The aim of research questions 3 was to assess the level of students' engagement in integrated indigenous knowledge-chemistry lessons (IIK-CLs). The study employed the use of the context of cassava dough production in the teaching of factors affecting a chemical reaction. Students' engagement in terms of behavioural, emotional and cognitive was assessed. Data collection was carried out, using students' responses to statements on students' engagement assessment sheet (Appendix F).

The behavioural assessment of the students was analysed based on a suggestion by Fredricks et al., (2004) who stated that behavioural engagement refers to the students' participation and involvement in school activities, academic, social or extracurricular. The participation of the students in the IIK-CL lesson was assessed based on students' response to whether the instructions were easy to follow and whether they clearly understood what was expected from them during the lesson. Though analysis of the results revealed a slightly different trend in students' response to statements 1 and 2 on the students' assessment sheet as indicated in Table 50, the IIK-CL recorded a high total behavioural achievement. According to Fredricks et al., (2004), participation, effort, time on task may indicate the strongest engagement as students really take part in schooling by displaying such active behaviours. The level of students' behavioural engagement achieved by the IIK-CL is an indication that lessons of this nature are capable of not just keeping students in school but enabling them to be active participants in lessons to achieve sustainable development and chemical literacy for all (UNESCO, 2021).

Furthermore, the emotional engagement of the students in the lesson was very visible hence, to have a proof of this, students were to respond to whether the lesson was meaningful to them, whether they enjoyed the lesson and whether they would like more lessons to be taught using the same strategy. While the analysis of responses to statement 3 revealed individual differences among the students in relation to the meaningfulness of the lesson, statement 4 revealed a unanimous decision among students. Of the three types of engagements assessed, emotional engagement recorded the highest percentage. The expression of joy and relevance of the lesson to the students was evident in their response to why they enjoyed the lesson. The students' responses showed the importance of, and the social connection in the lesson. They further noted that understanding was constructed by themselves, and hence the concept could not be forgotten and could be applied in relevant situations. According to Beale (2018), emotional engagement can be a highly advantageous educational tool but getting students emotionally engaged in lessons is sometimes difficult, given the abstract nature of some subject matter. The 'IIK-CL' has proved otherwise since it demystified the concept and resulted in stimulating students to be emotionally engaged in the lesson thereby constructing their understanding.

Finally, the impact of the IIK-CL on cognitive engagement of the students in the lesson was assessed. Cognitive engagement according to Li et al., (2020) is a matter of students' will, that is, how students feel about themselves and their work, their skills, and the strategies they employ to master their work. Education for sustainability (Breiting, Mayer & Mogensen, 2005; Burmeister & Eilks 2012; Burmeister, et al., 2012; UNESCO, 2021) and the quest for chemical literacy (Holman & Hunt, 2002) for all, demand that the effective teaching of any chemistry concept should be reflected in the students' life not only in terms of understanding but also as the ability to apply the concept learnt in relevant situations. The cognitive assessment therefore inquired students' understanding of the concept and whether they feel they can apply the concept learnt.

The analysis of responses on cognitive engagement revealed that the IIK-CL engaged a majority of the students in the lesson. Based on the students' responses, almost all (92%) of the students could be considered cognitively engaged, and hence be able to apply the concept learnt in relevant situations. The lesson plan, therefore achieved its purpose in fulfilling its' target. Indeed, it could be deduced that the emotional and behavioural engagement that created joy and the sense of belonging contributed to the students' cognitive engagement. The relationship between behavioural and emotional to cognitive engagement was also buttressed by Li and Lerner (2013) and Skinner et al. (2008) who noted that, the former two types of engagements correlates positively with the later.

To actually determine if students have achieved cognition of the concepts taught, the interrupted time series design (Cohen et al., 2018; Hudson et al., 2019) was used to assess the impact of the IIK-CL on students' academic achievement in chemistry to answer research questions 4 and 5.

Three chemistry concepts, factors affecting chemical reaction, properties of solids (metals and liquids) and distillation were taught using the indigenous knowledge practices involved in cassava dough production, blacksmithing and akpeteshie (local gin distillation respectively. The analysis of results of all the pre-tests and post-test conducted on the three chemistry concepts taught revealed significant improvements in students' performance in the post-test which was evidenced in all the paired sample test analyses in Tables 51, 55 and 57.

Again there were no gender differences in the performance of the students since both male and female students perform equally well. The null hypothesis hence failed to be rejected since the p-values recorded for independent samples test analysis in Tables 52, 56 and 58 were all greater than 0.05.

As discussed in the literature review, chemistry teaching strategies should offer students the opportunity to appreciate the impact of chemistry and chemistry-based technologies on society (Barnea & Dori, 2000; Dori & Sasson, 2008). The integration of relevant IK practices into the teaching of the chemistry concepts revealed the relevance of the concepts to the daily needs of the students. Students therefore expressed their excitement during the learning process which was evident in their answers provided during the response to questionnaire on engagement. Chemistry lessons taught by the integration of indigenous knowledge practices is therefore an antidote to the lack of interest in learning science as argued by Fredricks et al. (2019) that engagement of students behaviourally, emotionally and cognitively in the learning process increases their interest (Adesoji & Ogunniyi, 2012; Ameyaw & Amankwah, 2014) as such behaviours such as absenteeism and school drop-out will be minimised.

