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Indigenous Materials, Processes and Scientific Concepts Employed in the Production of Akpeteshie and Pito: Their Relevance to Teaching and Learning of Science

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Abstract

In indigenous knowledge are practices that have been repeated over time and have become products and processes with a sound underlying set of scientific principles. Using the qualitative research method, the study explored indigenous materials, processes and scientific concepts employed in the production of two local alcoholic beverages *akpeteshie* and *pito*. The target population comprised 41 indigenous practitioners and the accessible population consisted of 9 active *akpeteshie* distillers and 8 active *pito* brewers. The purposive sampling technique was used to select respondents and non-participant observation and interview used to collect data. It emerged from the study that diverse materials or artefacts were in use by the indigenous practitioners to either reflect their rich culture and the economic potential of the artefacts or to ensure their sustainable values.

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The use of the artefacts, especially including how they were set up by the indigenous practitioners, typically demonstrated how local artefacts can serve as intellectual adaptation tools for supporting learners to go through their Zone of Proximal Development. The study thus brought to the fore, the existence of an environment that is replete of equivalent scientific concepts, processes and materials/artefacts. It recommended that the local environment should be continuously explored by science teachers to discover relevant indigenous materials/artefacts, practices and concepts that can suitably be integrated into the teaching and learning of science.

Keywords: Indigenous knowledge; akpeteshie; pito; local beverages; indigenous materials.

1. Introduction

Indigenous knowledge encompasses a complex set of technologies that have been improved and sustained by an indigenous group of people [1]. In indigenous knowledge are found practices that have been repeated over time and have become products and processes with a sound underlying set of scientific principles. For instance, observing that animals did not eat certain plnts, likely because of the plants' toxicity, communities took extracts from these plants and tested them for a wide range of uses. Based on the results, the extracts of some of the plants have been used as pesticides in agriculture, as bait for fishing or treatment against maggot infestation in livestock [2].

Beliefs and practices vary across cultures or tribes. Underlining these beliefs in all cultures, however, are scientific concepts, principles and processes. In certain communities of Ghana for instance, people would rather scoop the top layer of oil off a pot of groundnut or palm nut soup, than serve it out for consumption. Superficially, this may seem a habitual customary practice. Scientifically, however, it is because large amounts of fats and oils consumed into the human body can produce detrimental health effects. Similarly, people consider whistling at night as serious taboo with damning supernatural consequences. Underlying this taboo, however, is the effort to instill fear among the people and stop them from polluting that time of the night with noise when neighbours need to sleep.

Notwithstanding the non-formal concept of indigenous knowledge systems, they have the potential to influence the content of formal school science curricula. This is because of their associated underlying scientific principles. Every science course is structured to emphasize three profile dimensions; namely acquisition of knowledge and comprehension, application of knowledge and experiment, and process skills [3]. These are the things that must help students to develop interest in understanding the natural world in order to meet the challenges of life in a systematic and logical way. But for this to be realized, students must be made to develop an interest in the subject itself. The integration of those indigenous knowledge systems that readily lend themselves to scientific reasoning, into actual classroom experiences would be critical in achieving this. In other words, pedagogies that transfer experiences and concepts from indigenous sources into lesson management can serve to both animate students' learning and as well as facilitate their acquisition and retention of new concepts.

Incorporating local community experiences into teaching and learning activities has been a long-standing issue for research. Some studies have seen the issue as having a strong motivational value that holds promise for enhancing learning, retention, and recall of what has been taught [4]. Some scholars, Reference [5,6,7,8] who have researched into non-western cultural settings consider indigenous knowledge to have alternative world views that demystify western science. Reference [9] hold the view that within any subject area, learners better understand and appreciate concepts when teaching is graduated from the 'known to unknown'. They explain that the immediate environment, observations and shared experiences from parents, friends and others in the community serve as primary sources of knowledge (the known) on the basis of which new concepts (the unknown) can be assimilated. In other words, the known or learner's previous knowledge (indigenous practices), when integrated into the teaching process helps to facilitate understanding and easy concept acquisition. In the particular case of science, it enables students to view the subject as a familiar everyday experience and hence helps diffuse any lingering phobia. Reference [10] as well as [11] affirm that indigenous knowledge incorporates technologies and practices that have been used by native people for their continuation of life, and it is comprehensive and holistic in nature.

In his Sociocultural Theory of Learning, Reference [12] emphasises the important role of the forces that operate within any socio-cultural space in shaping the development of any individual through learning. The development of cognition, which is particularly central to the theory, underscores how the community, being one of the influential forces, helps people to process into meaning things that happen around them. Vygotsky posits that, learning is a social construct. According to him learning ensues firstly through social interaction and then through individual internalisation of social behaviours. He adds that, learning is effective when knowledge that emanates from experience is made functional. He thus encourages teachers to explore learners' experiences in order to facilitate their comprehension of new learning concepts. He further advocates the use of materials, devices and activities as very valuable means of achieving this objective. He goes on to emphasise how important the culture of any society is to the learning environment. He believes that the environment within which children grow influences how and what they think.

In tandem with [12,13] had earlier canvassed the view that the development of a learner depends on the interaction with people and the culture. The culture provides tools to help learners form their own views of the world. A cultural tool can be passed on from one individual to another in three ways. The first is imitative learning, which implies that a person tries to imitate or copy another. The second way is instructed learning in which the learner requires recalling the instructions of the teacher and using these instructions to self-regulate. The third way is the passing on or sharing of cultural tools to or with others through collaborative learning. Collaborative learning normally involves a group of learners who strive to understand each other and work together to learn a specific skill.

A concept that is at the heart of Vygotsky's Theory is the concept of *'Zone of Proximal Development'* (ZPD), often referred to as the *Zone of Potential Development* or the *Zone of Next Development (ZND).* Vygotsky considers the ZPD as the ideal learning 'zone' where the learner's complex form of thinking originates from their social interactions rather than from solitary private explorations. In the local Ghanaian home for instance, female children learn to cook by imitating what their mothers do in the kitchen, using improvised materials like

milo tins, grinding stones, wooden grinders etc. in a play setting. Similarly, male children learn to hunt by chasing lizards around the home using improvised bows and arrows. Moreover, male children also learn to farm by following their fathers to assist them with activities in the farm. Thus, teachers can use local culture, indigenous artefacts and local methods of knowing, and community knowledge as intellectual adaptation tools to help learners go through their ZPD.

