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HIGH SCHOOL CHEMISTRY TEACHERS' PERSPECTIVES AND PRACTICES ON TEACHING MOLE CONCEPT

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Abstract:
Mole concept is one of the challenging chemical concepts in the teaching and learning of chemistry. West African Examination Council (WAEC) Chemistry Chief Examiners for years, have been hammering on students' difficulties in this concept at the senior high school level. This study, therefore, examined the practices of teachers on the perceived nature of the teaching and learning of mole concept. A concurrent triangulation mixed methods design was used to collect both quantitative and qualitative data from 32 chemistry teachers from four public schools in the Central Region. The teachers were selected through multistage sampling technique. Questionnaires, interviews, and observation checklist were used to collect data from the teachers. Data was analysed using percentages, means, standard deviations, and themes. The results showed that teachers have moderately positive perceptions of the nature of teaching mole concept, which are full of uncertainty and that, teachers barely practice that they profess to teach on mole concept. It is recommended, among other things, that Ministry of Education through Heads of senior high schools should monitor chemistry teachers to ensure that they effectively teach the concept to students by implementing their planned lessons.

Keywords: chemistry; mole concept; perception; practice; teachers

1. Introduction

Chemistry as a branch of science places much emphasis on chemical concepts which require macroscopic, submicroscopic, and symbolic levels in its teaching and learning (Sarkodie & Adu-Gyamfi, 2015). Classroom interactions on chemistry deals with the composition of the structure and properties of matter, including atoms and molecules. These atoms and molecules are extremely small in size and their number in even small amount of any substance is really very large. To properly handle this large number, a unit

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of comparable magnitude, the mole is required (Chang, 2008; Petrucci, Herring, Madura, & Bissonnette, 2017). This mole concept was originally intended to indicate any large mass which are macroscopic, not similar to a sub-microscopic or "molecular" mass (Bucat & Mocerino, 2009; Jensen, 2004). There are a number of studies on mole concept and there are different views to it based on researchers understanding of it. Indriyanti and Barke (2017) described the mole as a concept under submicroscopic level, and the basis of knowledge for solving problems in chemistry, especially quantitative problems. According to 14th Conference of National Institutes of Standards and Technology (NIST) held in 1971, the mole is the amount of substance of a system which contains as many elementary entities such as atoms, molecules and ions as are there in 0.012kg of carbon-12. These elementary entities are atoms, molecules and ions generally seen as compounds, and hence, the mole, in terms of chemical compounds, is the amount of compound containing Avogadro's number ($6.02214x10^{23}$) of formula units or molecules (Petrucci et al., 2017).

Vikasana-Bridge Course (2012) reported on the relationship between the mole of a substance and number, mass, and volume of that substance. Mole in terms of mass; is the amount of substance (elements or compounds) which has mass equal to its gram atomic mass. For example, one mole of oxygen atoms is equivalent to $16g$ and two moles of oxygen molecules is equivalent to $32g$. Mole in terms of number; is a substance containing one Avogadro's number. For example, $1mol$ of hydrogen atom contains $6.02x10^{23}$ hydrogen atoms. Mole in terms of volume; is a substance that occupy the volume of $22.4dm^3$ at STP or $0.0224m^3$. The mole is expressed mathematically as;

$$Mole = \frac{mass\ of\ substance\ (g)}{Molar\ mass\ of\ substance\ (g/mol)}$$

Mole concept is a need in the mass-mole calculations of chemical reactions because it concentrates on the number of particles and uses quantity that connects the mass unit of matter, number of particles and the volume of gases involved in chemical reactions (Chang, 2008; Petrucci et al., 2017).

Mastery of mole concept is crucial to equip students to learn the solution concentration concept with ease (Faizal, Helmi, Azilawaty, Nurulamirah, & Nurshuhada, n.d.). The theorist, Kolb (1978) asserted that there is no concept in the entire high school and university chemistry courses more vital for students to understand than the mole. One of the main reasons the mole concept is so crucial in the study of chemistry is stoichiometry. Review from Kolb experiential learning indicated that, in learning mole concept, students must have experience. Thus, knowledge about mole concept and then reflection on the experience, after which one gains understanding from that experience, to apply knowledge learnt in other situations it then leads to problem solving in concepts such as: chemical kinetics, chemical equilibrium and concentration (McLeod, 2017). Without a good mastery of mole concept, students would find it troublesome in understanding stoichiometry and other subsequent concepts (Musa, 2009).

Mole concept is generally acknowledged to be one of the most difficult concepts in teaching and learning and students find much problem working with because they see it to be extremely difficult and frustrating to understand (Shehu, 2015). According to Moss and Pabari (2010), mole concept is a concept which is not easily understood by students. This is because the mole is an unfamiliar concept to most students leading to rote learning of equations and solutions to application questions on the mole. This means that students cannot show a good understanding about standard question in mole. Nelson (2013) further indicated that most students lack accurate understanding of mole concept. The poor understanding and difficulty in identifying mole concept can lead to enormous errors and wastage of resources while performing scientific experiments. Experiments such as biochemical assays, animal cell culture, polymerase chain reactions, spectrometry, and routine buffer preparation require a very accurate understanding of mole concept (Arya & Kumar, 2018). Malcolm, Rollnick, and Mavhunga (2014) asserted that students' inability to understand mole concept could be poor conceptualisation of the concept by majority of teachers. This is often incorrectly defined in a large portion of teaching and learning materials like school textbooks thereby preventing proper comprehension by students. Teachers themselves may be unsure about their knowledge in this concept, and transmit it incorrectly (Moss & Pabari, 2010).