Furthermore, integrating indigenous knowledge practices into the teaching and learning of science, specifically chemistry (Zidny & Eilks, 2020 is the way forward in improving students' performance and promoting sustainable education (UNESCO, 2021). The 'IIK-CLs created opportunities for the individual student to construct knowledge and understanding (Bruner, 2009; Vygotsky, 1978) of the chemistry concepts learnt. Students were therefore able to apply the concepts in answering questions involving application. Learning chemistry this way promoted chemical literacy for all the students including those who would take careers in chemistry and its related fields. This mode of learning is also vital for those students who need the knowledge and understanding in chemistry to contribute to societal debates effectively, and be able to make the right decisions on their daily choices (Eilks & Hofstein 2013). Students can therefore apply concepts learnt in the classroom to relevant everyday life situations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents a summary of the major findings made in this study. The findings were based on the specific objectives and the research questions stated in chapter one of the study. Also included in this chapter are the conclusions and the recommendations made based on the major findings of the study.

5.1 Summary of the Study

The purpose of the study was to design chemistry lessons in the context of IK practices to engage students in constructing knowledge and understanding of selected chemistry concepts

. The focus of the research was structured into three phases. Phase 1 was based on an ethnographic case study of indigenous people in the Agona municipality for the collection of data on indigenous knowledge practices. Experts in various fields of IK practices were identified and a designed semi-structured interview schedule was used for the data collection. The Indigenous Knowledge experts were mostly to mention the Indigenous Knowledge (IK) of practices, describe the method involved and the benefit derived in its practice. This lead to the collection of various IK in palm oil, coconut and palm kernel oil production, cassava dough, cassava flour, gari production, akpeteshie distillation, local drinks (asaana and pito) brewing, blacksmithing, local soap preparation, food preparation and preservation, farming, pottery, bead making, and batik tie and dye, marriage, naming ceremonies, festivals. funerals, proverbs, wise sayings, folklore, folktales, superstitions and everyday practices

Phase 2 focused on the categorisation of the IK practices collected under selected chemistry concepts which led to the development of 'integrated indigenous knowledge-chemistry lessons'. The chemistry teachers were asked to complete a questionnaire to enable survey of the use of IK practices by teachers in their daily teaching, investigate students' interest in chemistry lessons integrated with IK practices and to seek their view on chemistry concepts that could be taught using suggested IK practices. 'Integrated indigenous knowledge-chemistry lessons were designed using the information provided by the teachers and the strategies for integration of indigenous knowledge into classroom teaching suggested in literature review.

Phase 3 addressed the use of the 'IIK-CLs to evaluate its effect on students' engagement and academic achievement. The Fredricks article on engagement was used as a guide in assessing students' engagement in the lessons which revealed that the 'IIK-CLs were effective in engaging students in the learning of chemistry. The interrupted time series (ITS) design was used to collect quantitative data from pre-test and post-test results to determine the impact of the 'IIK-CLs on the learning achievement of students. The analysis of the results showed that the integration of indigenous knowledge practices into the teaching of chemistry concepts through the use of 'IIK-CLs proved effective in improving the performance of the students in chemistry.

The research questions that guided the study are discussed below.

5.1.1 Research Question 1:

1. Which IK practices are known and practised in the Agona East and West municipalities?

The Agona Municipality is equipped with a rich culture and enormous indigenous knowledge practices which were common to all the localities. These included palm oil, coconut and palm kernel oil production, cassava dough production, cassava flour, gari production, akpeteshie distillation, local drinks (asaana and pito) brewing, blacksmithing, local soap preparation, food preparation and preservation, farming, pottery, bead making, and batik tie and dye. In addition, other customary practices such as marriage, naming ceremonies, festivals and funerals were assessed. others included the use of proverbs, wise sayings, folklore, folktales, superstitions and everyday practices.

Various chemistry concepts taught in Senior High School (SHS) such as factors affecting rate of chemical reaction, periodic properties, separation and purification of organic substances and many more (Appendix J) were found to have a direct or indirect link with the indigenous knowledge practices discovered. The IK practices collected and the views of the teachers used in the study guided the researcher in the categorisation of some chemistry concepts under the appropriate IK practice Tables 47, 48 and 49) Besides, the obvious IK practices such as akpeteshie distillation, local drinks (asaana and pito) brewing blacksmithing, local soap preparation, food preparation and preservation, IK practices in everyday practices, cassava dough production, palm oil production and marriage also proved to be beneficial when integrated into the teaching of chemistry. The integrated indigenous knowledge chemistry manual presented the various chemistry concepts with their respective IK.

5.1.2 Research question 2: What IK practices are used by teachers in teaching and learning chemistry?

The study revealed that most chemistry teachers integrated IK practices into the teaching of chemistry concepts. They stated the benefits of its use as arousing the interest of learners, and increasing learners’ participation in lessons. It was however revealed that most of the chemistry teachers have limited knowledge on IK practices that could be used in teaching and learning chemistry concepts.

5.1.3 Research Question 3,

3. What is the level of students' behavioural, emotional and cognitive engagement in 'IIK-CLs'?

The findings from the study revealed that the strategically planned integrated indigenous knowledge-chemistry lessons encouraged students' engagement behaviourally, emotionally and cognitively. The lessons ensured the systematic delivery of complete and accurate information based on the concepts hence developing students' positive attitudes towards learning. The lessons incorporated numerous activities that were relevant to the concept being learnt. Students interacted and shared knowledge with their peers and experts from the community. The IIK-CLs also catered for the development of scientific skills and talents such as speaking, writing, observing and creativity. The relevance of the activities to the students' everyday life encouraged their participation in the lesson. The contexts indigenous knowledge used were appropriate for the concepts since the lessons were successful in realising significant behavioural emotional and cognitive engagement of the students.

5.1. 4 Research Question 4

4. What is the impact of the IIK-CLs on students' learning outcome?

The integration of indigenous knowledge practices into the teaching of the selected chemistry concepts resulted in the improvement in the learning outcome of the students. Students offered better answers and explanations to concepts in the post-test compared to the pre-test. Students' answers reflected their cognition of the concepts learnt. Every individual student had better scores in the post-test than the pre-test. The paired samples tests recorded p-values of 0.00 when students' pre-test scores were compared to the and post-test in all three chemistry concepts taught.