Vygotsky theory draws a connection between the social settings of learners and what they learn. Thus, the theory has implications for formal school education. It paves way for educators to rethink their lesson approaches in order to modify and implement them within the context of a socially friendly learning environment. As on-going research suggests ways of taking advantage of the theory to improve on teaching and learning in school, there is evidence that some educators are engaging small group learning to improve on the performance of learners. The approaches allow learners to take advantage of their individual cultural backgrounds such as the language they speak as well as their individual strengths and experiences. In this way they readily assimilate concepts, especially when the collaborative approach with their peers is used. Scaffolding and apprenticeship are relevant to learner's cognitive development in every instruction. The teacher must provide learners with frameworks and experiences that will encourage them to extend existing schemata to incorporate new skills, competences and understanding of the new concepts.

Indigenous knowledge practices not only make valuable input to the social environment but also help in the effective management of natural resources. There is, for instance, the use of plant parts, soils, animals, climatic conditions, and seasonal changes to support and guide peoples' interaction within the social milieu. Products of indigenous knowledge practitioners enhance the people's cultural heritage as well as make the people proud about this heritage. Indigenous handiworks come in handy when it comes to solving local problems using local ingenuity and resources. An indigenous practice that probably impacts greatly on the people's livelihood is the production of artefacts. Artefacts serve as psychological tools that mediate learners' cognitive development as they engage in learning under a more knowledgeable person such as a parent, teacher or peer. Artefacts generally reflect the wisdom of a people that have lived through time at the same location and have a great deal of knowledge about their environment [14]. Thus, artefacts provide culturally sensitive scaffolding while serving as meditating tools to facilitate a deeper grasp of concepts. Reference [15] holds the view that the ZPD should be considered as the distance between the learner's lower and higher mental functions which can be overcome with the assistance of an adult, educator, parent, or a more knowledgeable peer. The call for indigenous artefacts to be integrated into the teaching and learning of science, therefore stems from the fact that they impact positively on the learner's performance.

Two common local industry occupations that are quintessential indigenous knowledge practices in many communities in Ghana are the distillation of *'akpeteshie'* and brewing of *'pito',* which are alcoholic beverages. The two industrial activities are classic examples of indigenous knowledge practices because the materials, processes and skills involved occur naturally with the people, having been passed down to them generationally. This study sought to investigate the extent to which knowledge, extending from the two industrial practices - *akpeteshie* distillation and *pito* brewing - could impact teaching and learning outcomes in General Chemistry lessons if rightly integrated into science lessons. The study particularly focused on exploring the materials and

processes involved, with the view of identifying scientific concepts for integrating them (indigenous practices) into the teaching and learning of the topic '*the separation of mixtures'*, at the College of Education level. The study identified indigenous artefacts and the processes related to their usage and also deduced the scientific concepts linked with the production of *akpeteshie* and *pito.*

The questions that guided the research were as follows:

1. *What indigenous materials are incorporated into the production processes of akpeteshie and pito?*
2. *What scientific concepts can be derived from these production processes?*

2. Materials and Methods

The study explored indigenous artefacts and the processes related to their usage and deduced the scientific concepts in the production processes of *akpeteshie* and *pito.* The qualitative research method was adopted for the study. The choice for this method was based on the nature and purpose of the study. This included observing and interviewing indigenous people who engaged in *akpeteshie* and *pito* production as well as the identification of relevant materials and concepts. The study was carried out in the Offinso municipality of the Ashanti region of Ghana. The exploration covered indigenous practitioners and their activities within the communities. The target population comprised all 41 indigenous practitioners in the Offinso municipality who had registered their businesses with the Municipal Assembly and were thus taxpayers. Twenty-two of them were into the production of *akpeteshie* and the other 19 were *pito* brewers. The accessible population comprised 9 *akpeteshie* distillers and 8 *pito* brewers who were all active (were producing) at site at the time of the study.

The purposive sampling technique was used for respondents engaged in indigenous activities. The snowball sampling procedure was used to identify and select the respondents from various communities. Assemblymen and women within the communities helped to identify the individuals. Once selected, practitioners were relied on to disclose the location of others that were also distillers and brewers of *akpeteshie* and *pito* respectively. Indigenous practitioners were interviewed, and their activities were observed. Items on the interview schedule for the selected respondents were based on the 'when', 'how' and 'why' they do what they do. All these were achieved through visits to the identified localities. Since the research focused on exploring the environment for scientific concepts and their relevance to the classroom space, it was appropriate to situate it in a geographical location where the specific practices – *pito* brewing and *akpeteshie* distillation – were commonly undertaken. In this way the learners had a greater opportunity to observe the activities of the indigenous practitioners and internalize the practices.

Non-participant observation and interview were used to collect data with the unit of analysis being indigenous practitioners. To facilitate data analysis, the two processes were video-recorded. The interviews facilitated the exploration of the activities of the people engaged in *akpeteshie* and *pito* production as well as the type of materials and scientific principles involved. Through the non-participant observation that went on alongside the interview sessions, great opportunity was afforded for collecting valid or authentic data directly from a naturally occurring social environment [16, 17].

In order to safeguard validity and reliability concerns of the study, data were collected from multiple sources including observation and interview. Besides, observation from the field settings was repeated until data saturation occurred. Moreover, data from interview sessions were recorded, transcribed and for the sake of cross checking and triangulation, reviewed with respondents. Authenticity was promoted in the study by establishing and maintaining rapport, before and after field work, with the respondents. This was largely achieved through regular visits to respondents' places of work to interact with them. The rapport set the stage for the observation and interviews to kick start and proceed as naturally as possible to the end. The study was, therefore, authentic, naturalistic and data were collected as activities unfolded. To ensure credibility, there was extended engagement in the field as well as triangulation through the use of multiple sources of data. For days, respondents were observed by the researcher until final products from what they engaged in were obtained. Observations were followed up with interview sections to further obtain information on 'how' and 'why' certain activities were performed in a particular manner.

Dependability was safeguarded through purposive sampling of respondents as well as ensuring confidentiality. The respondents were selected because they were information rich and experienced in the work they did. Results that emerged from data analysis were given to more experienced people in the field of qualitative research to cross-check and advise. Transferability was ensured with thorough description and explanation of data collection and analysis processes for each step of the study. This was achieved by looking back at field notes that had been taken and by playing and listening to video and audio recordings taken in the field. And to ensure confirmability, scrupulous and accurate data collection and recording proceedings were undertaken throughout the field study. There was a careful and detailed transcription of notes taken during interview sessions and every data entry was double-checked with what was obtained from the participants.