5.1.5 Research Question 5

5. What is the effect of gender on 'IIK-CLs'?

The performances of both male and female students improved in the post-test after the intervention. The independent sample test analysis for the pre-test and post-test of males as well as females recorded the p-values 0.697, 0.445 and 0.786 in the three chemistry concepts that the researcher taught. These were all greater than of 0.05 (p.0.05) and implied that the 'IIK-CLs impacted similar positive effect on the performance of both gender.

The null hypothesis, which states that there is statistical significant difference in the mean achievement scores of male and female students taught using 'integrated indigenous knowledge-chemistry lessons, was therefore rejected.

5.2 Conclusions

Indigenous knowledge practices are indeed of utmost value to the teaching and learning of chemistry concepts if they are appropriately integrated into the teaching and learning process. Strategically planned ‘integrated indigenous knowledge-chemistry lessons encourage students’ engagement in the learning process. Relevant and context appropriate indigenous knowledge practices reveal the relevance, practicality and applicability of concepts to the everyday need of the students which ensures students participation in chemistry lessons. Indeed, students’ involvement in the appropriate activities during the teaching and learning process has a high potential of increasing students’ engagement which enables them to construct understanding of concepts and their subsequent application in relevant situations.

Integrated indigenous knowledge-chemistry lessons focus on the individual student including those who would like to pursue careers in chemistry and related fields and those who would divert to other field but need the understanding and application of concepts in chemistry to engage in societal debates and make the right decision in their everyday choices. The result is the production of holistic graduates who will not only learn by rote to gain admission to higher institutions but with real cognition of concepts. Chemistry should therefore adopt the ‘IIK-CL’ approach in planning their lessons to promote students’ engagement and consequent improvement in their learning outcome.

The benefits of integrating IK into the teaching of chemistry can be summarised as, demystifies chemistry concepts, increases students’ participation in lessons, creates connectivity between the home or environment and the school, helps students to apply scientific knowledge to indigenous practices, improves performance of students, facilitates school-community relationships and results in national development.

5.3 Recommendations

- Indigenous Knowledge practices should be integrated into the teaching and learning of chemistry in Swedru SHS

- The use of IK experts as resource persons in the teaching and learning of chemistry should be encouraged.
- Chemistry teachers in Swedru SHS, Nyarkrom SHS, Nsaba SHS and Kwanyako SHTS should be encouraged to survey more IK practices for teaching and learning chemistry

5.3.1 Suggestions for Further Research

- Collection of relevant Indigenous knowledge practices should be carried out in other parts of the country to increase the number of concepts that can be taught using IK practices.
- The study should be replicated in other areas to determine the impact of 'integrated IK-Chemistry' lessons on students' performance.
- Parents should be educated on the need to teach their wards, the indigenous Knowledge practices they are involved with, as the home and community environment play significant roles to student success in learning and developing a positive attitude towards science, specifically chemistry.
- Parents should be advised not to be discriminative in terms of IK acquisition
- A culturally responsive science curriculum should be developed with community leaders, teachers, curriculum developers, colleges of education, universities and civic organisations,
- Textbooks for the teaching of chemistry should be designed to be indigenous learner friendly.
- Teachers and teacher educators should be trained and equipped to design and implement IK chemistry teaching strategies.

- Research in the area of Indigenous Knowledge should be encouraged by the provision of funding.

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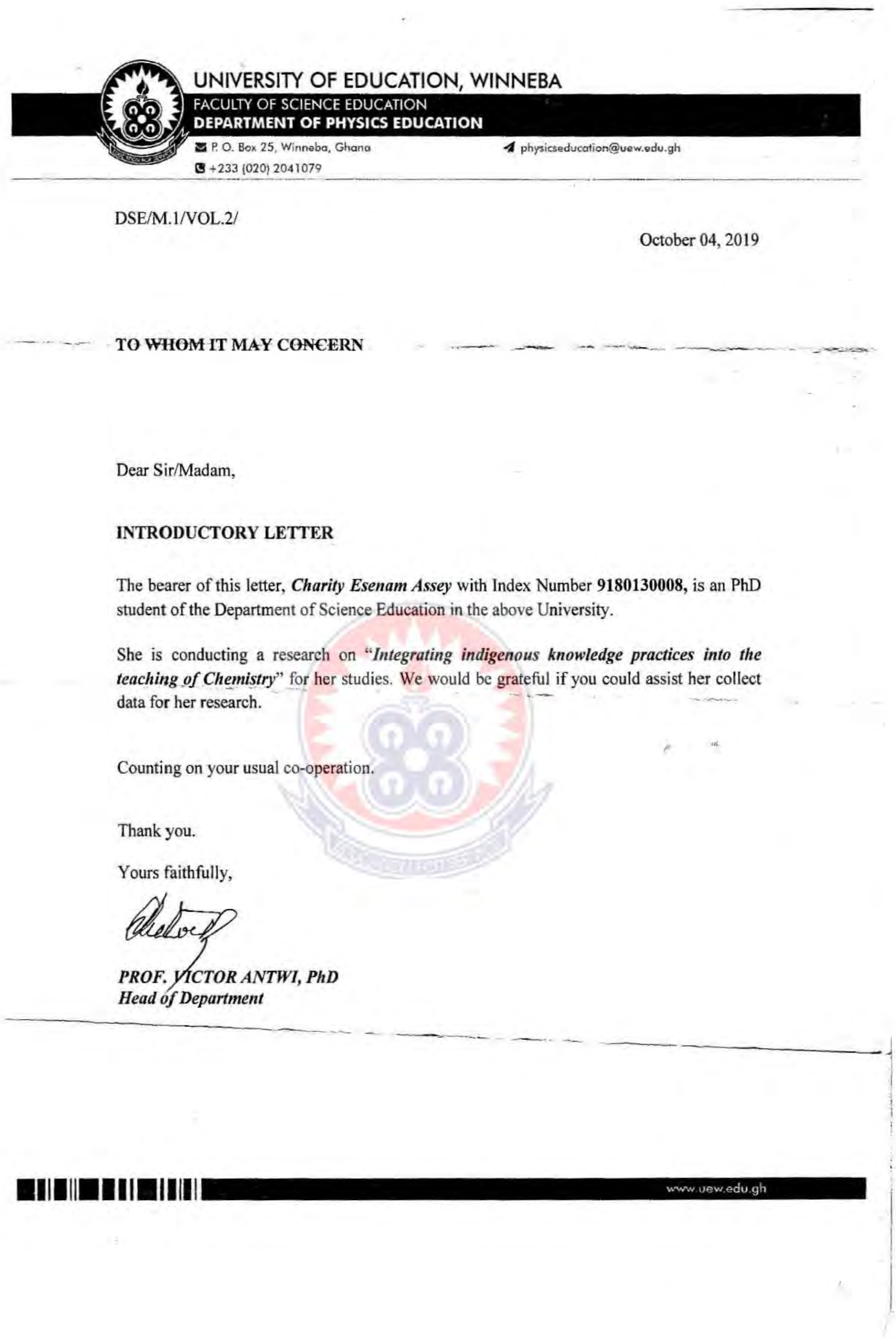
APPENDICES