Data gathered was transcribed. The transcription was preceded by accurate translation of the information that was captured. Indigenous practitioners were interviewed in the local language (commonly spoken by community members) using an interview guide. Some of the words, for example *'vuolung'* (Dagaare), which could not be translated into English, were captured verbatim in the study. The data translation was done during the interview session using the interview guide. In translating the words, the context of the interaction was considered, to ensure that the translation was as accurate as possible.

Before moving on to the actual coding in the second step of data analysis, the data was pre-coded in line with [18]. The pre-coding in this study involved capitalizing, bolding, underlining, and circling pertinent information from the respondents. To allow for later retrieval, straightforward codes were utilised. The researcher made it a habit to make backup copies of every piece of information collected and to safely store the original copy somewhere because she was convinced that the information was valuable and one-of-a-kind that could never be accurately captured through new observations or interviews. Thus, preserving the data was consistent with the moral duty to maintain confidentiality.

Data summaries were created from the information gathered. First data summaries were created from each respondent and then coding schemes were created depending on the questions that were based on the objectives of the study. The coding was made using tacit and intuitive knowledge to identify which pieces of data

resembled one another visually and physically [16]. A limited number of codes were used, in line with [19], in order to make the process of data analysis that was later done, much easy. The most salient areas or the portions related to the research questions were examined. After coding, there were chunks of explicitly related data that could be described with a single word or phrase. Such similar coded data were categorised and grouped because of the commonalities they shared. The researcher's familiarity with some of the identified indigenous knowledge artefacts and procedures, coupled with observational checklist that contributed to formation of themes helped to increase the degree of credibility and rigour.

3. Results

This study explored the environment within which indigenous practitioners (*akpeteshie* and *pito* producers) operate. It focused on responding to the two research questions as stated earlier, by identifying the type of materials, processes and scientific concepts employed in the production of the local alcoholic beverages by indigenous practitioners. In order to address research question one, the activities of two groups of indigenous practitioners; namely *akpeteshie* and *pito* production were explored through observation and interviews.

The practitioners that were into the *akpeteshie* distilling business were all Akan-speaking people of Southern Ghana whiles those that brewed *pito* were Dagaaba and Frafras from the Upper East and Upper West Regions of Ghana. The practitioners considered the production and sale of *akpeteshie* as a lucrative business. Fresh palm wine could be sold, branches of uprooted palm tree serve as sources of firewood and brooms, and decomposed uprooted and tapped palm trees serve as sites for mushroom growth. All these translate into family incomes. Besides, it is an all-year-round activity for practitioners to operate uninterruptedly. This likely explained why most of the practitioners had been in the business for up to 20 years and over. They depended on the business for survival, especially for the upkeep of homes and the care of their wards in school. The business was male dominated with few females on site on a regular basis. Mostly, female presence at the sites was on weekend when they were around with their kids to pick food items and some fire wood. They also took advantage of their presence on such days to prepare lunch for the men.

The data obtained from the observation and interviews of the indigenous *akpeteshie* distillers were categorised into two themes. The identified themes were: materials/artefacts and their uses, setting up and using the materials/artefacts in the production process, scientific concepts within the activities.

3.1 Indigenous materials and processes used in the preparation of akpeteshie and pito

3.1.1 Materials/artefacts used

The socio-cultural space plays an important role in shaping the development of any individual through learning. Learning ensues firstly through social interaction. The culture of any society constitutes the learning environment a learner is immersed in. This environment within which learners grow influences how and what they think. Materials, devices and activities are very valuable means of facilitating learning. Learners learn better when concepts are first presented or demonstrated in a social setting such as a community. Such a setting is naturally presented by the sites within which *akpeteshie* distillers and *pito* brewers operate.

It was observed that most of the sites visited, within the communities known for the production of *akpeteshie*, were remote from the communities. However, a few of these sites had new residential buildings coming up. Basically, the sites were farmlands on which palm plantations were cultivated. They seemed to have been strategically chosen for the obvious reason that the main raw material used for distilling *akpeteshie* was palm wine. Since water was also largely used to condense vapour generated during the production process, the sites were again strategically located close to streams. Where there were no nearby streams, dugouts were constructed to hold the much-needed water. Other materials used in the production process consisted of empty barrels, plastic funnels, copper tubes, hosepipes, gallons, firewood and sliced pieces of foam. Though most of these items were no longer in use their owners did not discard them as waste. Practitioners, did not therefore pick them up as abandoned items but bought them, albeit at minimal costs. Some of these materials are shown in Figure 1. Apart from the *akpeteshie* distillation process other side activities observed around the sites included farming, cooking, and washing of clothing.