APPENDIX A

Ethical Permission from the University of Education, Winneba



UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
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P. O. Box 25, Winneba, Ghana
+233 (020) 2041079
physicseducation@uew.edu.gh

DSE/M.1/VOL.2/

October 04, 2019

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER

The bearer of this letter, ***Charity Esenam Assey*** with Index Number **9180130008,** is an PhD student of the Department of Science Education in the above University.

She is conducting a research on "***Integrating indigenous knowledge practices into the teaching of Chemistry***" for her studies. We would be grateful if you could assist her collect data for her research.

Counting on your usual co-operation.

Thank you.

Yours faithfully,

PROF. VICTOR ANTWI, PhD
Head of Department

www.uew.edu.gh

APPENDIX B

Letter to seek the Consent of Indigenous Knowledge People

University of Education, Winneba
Faculty of Science Education
Department of Science Education
P. O Box 25
Winneba.

21/10/2019

Dear IK Practitioner

Letter for consent

You are kindly invited to participate in a research project on the topic 'Integrating indigenous knowledge practices into the teaching of chemistry concepts'. The study is aimed at categorising of indigenous knowledge practices under appropriate Chemistry concepts to design an integrated 'Integrated Scientific Knowledge-Chemistry teaching manual'. The manual will be used to teach the selected concepts to evaluate its effect on students' performance in Chemistry. The importance of this study is to demystify and de-abstract Chemistry concepts and make students realise the relevance of the practices in their environment to the learning of Chemistry.

You will be given a questionnaire to answer mainly on IK practices in your locality and those practices you are involved in. I will be available during this period to explain any aspect that bothers you.

Please note that participation in this study is completely voluntary. Your confidentiality and anonymity is guaranteed as the researcher will ensure that all the ethical standards required for conducting a study of this nature, as set by the University of Education, Winneba, are adhered to. You will be assigned codes which will be used whenever reference is made to you, so that your true identity will not be revealed. Your name, address, and place, will not be revealed in the study report.

kindly register your consent by filling the portion below:

Agreement:

I, by this signature……………………………………and on this date…, having considered your research topic and purpose, voluntarily agree to participate in the research.

Video Recording

The researcher may take pictures or video record you and some processes when necessary and therefore requires your permission to do this. The video-recording will only be used for purposes of the research project.

Agreement

I, by this signature…………………… and on this date……………agree to video-recording.

Your cooperation is very much appreciated.

Yours sincerely,

……………………………

(Charity Esenam Assey)

(Researcher

APPENDIX C

Letter to Seek the Consent of Chemistry Teachers

University of Education, Winneba
Faculty of Science Education
Department of Science Education
P. O Box 25
Winneba.

21/10/2019.

Dear Chemistry Teacher,

Letter for consent

You are kindly invited to participate in a research project on the topic, 'Integrating Indigenous Knowledge (IK) practices into the teaching of Chemistry concepts'. The study is aimed at the categorisation of indigenous knowledge practices under appropriate chemistry concepts, to design an integrated 'Indigenous Knowledge (IK)-Chemistry teaching manual.

The manual will be used to teach the selected concepts and further evaluate its impact on students' performance in chemistry. The basis of this study is for students and teachers to realise the unconscious utilisation of chemistry concepts in indigenous practices. This realisation is expected to concretise and demystify chemistry concepts and further motivate students to learn chemistry.

Please note that participation in this study is completely voluntary. Your confidentiality and anonymity are also guaranteed. Kindly consent by signing and completing the agreement portion below:

I, with this signature……………………and on this date…………., having considered your research topic and purpose, voluntarily agree to participate in the research.

Your cooperation is very much appreciated.

Yours sincerely,

………………

(Charity Esenam Assey)

(Researcher)

APPENDIX D

Questionnaire for Indigenous People

1. Which IK practices are present in your locality? (Industrial, Agricultural and Cultural practices)

……

……

……

……

………………………………………………

2. Which of the IK practices mentioned do you often utilise?

……

……

……

3. How long have you been involved in this practice?

a. 5-10years b. Above 10years

4 What are the processes involved in the utilisation of the IK practices mentioned?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

5. What are some of the benefits derived from those IK practice?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

6. Are you aware of any other IK practices that use similar procedures?

Yes☐. No ☐

7. If ‘Yes’, mention the IK practice(s)

……………………………………………………………………………………

……………………………………………………………………………………

…………Do you think your IK practice have any link with classroom science?