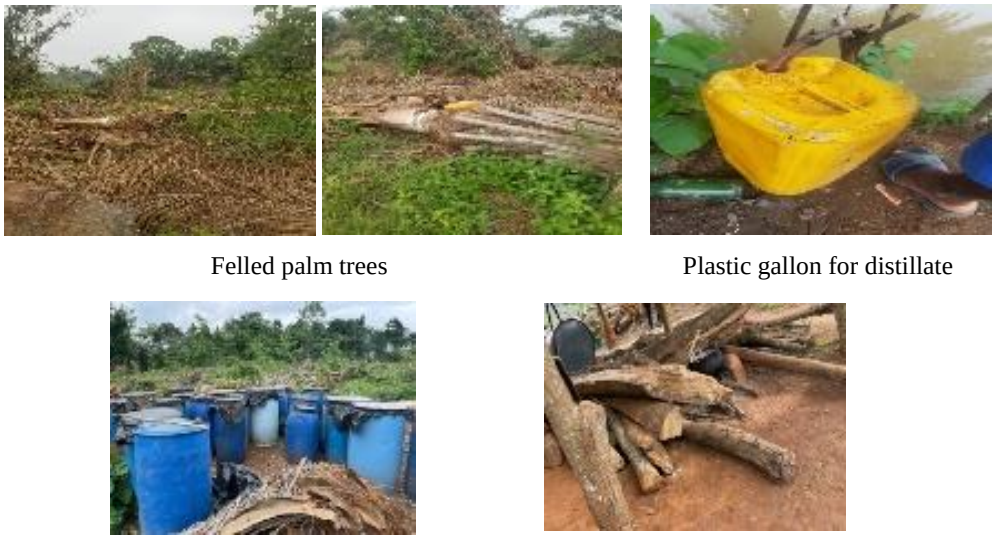
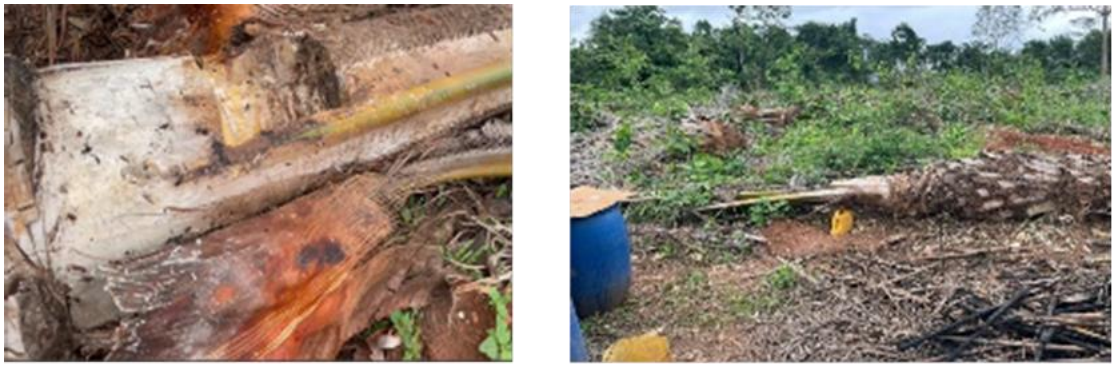


Figure 1: Indigenous materials/artefacts used in *akpeteshie* distillation

3.1.2 Setting up and using the materials/artefacts in the process

The main source of palm wine is the palm tree. To obtain the palm wine from the palm tree, the tree is first uprooted and dressed by pruning, trimming or totally removing the fronds. The tree is then left for a week for the palm sap in it to ferment. Thereafter, as shown in Figure 2, a hole is drilled through the tree trunk to serve as conduit for the outflow of the sap to be tapped into a gallon placed beneath. The tapper then begins to harvest and store the palm wine in barrels.



Dressed palm tree with drilled hole

Tapping of palm wine into a plastic gallon

Figure 2: Tapping of palm wine into a rubber gallon

Whiles in the barrel, the palm wine undergoes further fermentation until a loud sustained hissing sound is heard from within the barrel, which serves as a signal of full fermentation. The first phase of the industrial process of *akpeteshie* distillation ends with this important hissing sound signal.

The second phase of the process begins with the setting up of the distillery units. These units are mostly set up close to the palm plantations, away from home. However, some of the practitioners set them up close to their dwelling places. Among the practitioners observed and interviewed, only two of them indicated conveying their freshly tapped palm wine home to continue with the process. Apparently, they had set up their distillation units at home. But it was also confirmed that sending the palm wine home was partly motivated by the fact that they sold some to residents.

A distillery unit is set up as follows: A hole is bored either through the sealed lid or upper side of the metal barrel. The diameter of the perforation is such that one end of the about 500 cm long copper tube fits perfectly and tightly into it. The other end of the tube is connected to one end of a water hose of about 1500 cm in length. The longer part of the water hose is dropped into a dugout filled with water. As some practitioners were close to streams, the hosepipe could also be dropped into the stream. The other end of the water hose is connected to a funnel stuffed with some foam layers and fitted into a gallon. The stored fermented palm wine is scooped from the barrel into another, and wood fire is prepared to heat up the barrel and its content from beneath. The barrel is tightly covered and sealed to prevent any vapour escaping into the atmosphere other than through the copper tube connected to the water hose. Boiling for close to two hours generates a lot of this vapour, which on getting to the part of the water hose in the water as it escapes, cools and condenses back to liquid. This liquid flows into the foam-stuffed funnel and filters out as a stream of distillate into the gallon. Occasionally, little amounts of the distillate – *akpeteshie* is sipped to test its alcoholic strength. This goes on until the taste weakens and is like that of water. At this point, the barrel content is discarded and new fermented palm wine is scooped into the barrel and another round of the process is restarted. The process setup is depicted in Figure 3.

Figure 3: Distillation set up

The practitioners mainly relied on palm wine as raw material for *akpeteshie* distillation. Alternative materials like sugar and sugar cane were available, however using them as raw materials was considered economically unsustainable due to their high cost. Moreover, the time it takes to distil an equivalent quantity of *akpeteshie* from sugar is more than twice the time required when palm wine is used.

3.2 Production of pito

It was found *pito* brewing is a female dominated business. Out of the 12 women of northern extraction who were found to be engaged in the brewing of *pito*, 11 were from the Upper West Region with only one hailing from the Upper East Region (of Ghana). It was also found that very much like *akpeteshie* distilling, *pito* brewing business is a lucrative all year-round activity. Brewers produce *pito* on a daily or weekly basis and use the proceeds to meet housekeeping costs, finance children's education as well as meet other financial obligations. Many of the *pito* brewers indicated they had been in the business for between 20 and 30 years.

The by-products of *pito* brewing find uses in many ways. The ash from burnt firewood is used in cleaning cooking silverware. The ash is also used as a pesticide and an insecticide when it is sprinkled on vegetables in backyard gardens and farms. Besides, the residue that results from the filtration of sediments during the brewing process serves as animal feed for live stocks (e.g. pigs). In this way *pito* brewing provides employment opportunities for the youth.

Data gathered from the group of indigenous practitioners in the *pito* brewing industry per the interviews and field observation revealed several themes. The identified themes, which were similar to those for the *akpeteshie* distillers' group, were: materials/artefacts and their uses; setting up and using the materials/artefacts in the process.