8. Strongly Disagree ☐ 2. Disagree ☐ 3. Agree ☐ 4. Strongly agree ☐

9. Will the integration of IK practice into the teaching of science have a positive effect on the teaching and learning of science?

Yes☐. No ☐

PERSONAL DETAILS

10. How old are you?

(I) 20-30 (ii) 31-40 years (iii) 41-50years (iv) 51-60years (v) 61and above

11. Sex? Male ☐ Female ☐

12. Name of locality……………………………………………………………

APPENDIX E

Questionnaire for Chemistry Teachers

1a. Do you relate concepts in chemistry to IK practices during Chemistry lessons?

Yes☐. No ☐

1b. If yes, how often?

1.Never ☐ 2.Rarely ☐ Sometimes ☐ 4. Most times ☐ 5. Always ☐

1c. What is the extent of the students' familiarity with these IK practices?

1.Never ☐ 2.Rarely ☐ Sometimes ☐ 4. Most times ☐ 5. Always ☐

1d. Give at least five examples of some of these chemistry concepts and the IK practices that were used

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………

1e. Do students show interest in lessons involving IK practices?

1f. To what extent do students show interest?

1. Never☐ 2. Rarely ☐ 3. Sometimes ☐ 4. Most times ☐ 5. Always ☐

PART II

2. Consider the processes involved in the IK practices listed below and provide answers to the following questions:

Cassava dough and Gari processing	farming	Blacksmithing
Food preparation and preservation	Distillation of Akpeteshie (local gin)	Palm oil production
Parenting in the typical Ghanaian indigenous setting (with regards to: parental care and responsibilities)	Indigenous remedies for cleaning, stain and odour removal, and treatment of simple ailments	Soap production (local soap),

2a. Complete the table by suggesting the chemistry concepts that the IK practices listed can be used to teach.

.IK PRACTICE	CHEMISTRY CONCEPT
Cassava dough processing	
Gari processing,	
Farming	
Palm oil production	
Food preparation and preservation	

Indigenous remedies used in the removal of stain on buckets and saucepans (Cleaning)	
Medication (treatment ailment such as stomach ache)	
Distillation of Akpeteshie (local gin)	
Marriage and Structure of the family	
Blacksmithing	
Brewing of Beverages	

2b. Are all the IK practices listed above useful for the teaching of chemistry?

1. Strongly Disagree ☐ 2.Disagree ☐ 3. Agree ☐ 4. Strongly agree ☐

2c. Can a teaching manual be developed using the categorisation done above?

1. Strongly Disagree ☐ 2. Disagree ☐ 3. Agree ☐ 4. Strongly agree ☐

2d. Will the teaching manual have a positive impact on the teaching of chemistry?

Yes ☐ No ☐

2e. If 'Yes' in 2d, to what extent

1. Strongly Disagree ☐ 2. Disagree ☐ 3. Agree ☐ 4. Strongly agree ☐

PERSONAL DETAILS

3. How old are you?

(i) 21-30 years (ii) 31-40years (iii) 41-50years (iv) 51-60years

4. Sex Male ☐ Female ☐

5. School code…………………….

6. Are you a professional science teacher? YES ☐ NO ☐

7. How many years of teaching experience do you have?

(i) 5-10 (ii) 11-16 (iii) 17-22 (iv) 23 and above

8. What is your highest qualification? Bachelors ☐ Masters ☐ PhD ☐ Other ☐

APPENDIX F

Students' engagement assessment sheet

The following statements are to assess the level of students' engagement in 'integrated indigenous knowledge-chemistry lesson involving cassava dough production. There are five statements in all. Please read the statements and choose the option that best suits you. Your anonymity is assured. Please do not provide your name or any form of identification on the sheet. All sheets should be deposited in my pinhole after completion

1. It was easy to follow the instructions during the lesson.

☐ strongly disagree ☐ disagree ☐ slightly disagree ☐ slightly agree ☐ agree ☐ strongly agree

2. I understood what was expected from me during the lesson

☐ strongly disagree ☐ disagree ☐ slightly disagree ☐ slightly agree ☐ agree ☐ strongly agree

3. The lesson felt meaningful for me

☐ strongly disagree ☐ disagree ☐ slightly disagree ☐ slightly agre ☐ agre ☐ strongly agree

4a. I enjoyed the lesson.

☐ strongly disagree ☐ disagree ☐ slightly disagre ☐ slightly agre ☐ agre ☐ strongly agree

4b. why? ……………………… ……………………………………………………………

5. I want more of such lessons.

☐ strongly disagree ☐ disagree ☐ slightly disagre ☐ slightly agre ☐ agre ☐ strongly agree

6. I understand the concept learnt

☐ strongly disagree ☐ disagree ☐ slightly disagree ☐ slightly agree ☐ agree ☐ strongly agree

7. I am able to apply the concept learnt in relevant situations

☐ strongly disagree ☐ disagree ☐ slightly disagree ☐ slightly agree ☐ agree ☐ strongly agree

APPENDIX G

ENGAGEMENT OBSERVATIONAL SCHEDULE

S/N	Statement	SD	D	SLD	SLA	A	SA
1	Pays attention to task						
2	Follows instructions						
3	Expresses excitement during the task						
4	Shows eagerness to learn						
5	Contributes during group discussions						
6	Links contributions to observed IK						
7	Explains concepts with ease						

SD- strongly disagree, **D**- disagree, **SLD**- slightly disagree, **SLA**- slightly agree, **A**- agree, **SA**- strongly agree

APPENDIX H

Questions for Students Assessment

Questions on Rates of Chemical Reactions

1. Briefly explain the effect of the following on reaction rates
   - i. Surface area
   - ii. Pressure
   - iii. Temperature
   - iv. Catalyst
2. Define Rate of reaction
3. Draw and label an energy profile diagram for an endothermic reaction. Indicate on the same diagram the effect a catalyst would have on the path of the reaction.