3.2.1 Materials/artefacts used

From the field observation, it was found that *pito* brewing generally went on within the dwelling places of people in the communities. The brewing was mostly done in either enclosed places such as the kitchen or in open spaces within the compound of the house. The most important observation, however, was the fact that the

practitioners used guinea corn as the main raw material for the brewing process. Guinea corn is mostly cultivated and used as a staple food item in the northern part of Ghana. It is particularly used to prepare porridge *(kooko)* and *tuo zaafi (TZ).* This raw material was thus either purchased from the north and transported down south or gotten from satellite markets around the municipality and sent to the sites for the brewing to take place. The apparatuses and other materials used for the brewing process were: a cooking pot (size of the pot depended on the quantity of *pito* being produced), a basket, a net, barrel, fire wood, foam and a collection of stalks of the okro plant. These materials were generally obtainable from the neighbourhood but they could also be purchased depending on the prevailing exigencies. Some of these materials/artefacts are shown in Figure 4.

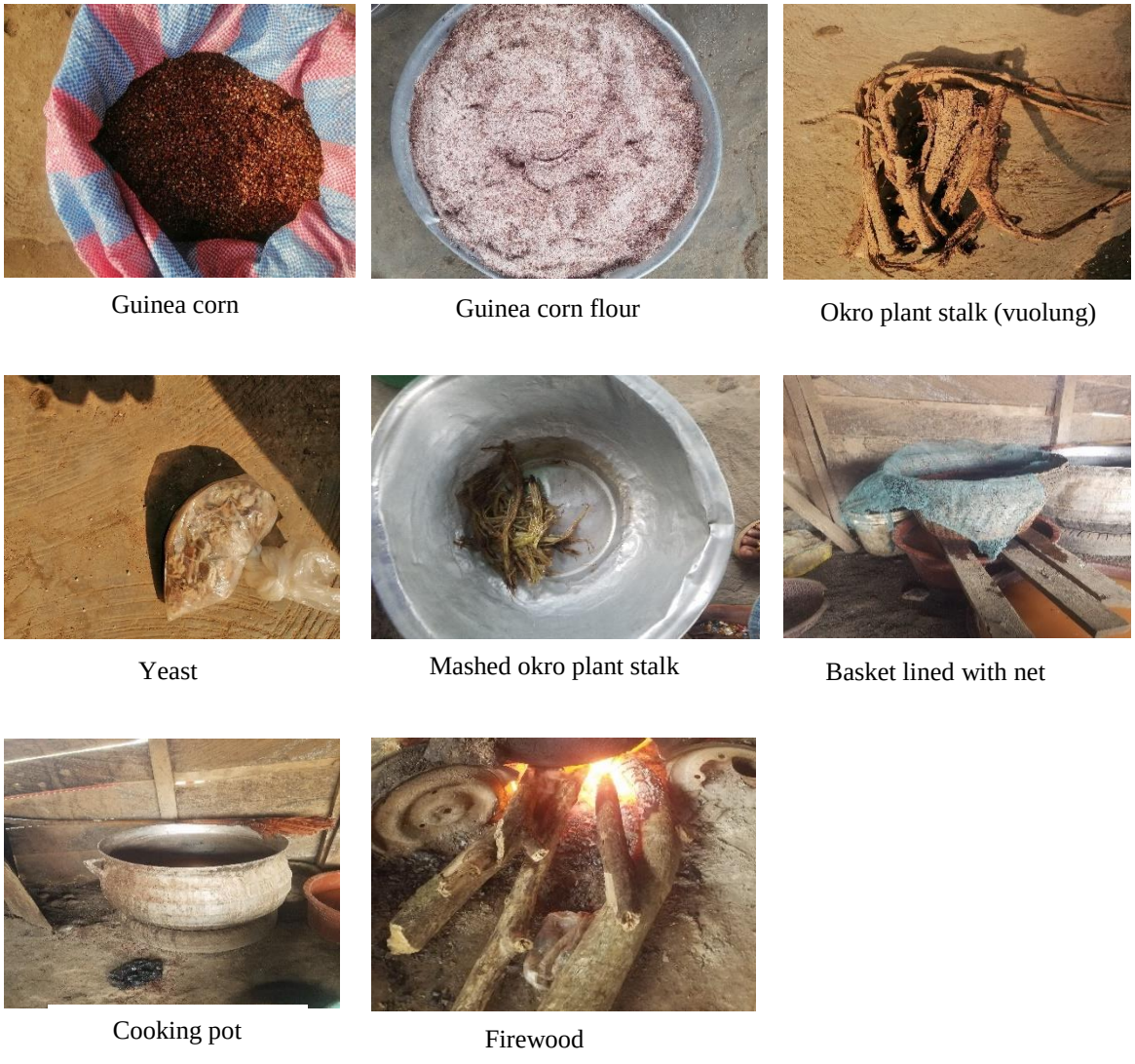


Figure 4: Indigenous materials/artefacts used in *pito* brewing

Indigenous materials or artifacts are important to the communities in which they are fabricated because the people have relied on them for a long time. Consequently, using them in the explanation of science concepts is a

way to promote their preservation as well as get their uses enhanced through improvement in the way they are fabricated.

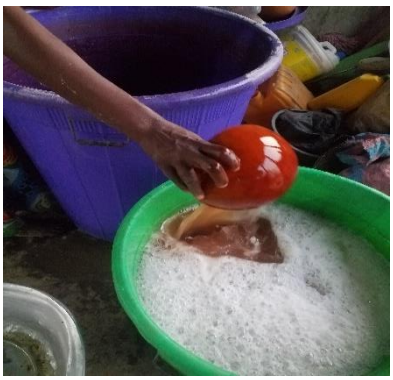
3.2.2 Setting up and using the materials/artefacts in the process

The main raw material used in *pito* brewing is guinea corn. It is important to ensure that all materials /artefacts to be used for the brewing are ready from the onset. This is particularly so with water since the process uses a lot of water. The guinea corn must first be turned into malt. To achieve this, it is steeped in water overnight and 'nursed' on a cleaned floor surface at a corner of the room to trigger germination of the grains. The nursery is mulched with leaves to both prevent rapid loss of water and limit aeration to the grains. On a daily basis, the mulch is briefly removed and placed back after water has been sprinkled on the nursery. This process ensures that within three to four days the guinea corn germinates. By this time the starch in the guinea corn, by virtue of anaerobic respiration, is converted to sugar. The entire mass of germinated guinea corn on the nursery is collected, kneaded and dried up in the sun in two or three days. Thus, the guinea corn has been turned into dry malt ready for milling.