Assessment questions on the Properties of Metals and Liquids

1. Describe the blacksmithing process and explain how metals behave when heated.

2. Discuss the importance of blacksmithing in protecting the environment (focus on recycling).

Individual

SET A: 1. State three (3) physical properties of metals.

2. Explain the three (3) properties stated above.

3. Briefly describe what happens when a metal is heated.

4. What property of liquids is applied by the blacksmith in producing metal pots?

SET B: 1. Explain how you can help a friend open a very tightly closed glass bottle with a metal lid.

2. Explain the principle adopted.

3. Why is so much heat needed to melt a metal.

4. Write down five uses of metals

5. State three properties of liquids

Questions on Distillation

1. What is distillation?

2. State the principles governing the process of distillation

3. Describe the distillation set-up by writing the names of the various apparatus and their functions

4. Briefly describe the process of separating a liquid mixture by distillation

APPENDIX I

Paired Samples Correlation for T1 and T2

	N	Correlation	Sig.
Pair 1 TEST 1 & TEST 2	26	0.966	.000

APPENDIX J

Indigenous Knowledge- Chemistry Manual

The Chemistry Teacher's Guide

Table of Contents PAGE

Introduction and Purpose

'The Indigenous Knowledge-Chemistry (IK-C)' manual is a teaching manual designed to focus on the practical ways of integrating indigenous knowledge practices into the teaching of senior high school chemistry.

This teacher's manual, which is one of its kind, is loaded with the appropriate pedagogical content knowledge and consists of carefully interwoven IK and Western Scientific Knowledge for effective teaching of chemistry concepts.

The manual seeks to concretise and promote the understanding of chemistry concepts, motivate and encourage students during chemistry lessons, help students to visualise the school as a continuation of the home and to inspire students to develop their environments scientifically. The manual provides teachers with a collection of

Indigenous Knowledge practices that are directly linked to various chemistry concepts. It should however be noted that this teaching manual is not a substitute for the government approved manual but it is hoped to serve as the best supplement.

Basic Premises and Theoretical Framework

The development of various teaching strategies specifically in the teaching of chemistry, is for the effective communication of the subject to learners, which researchers believe can be achieved through the identification and integration of relevant IK into the teaching process. There is an increasing consensus by researchers that the problems currently confronting Africans can be resolved by initially understanding the dynamics within the local context. Such dynamics include the role of IK practices in the teaching and learning process. Thus the adoption of an endogenous approach to the contextualisation of chemistry by integrating Indigenous Knowledge (IK) practices into the school curriculum is the strategy.

The basic premise of this teacher’s manual is therefore to: create the awareness that: chemistry begins from the environment and hence should not be viewed as abstract, the classroom is a continuation of experiences from the home or environment. The manual is also designed to motivate students, develop in students the ability to construct their own meaning and to foster development of collaborative practices at school and community.

The theoretical framework of this manual is based on the theory of constructivism by Jerome Bruner. Bruner believes that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. (Bruner, 1966).

Bruner's theory also says that individuals are able to make meaning of a reality that exists in the environment (Lee, Yen & Aikenhead, 2011).

The relevance of this theory to the manual is based on the fact that children come to the classroom with Indigenous Knowledge practices they have grown up experiencing. These IK practices form relevant previous knowledge unto which related concepts can be developed to make understanding of Chemistry concepts easier thereby improving students' learning outcome.

The use of constructivist strategies in teaching integrated IK-Chemistry lessons can provide viable mental models to enhance new ways of conceptualising and computing the fundamental principles of chemistry.

Overview

The teacher manual is organised into two main sections. The first section consists of some selected chemistry concepts and suggested IK practices that can be used to teach them. It must however be noted that, these selected concepts form about 63% of the total chemistry concepts in the SHS chemistry syllabus.

The second section considers an integrated IK-Chemistry lesson plan for three chemistry concepts areas thus, the structure of the atom and introduction to periodic properties, rates of reaction and factors affecting the rates of reaction and alkanoic Acid derivatives. The lesson plans notwithstanding; teachers can make their inputs where appropriate.

Section One:

Categorisation of selected chemistry concepts under Indigenous practices

CHEMISTRY CONCEPTS	INDIGENOUS KNOWLEDGE PRACTICES
Chemistry as a discipline	Description of a particular indigenous group
Measurement of Physical Quantities	Everyday life activities
Basic Safety Laboratory Practices	Safety measures observed by indigenous people during work
Particulate Nature of Matter	Things in the environment
Structure of the Atom	Structure of the family
Periodicity	Structure of the family, naming a new born
Interatomic Bonding	Family structure, relationships and marriage
Intermolecular Bonding	Family and relationships and marriage
Hybridization and Shapes of Molecules	Structure of the family and marriage

Carbon-12 Scale	Marketing practices example, One ‘olonka’ of any substance contains six margarine tins of that substance.
Solutions	Food preparation
Stoichiometry and Chemical Equations, naming of compounds	Naming a new born, food preparation
Solids and Liquids	Through everyday interactions, food preparation
Gases and their properties	Food preparation
Kinetic model of matter	Food preparation
Energy changes in Physical and Chemical Processes	Food preparation
Rates of reactions	Gari and cassava dough and flour production, food preparation
Chemical equilibrium	
Properties of Acid, Bases and acid-base Indicators	Medication, cleaning, preparation and preservation of food