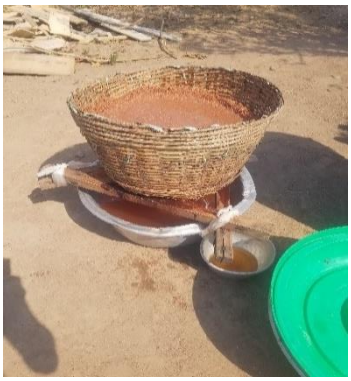
The malt is milled into a coarse material. It is then mixed with water to form a suspension. An okro stalk is mashed and added to the mixture. This acts as a coagulant, causing the suspended milled malt particles to settle to the bottom by sedimentation. The mixture is left for some 30 minutes to ensure complete sedimentation. Using a calabash, the relatively clear liquid at the top is gently scooped off into a different pot leaving the sedimented mass of malt particles at the bottom of the first pot.

The sediment is transferred into another pot and boiled for over two hours. As it boils, water is added to it as a top up or replace what has vaporized. It is also stirred occasionally to ensure an even distribution of heat throughout the boiling stuff. When well boiled, the original sediment on fire changes from grey colour to brick red. The heat is reduced for it to simmer for a while and then it is fetched hot in buckets full and mixed with the relatively clear liquid that had been scooped off into a pot. The mixture is left to cool overnight. By morning, the mixture develops a sour-sweet taste. This taste confirms all is going well, so until the special taste is felt the process is held up until it manifests. By then also the cooked malt flour has ~~should~~ settled completely to the bottom of the pot. The now brick red coloured liquid on top is transferred to the cooking pot where it is boiled to concentrate it. At this level of concentration, the liquid feels sticky to touch. At this point the boiled liquid is transferred to a large pot or basin for it to cool.

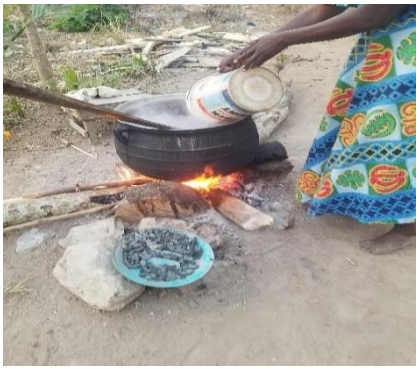
As boiling proceeds, the sediment earlier left behind is filtered using a cane basket lined with a fine mesh. The filtrate is also now boiled to an appreciable concentration. It is then transferred into another large pot or basin and left to cool. At about bedtime, yeast is added to this cooled sweet tasting liquid (unfermented *pito*) for fermentation to take place overnight. Thus, by morning the next day, the whole process of brewing is over and the *pito* is bottled or served into clay pots for sale. Figure 5 depicts the processes involved in *pito* brewing.



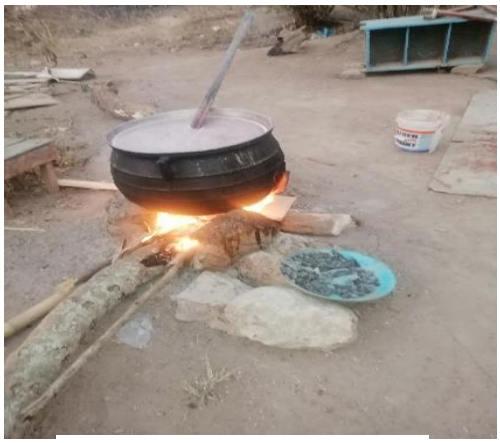
Separating solution from mixture



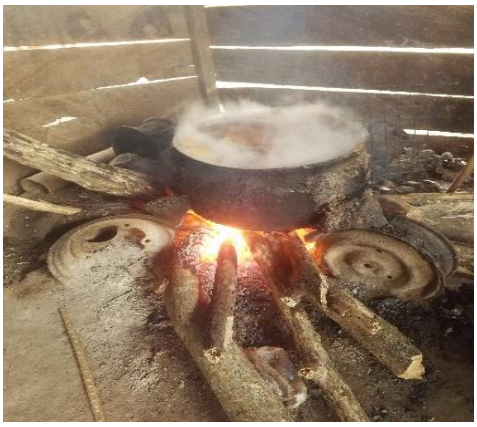
Filtering boiled mixture



Pouring filtrate into cooking pot



Boiling done in an open



Boiling done in an enclosed place

Figure 5: Brewing Process

Maize, which is more common in the study locality than guinea corn can serve as an alternative raw material. Maize is also much cheaper than guinea corn. However, the brewers indicated they mostly used guinea corn for the brewing because majority of consumers prefer guinea corn *pito* to *pito* brewed from maize. *Pito* brewing is a booming industry as *pito* consumption has a wide patronage. *Pito* is sold in both the fermented and unfermented form. The fermented form is more preferred than the unfermented for its higher alcoholic content. Generally, however, *pito* is referred to as an alcoholic beverage.

3.3 Scientific concepts within the activities

3.3.1 Scientific apparatuses, processes and underlining concepts in akpeteshie production

Indigenous artefacts/materials have a lot of potential that can be used in teaching and learning of science. Artefacts/materials are required in carrying out processes. As shown in Table 1 the basic materials/artefacts used in the local distillation process of *akpeteshie* are matched with their equivalent apparatuses that are used in the school science laboratory.

Table 1: Materials/artefacts and equivalent laboratory apparatus

Local materials	Laboratory apparatus/ equivalent
Barrel	Distilling flask
Gallon	Conical flask/beaker
Copper tube	Condenser
Water hose	Condenser
Dugout	Water
Foam (polyurethane)	Filter paper
Fire	Bunsen burner
Palm wine	Mixture

Indigenous materials/artefacts with scientific concepts are significant and pertinent to the communities in which they are made, since they have supported those communities for a long time. As a result, by including them in the teaching of science, it will not only lead to their proper conservation, but also have them improved and used more effectively and efficiently. Examining the natural world and the information that comes from it is what science is all about. The processes of science apply the concept of procedure to recognize sequences of action. Table 2 displays a list and explanation of the scientific processes and underlining scientific concepts involved in the distillation of a*kpeteshie* from palm wine.

Table 2: Processes and underlining concepts

Indigenous process	Processes involved	Underlining scientific concepts
Akpeteshie production	Method of separation	Distillation
	Chemical reaction	Fermentation and burning
	Fermentation	The sugar in the freshly tapped palm wine is converted to alcohol. The fermentation takes place in the presence of yeast (anaerobic respiration).
	Burning	The firewood is burnt to ashes (combustion takes place in the presence of oxygen)
	Heat transfer	Heat from the burning wood is conducted through the barrel to the mixture. The heat is further transferred through the mixture from bottom to top by convection. The heated molecules become less dense than the upper surface of the mixture. This makes them rise up to replace the denser molecules at the surface. This process becomes cyclical, continuing until boiling.

It is generally important to understand scientific processes and concepts through the scientific method as it

equips people with the skills they need to understand nature. These includes being able to observe, analyse, formulate hypotheses, conduct experiments, draw conclusions and generalize. In this way, people are able to apply knowledge to define issues that confront them in real life situations. Application of the scientific method thus helps people to understand natural phenomena. This impacts in no small way to improve the quality and standard of their daily lives

3.3.2 Scientific apparatuses, processes and underlining concepts in pito production

A working artefact can be utilized to advance and solidify students' comprehension of a number of connected scientific concepts. A number of materials/artefacts are used in the process of *pito* brewing. Table 3 displays a list of these materials/artefacts and their equivalent apparatus used in the school science laboratory.

Table 13: Materials/artefacts and equivalent laboratory apparatus

Local materials	**Laboratory apparatus/equivalent**
Guinea corn	Substance
Barrel	Beaker
Cooking pot	Round bottom flask
Okro stalk/vuolung	Coagulants
Net/Mesh	Filter
Fire	Bunsen burner
Guinea corn flour mixed with water	Mixture
Basin	Conical flask/beaker
Plank	Serves as a supporting base

Indigenous materials and artifacts that incorporate scientific ideas are valuable and relevant to the communities in which they are produced because those cultures have relied on them for a long time. Thus, using them in the teaching of science in school will not only help to conserve them but also possibly lead to their improvement for a more effective and efficient usage. Thus, using them in the teaching of science in school does not only help facilitate learners understanding of what is being taught in the classroom setting but also help them to appreciate the materials in the environment.

Chemical processes play very significant roles in industry, customs and even in our daily lives. A chemical process involves a chemical and/or physical transformation of raw materials into products or intermediates that are then further processed into entirely different products. Through a careful study of chemical processes or reactions, people get to understand and appreciate the properties of matter better. An adequate knowledge of chemical interactions helps people, especially learners, to demystify the many supposed mysterious happenings encountered in their learning and the natural world in general. Chemical reactions also play a significant role in chemical analyses that provide chemical information about samples. Chemical reactions are, therefore, the most

important types of events in the cosmos. Table 4 presents the chemical processes involved in *pito* brewing alongside their equivalent scientific concepts. Essentially, five underlining concepts involved in the processes have been captured in the table.

Table 4: Chemical processes with scientific concepts

Chemical processes involved	Underling scientific concepts
Germination	The guinea corn is soaked in water and hydrolysis takes place. The hydrolysis process activates the enzymes responsible for converting the starch to sugar.
Hydration	The starch in the guinea corn is hydrated with water when soaked for the starch to be soft to facilitate enzymes activities.
Fermentation	The carbohydrate in the guinea corn is converted to sugar in the brewed malt. The sugar is further converted to alcohol called *pito* in the local parlance. The fermentation takes place in the presence of yeast (anaerobic respiration).
Burning	The firewood is burnt to ashes (combustion takes place in the presence of oxygen)
Heat transfer	Heat from the burning wood is conducted through the pot to the mixture. The heat is further transferred through the mixture from bottom to top by convection. The heated molecules become less dense than the upper surface of the mixture. This makes them rise up to replace the denser molecules at the surface. This process becomes cyclical, continuing until boiling begins.

Physical processes come in many forms. In physical processes neither the composition nor the chemical nature of matter is changed. A physical change does not affect the chemical property of a substance. Physical processes or changes lead to the alteration of features like texture, shape, or condition. When a physical change occurs, the material affected by the change retains its structural integrity, both before and after the change. The physical processes that take place in the course of brewing *pito* can be used to explain and demystify some scientific concepts that learners find hard to comprehend. Table 5 provides a list of the physical processes that take place in the brewing of *pito* and how they are applied during the process.

Table 5: Physical processes and their application

Physical process	Application
Decantation	Scooping the solution from the barrel in the pot
Boiling	Causes evaporation of water in the mixture leading to the concentration of the solution.
Filtration	Separating the solution from the guinea corn flour
Sedimentation	The okro stalk allows the guinea corn flour to settle at the bottom, thus causing sedimentation to take place.

4. Discussion

From the study the production of *akpeteshie* and *pito* is an all-year round activity. In other words, practitioners operated uninterruptedly to produce and sell the drinks. They were pleased with this development because they depended on the business for survival - to see to the upkeep of their homes and support the education of their children as well as meet other financial obligations. This finding was in keeping with the views expressed by [11]. These researchers had affirmed indigenous knowledge as fundamentally established outside the formal education system, enabling the community to live on.

According to [14], artefacts reflect the wisdom of a people that have lived through time at the same location and have a great deal of knowledge about their environment. He affirmed that indigenous practitioners do not only make valuable input into the social environment but also help in the effective management of natural resources. They make use of these resources or materials that are obtainable from the neighbourhood in an economically sustainable way, he explained. Diverse materials or artefacts are used by indigenous practitioners to either showcase their rich culture in terms of the availability of these resources and how they are used or take advantage of their economic potential and also ensure sustainability values. The findings from the study, highlighting the use of indigenous artefacts from the environment by the *akpeteshie* distillers and *pito* brewers confirm Mudzamiri's assertions. From what was observed, the indigenous knowledge practitioners gathered these artefacts or made, constructed, or improvised them to function in the way they required of them in their operations.

Artefacts help to mediate learning through scaffolding and transform the learner's lower mental or cognitive functions to higher ones as they progress from the acquisition of one concept to the next in the learning process [15]. Learning and development then become sustainably guaranteed when artefacts, including physical and symbolic tools are used.

The use of artefacts by the indigenous practitioners, especially including how they were set up in the study, typically demonstrates how local artefacts and local methods of knowing serve as intellectual adaptation tools for supporting learners to go through their ZPD. Moreover, the artefacts used were tangible and had equivalent laboratory apparatuses. Hence it was possible to later apply the artefacts seen in the field in an actual classroom setting to teach and explain relevant scientific concepts to learners (pre-service teachers). Besides, the researcher got so inspired by the way the practitioners used the artefacts that she also not only used them to successfully plan and deliver lessons, but in fact thereafter developed an acceptable guideline for the preparation and delivery of effective integrated lessons for use by teachers.