Classification of acids and bases	Cleaning
Solubility of Substances	Food preparations
Salt and Chemicals from Salt	Food preparations, Soap making
Oxidation – reduction processes and oxidizing – reducing agents	Cleaning, for example the use of lemon to remove rust from surfaces
Corrosion of Metals	Cleaning
Bonding in Carbon	Marriage
Separation and purification of Organic Compounds	Distillation of akpeteshie, salt production
Alkanes	Preparation of food
Alkenes	Farming
Alkanols	Distillation of akpeteshie, brewing of local beverages and food preparation

Alkanoic Acids	Food preparations, tire and dye industry
Alkanoic Acids derivatives: Alkylalkanoate(esters)	Pleasant smell of fruits, scented plants around homes, preparation of local soap
Chemical Industry	Local soap production, pito brewing
Extraction of metals and properties of metals.	Extraction of salt, gold, diamond and bauxite Blacksmithing, Goldsmithing.
Environmental pollution	Farming, everyday practices
Biotechnology	Food preparations, palm oil production, gari and cassava dough processing, distillation of akpeteshie
Cement and its uses	Mining, pottery, building and construction
Fats and oils	Food preparation, local soap manufacturing, medication
Proteins	Food preparation
Carbohydrates	Food preparation

APPENDIX J CONTINUED

Section Two

Section two consist of:

- Integrated Indigenous Knowledge-Chemistry lesson 1
- Integrated Indigenous Knowledge-Chemistry lesson 2
- Integrated Indigenous Knowledge-Chemistry lesson 3
- Integrated Indigenous Knowledge-Chemistry lesson 4

Integrated Indigenous Knowledge-Chemistry lesson 1

Topic: Rates of Reactions Sub-topic: Factors Affecting the Rates of Reaction

Time: 1hr: 30mins

Objectives: By the end of the lesson, the student will be able to:

1. state at least three factors that affect the rate of reactions
2. explain at least three factors that affect the rate of reaction

Indigenous Knowledge practices that can be used include: Cassava dough Gari and cassava flour production to teach the factors affecting rate of chemical reaction.

Keynote information: The processes involved in the production of cassava dough include:

1. Peeling of the cassava tubers
2. Milling (with few fermented cassava)
3. Bagging and pressing milled cassava in an open space

APPENDIX J CONTINUED

The fresh cassava is peeled and mixed with some few cassavas that has been soaked for about two days. The mixture is milled, bagged and pressed between two solid surfaces, usually wooden boards with a heavy load such as a block placed on it or screwed between the two boards. The production of gari follows all the three stages listed above in addition to sieving and dry fried. For cassava flour, the cassava after peeling is washed and chopped into small pieces which are dried in the sun and milled.

It is suggested that the teacher take the students on a field trip to the community to witness the production of cassava dough and gari

RPK

1. Students live in communities where cassava dough, gari and cassava flour are processed and used.
2. Students consume gari and banku

Activities

1. Plan a field trip to an identified place in the community where cassava dough is produced.
2. Let students be aware of the relevance of the visit
3. Ask students to observe the production process and note the stages as the producer educates them on the importance of each stage.
4. Guide the students to link the relevance of each stage in the production process to the factors that affect the rate of reaction. For example:

APPENDIX J CONTINUED

Relevance of the stages involved	Related Factor
Peeling and milling reduces the particle size	Increase in surface area
Fermented cassava added to enhance the texture	Catalyst effect
Bagging and pressing	Increase pressure or concentration

5. Emphasize that the relevance of the stages involved in the production process speed up the time taken for the fresh cassava to be converted to cassava dough, gari or cassava flour.
6. Guide the students to come out with the definition for rate of a reaction.

Assessment: 1. Define rate of reaction.

2. List and explain three factors that affect the rate of reaction.

Integrated Indigenous Knowledge-Chemistry lesson 2

Topic: Metallurgy   Sub-topic: Properties of metals and liquids   Time: 1hr.

Objectives: by the end of the lesson, the student will be able to:

1. identify at least five properties of metals
2. state at least five uses of metals
3. state at least three properties of liquids

Indigenous Knowledge practice to be used: Blacksmithing

Keynote Information: Blacksmithing is an Indigenous Knowledge that is practiced in several communities in Ghana. The Blacksmith is able to make tools and other materials through the knowledge of the properties of metals and liquids. The

APPENDIX J CONTINUED

Blacksmithing process can be used to teach students the properties of metals and liquids for conceptualization and easy recall. The processes involved in Blacksmithing are detailed below:

f. Acquire your aluminum (from scraps)
g. Make a furnace from charcoal
h. Heat or melt the metal
i. Shape heated metal using hammer, an anvil and a chisel and cooling in water
j. Pour out melted metal into molds and allow to cool and solidify.

NB: The charcoal provides the very high temperatures that are needed to heat or melt the metal, the hammer, the chisel and the anvil are used to shape the metal into materials such as knives, cutlasses, planting rods and hoes. Cooling and hardening of the product is done using water. With the molds, pots, coal pots, buckets, pans, spoons, ladles, and many more can be made and sold for income.

Teaching and learning materials: Pictures of processes involved in blacksmithing. NB: Teacher could also have taken students on a field trip to a local blacksmithing shop.