It was amazing to observe how orderly and sequentially the indigenous practitioners carried out the production activities. The routine did not allow room for skipping or sidestepping as that could lead to undesirable products. In every step of the production, chain of activities, scientific concepts and processes were identified. Doing so, however, was no easy job to the untrained eye. It required a knowledgeable and skillful person, someone that is well versed in the content and demands of the curriculum, as well as someone really committed to explore and tap the rich knowledge of the practitioners, to be able to identify these concepts and how relevant they are to indigenous knowledge practices. Any science teacher worth their salt should be in a position to do this because teachers play a crucial role in the effectiveness of indigenous knowledge integration into lesson management. Exploration of the environment involving indigenous people such as was done in this study is never an easy task. The process was rigorous, time and energy consuming as well as hazardous and generally challenging. The end results have, however, been rewarding, given the rich knowledge and experiences that have been tapped to further the cause of integrating indigenous knowledge practices into formal classroom teaching and learning.

The study identified tangible artefacts that were mostly reconstructed from used materials bought or obtained from the community. The reconstruction of these indigenous artefacts involved the application of special traditional techniques or skills set to suit the purpose of its use. These artefacts are used by the indigenous practitioners in carrying out their daily activities. A lot of scientific meaning were associated with the indigenous activities.

5. Conclusion

The artefacts used were tangible and each matched with an equivalent laboratory apparatus as they were applied in an actual classroom situation to teach and explain relevant scientific concepts to learners. The study has contributed to improve an understanding and appreciation of the value of including indigenous knowledge practice in science lessons. It has emphasized the existence of an environment that is replete of equivalent scientific concepts, processes and materials/artefacts, advantage of which can be taken to facilitate science teaching and learning in the classroom. It is recommended that the local environment should continuously be explored by science teachers to get acquainted with relevant indigenous knowledge materials/artefacts and practices as well as the connected concepts that can suitably be integrated into teaching and learning of science. It also important for the exploration of the environment to encompass learning that furthers the acquisition of the skills of improvisation to enable teachers make and use artefacts that serve as relevant teaching and learning materials from local resources to replace orthodox school laboratory apparatuses, which most often are difficult

to come by in local and deprived schools.

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I also wish to express my heartfelt gratitude to the indigenous practitioners (*akpeteshie* and *pito* producers) who welcomed me to their places of work and made it possible for data to be gathered for the study.

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Appendix A

Observation Guide

Table 6

Contextual information	
Date and time of observation	
Location/Site	
Duration of the meeting	
Gender	
Materials used	
Raw materials	
Chemicals	
Equipment	
Notes	

Reflections	
Hazard and risk involved	
Departure Time	

Appendix B

Interview with Indigenous Practitioners

A. Basic Information

Date of Interview: ……..……..… Time: ……. Time line: ……. Location/Venue……...……...…….…….……

Age of Interviewee: …… Gender of Interviewee: ……...…….

Device for Recording: ……...

B. Opening of Interview

1. Establishing Rapport

i. [Shake hands exchange pleasantries with interviewee and introduce yourself] *My name is _____ a tutor at the Offinso College of Education and also a student of the Kwame Nkrumah University of Science and Technology.*

ii. [Ask the interviewee to introduce himself/herself] *Please kindly tell me something briefly about yourself.*

2. Purpose of the Interview

[State the purpose of the interview] *I would like to ask you some questions about your experience in the akpeteshie distilling/pito brewing industry. This interview session is intended to provide an in-depth knowledge on the how, why and what surrounds your activities. The information from it will be used to support the design of a science lesson for learners in the classroom. I therefore urge you to feel free and open up to me with as much information as my interaction with you will seek to obtain.*

Following this interview, I may, if necessary, invite you at some point in time to serve as a resource person in throwing more light on some concepts the learners may find difficult to grasp.

I believe you would not mind my recording our interactions. This is to enable me to listen to our interaction over and over again in order to facilitate the process of transcription of the information coming out if it. Please do rest assured no information from this interview will be shared with any third party.

I thank you in advance for your kind cooperation.

C. Main Body of the Interview

Table 7

S/N	Guiding Questions	Feedback/ Responses from Interviewee
i	What motivates you to be in the *akpeteshie* distilling/*pito* brewing business?	
ii	How long have you been in the business?	
iii	Do you have a registered business name?	
iv	Do you operate alone or you work in a team/cooperative?	
v	How many team members do you have if you work as a team?	
vi	What does it take in terms of funds and materials to start an *akpeteshie* distilling/*pito* brewing business?	
vii	Kindly specify the key equipment, artefacts and/or tools used for your operations	
viii	Would you have preferred better equipment or tools?	
ix	What raw materials do you use to produce the *akpeteshie*/*pito*?	
x	How do you obtain these raw materials?	
xi	Kindly describe in detail the entire process that will give *akpeteshie*/*pito* as end product.	
xii	I should be pleased if you go over, emphasizing and explaining in particular, the main processes involved.	
xiii	How long does it take to go through this entire process in order to come out with the product?	
xiv	Are they any other processes involved after obtaining the product before it goes to the market?	
xv	How is the product packaged for sale?	
xvi	Is there a ready market for the product?	
xvii	What challenges are associated with the activities and processes entailed in the business?	
xviii	What also are the possible dangers, hazards and risked involved in the business	
xix	What do you do to minimize the associated dangers and hazards?	
xx	How do you think the processes associated with your business can be helpful to teachers who teach separation of mixtures in the classroom?	

D. Closing of Interview

[Summary] I have learnt a lot from our brief interaction today. Beginning from what motivates you to be in the *akpeteshie* distilling/*pito* brewing business you have among other things told me of the local raw materials you use in the distilling/brewing process. You have as well given your opinion of how processes in this your local distilling/brewing industry could be integrated into the classroom teaching process.

[Maintaining rapport] It has been such a wonderful honour talking to you. I am so grateful and wish to thank you for finding the time to be here to share this invaluable information with me.

[Action to be taken] As I said at the beginning, the information from this interview shall be used to support the design of a science lesson for learners in the classroom. I may need you again for some clarifications at any point in time in the design process, and I am certain you will continue to give me your very best of assistance.