RPK: Students living in communities where blacksmithing is done OR Students have visited a blacksmithing shop. (The field trip is encouraged because it helps promote School-Community relationship)

APPENDIX J CONTINUED

Teacher-Learner Activities

Introduction:

1. Let students brainstorm to tell what Blacksmithing is
2. In five minutes, let students discuss and write down the processes involved in Blacksmithing as witnessed during the field trip

Main Activities (To identify the properties of metals)

1. Show visuals of the processes involved in blacksmithing and let students compare the processes to their answers.
2. In groups of three guide the students discuss the properties of metals as evident in the process of blacksmithing.
3. Let students write down the properties of metals identified in their discussion.
4. Write down the properties of metals on the board and let students mark themselves.
5. Guide the students to identify the properties of liquids from the use of a molten metal to produce a pot.

6. Summarise the lesson by stressing on the properties of metals and liquids.

Evaluation Questions

1. State five properties of metals
2. The property of metals that allow them to be hammered into shapes is ………………….

APPENDIX J CONTINUED

3. Briefly describe what happens when a metal is heated
4. Why is so much heat needed to melt a metal?
5. Write down five uses of metals
6. State three properties of liquids
7. What property of liquids is applied by the blacksmith in producing a metal pot?

Integrated Indigenous Knowledge-Chemistry lesson 3

Topic: Separation of Mixtures **Sub-Topic**: Distillation

Objectives: By the end of the lesson, the student will be able to:

1. define distillation
2. state the principles governing the distillation process
3. briefly describe how to separate a liquid-liquid mixture using distillation

Indigenous Knowledge Used: Distillation of Akpeteshie

Keynote information: The processes involved in the distillation of akpeteshie can be used to teach distillation liquids to students since both processes are the same. Akpeteshie distillation is a common practice in some communities in Ghana, hence most students may be familiar with the practices. The use of this IK practice will help students understand the basic principles on which distillation is based which will enable them to concretise the concept for easy recall. The processes involved are outline below:

APPENDIX J CONTINUED

f. Store fresh palm wine for about a week
g. Put the palm wine in tanks connected with tubes (the tubes made of copper) are connected to the tank and passed through water to the container in which the distillate will be collected
h. Apply intense heat and allow to boil
i. The vapour passes through the copper tubes
j. The vapour is cooled and the liquid (Akpeteshie) is collected

NB: Storing the palm wine for a week is for it to ferment to produce the alcohol, the mixture contains water and the alcohol so, the intense heat allows the mixture to boil faster for the alcohol to be collected, the tubes are passed through water to cool the hot vapour into liquid (Akpeteshie).

Before and During the Field Trip Activities

1. Plan a field trip to a local gin (Akpeteshie distillation) site in the community
2. Brief students on the objectives of the visit. NB: this should focus on the objective of the lesson.

3. Let students observe and take notes of the materials used, the steps involved and the precautionary measures taken in the distillation process.
4. Encourage students to ask questions for clarification.
5. Guide students to define distillation based on their observation

APPENDIX J CONTINUED

Classroom Activities

1. Let students describe the distillation process observed during the field trip
2. Let students write down the equipment used in the Akpeteshie distillation process
3. Post visuals of the akpeteshie distillation process
4. Let students compare it to the distillation apparatus set-up in the laboratory (they can compare it to a drawing made in the absence of the real set-up)
5. Explain to learners that, the distillation set-up observed on the field trip and the one in the classroom both perform the same function and work on the same principles
6. Let students write down the names of the equipment used in the conventional set-up.
7. Let students discuss the principles governing the distillation process
8. Guide students to describe the process of distillation using the visuals
9. Summarise the lesson by stressing on the core points as stated in the objectives of the lesson

Evaluation Questions

1. What is distillation?
2. State the principles governing the process of distillation.
3. Describe the distillation set-up by writing the names of the various apparatus and their functions.
4. Briefly describe the process of separating a liquid mixture by distillation.

Integrated Indigenous Knowledge-Chemistry lesson 4

APPENDIX J CONTINUED

Topic: Alkanoic Acid Derivatives (Fatty acids of esters)

Objectives: By the end of the lesson, the student will be able to:

1. identify sources of fat and oils
2. demonstrate preparation of soap
3. define saponification
4. write a chemical equation for saponification reaction

Indigenous Knowledge Used: Preparation of local soap

Keynote information: Fats and oils abound in the Ghanaian environment. These are from animal origin, for example, lard, tallow, and butter and from plant origin such as coconut oil, palm oil, palm kernel oil cocoa butter and shear butter. Apart from their use in the preparation of food, fats and oils are also used in the medicine industry and for the preparation of soap.

Indigenous people use palm oil, coconut oil, and palm kernel oil to prepare local soap in both small and commercial quantities. They do this by mixing lye water which is made by pouring boiling soft water over cooled white hard wood ashes (potash) made from cocoa pods or plantain peels and the oil. A process known in chemistry as saponification (alkaline hydrolysis of fatty acids esters) to produce soap (potassium or sodium salt of a fatty acid). Using fatty acid ester of palmitic acid n palm oil, the reaction process is as follows:

Ethyl palmitate + Potassium hydroxide → Potassium palmitate + Ethanol

$C_{15}H_{31}COOC_2H_5 + KOH \rightarrow C_{15}H_{31}COONa + C_2H_5OH$

APPENDIX J CONTINUED

Taking students on a field trip will be of enormous benefit to the students to acquire the practicalities involved in the soap production process.

Before and During the Field Trip Activities

6. Plan a field trip to a local soap preparation site in the community
7. Brief students on the objectives of the visit. NB: this should focus on the objective of the lesson.
8. Let students observe and take note of the materials used, the steps involved and the precautionary measures taken in the preparation of the soap.
9. Encourage students to ask questions for clarification.
10. Guide students to define saponification based on their observation

After Trip Activities

1. Let students write a report on the trip. NB: Focus should be on materials used (reactants), the process, the product and precautionary measures.
2. Let students write a chemical equation for saponification

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