Bond-Robinson (2005) revealed that mole concept is a concept at sub-microscopic level, but chemistry students' reasoning is at a macroscopic level, based on personal interactions with objects associated with chemical processes. Hence, teachers and students need to shun semantic mistakes in mole concept due to what Pekdağ and Azizoğlu (2013) referred to as a 'missing concept, which cannot be located at either the macroscopic, microscopic or symbolic level of representation. For example, asking 'how many moles are in 20g of sulphur(IV) oxide?' is missing the macroscopic level of representation and should rather be expressed as; what is the amount of substance in 20g of the sulphur(IV) oxide? This would also ensure that the expressions are in consonance with the SI unit definition.

In Ghana, one of the aims of teaching chemistry is to help the Ghanaian student "*demonstrates an understanding of the mole concept and its significance to the quantitative analysis of chemical reaction*" (Ministry of Education [MOE], 2010, p. 11). The mole concept is introduced at SHS1 under Section 4 of the chemistry teaching syllabus (MOE, 2010). The mole concept covers areas such as: Carbon-12 scale, Solutions, Stoichiometry and Chemical Equations, Acids and Bases, Chemical Equilibrium and Power of Hydrogen ion (pH) and Power of Hydroxide ion (pOH). However, the West African Examinations Council (WAEC) Chief Examiners' Reports (WAEC 2015; 2016; 2017) on chemistry revealed that students had difficulties in answering examination questions on mole concept, which is an important fundamental concept in studying other chemistry concepts noted earlier. Mole concept seemed a great challenge to students and unfortunately, not much had been done to look into the teaching mole concept in Ghana. Hanson (2016) indicated that there are challenges in learning mole concept and that teachers and students encounter those challenges being the basis for correct comprehending of other concepts in chemistry and the sciences in general (Taber, 2001).

The purpose of the study was to examine the practices of teachers on the perceived nature of the teaching of mole concept in high schools. To achieve this, a research question was raised to guide the study as: *How do the perspectives of the practices of chemistry teachers vary on the nature of teaching mole concept in senior high schools?*

Teachers like their students perceived chemical concepts in different ways relating to terminologies, structures and calculations of these chemical concepts (Mahdi, 2014). For instance, the mole is perceived as a certain mass, a certain number of gas particles, and a property of molecules (Novick & Menis, 1976). These are very important tool because they influence the information that enters the working memory (Davis, Petish & Smithey, 2010) and teachers' and students' interest in teaching and learning of chemical concept, particularly mole concept (Sözbilir, 2004). Strömdahl, Tullberg, and Lybeck (1994) reported that only 11% of teachers perceived the mole as the unit of amount of substance, 61% as Avogadro's number, and 25% as mass. Students' conceptions of the mole are as a result of teachers' accumulated knowledge and views expressed by teachers vary from those expressed by the science community (Strömdahl et al., 1994). Teachers have difficult perceptions about chemical concepts. These difficult perceptions are transferred to students in lessons which go a long way to affect the students' learning outcomes (Boz & Uzuntiryaki, 2006). Hence, the need for this study in a pragmatic worldview.

2. Research Methods

The design employed for this study was concurrent triangulation mixed methods design. In this concurrent triangulation mixed methods, quantitative and qualitative approaches were concurrently used to complement each other in understanding teacher perceptive and practices in teaching mole concept. The quantitative stage was the survey of perceptions of teachers on mole concept, qualitative stage was about the observation of lessons on mole concept and interviews with teachers before and after the lessons, and interpretation stage was about the analysis and discussion of findings on both the quantitative and qualitative data. The interpretation stage helped to merge the results to achieve the aim of using concurrent triangulation mixed methods design.

2.1 Sample and Sampling Procedure

A multistage sampling procedure was used to select 32 teachers to participate in the study. To achieve the sample size, three districts were randomly selected from 20 Metropolitan, Municipal, and District Assemblies (MMDAs) in the Central Region to form the study area. This was necessary as the 20MMDAs were widely spread in the region and the characteristics of the schools in the three districts were similar to the other MMDAs. Four schools from the eight schools of the three districts offering general science were simple randomly selected for the study. The four schools were classified as schools A, B, C, and D with respect to available resources and academic achievements in eternal examinations (Adu-Gyamfi, Ampiah, & Appiah, 2013). All teachers teaching chemistry were purposively selected from the four schools to take part in the study. There were 6, 7, 9 and 10 teachers from schools A, B, C and D respectively teaching chemistry. Majority of the teachers were males (75%) and others being females (25%). A teacher each from school A, B and C who were teaching mole concept, at the time of the research, was randomly selected for the lesson observations. The purpose was to have an in-depth study into the nature of the teaching of the mole concept. Three teachers who participated in the observed lessons were interviewed before and after the lessons. From school A (a well-endowed school), Teacher A with 8 years of teaching experience taught the mole ratio and the lessons were observed. In school B (an endowed school), Teacher B with 2 years teaching experience taught stoichiometry and molar mass and the lessons were observed. In school C (a less endowed school), Teacher C, with 7 years teaching experience taught lessons on introduction to mole and stoichiometry, were observed. For school D, all the teachers have already treated all the aspect of the mole concept and as such, no lesson was observed in the school.

2.2 Data Collection Instruments

Teacher Knowledge and Perception of Mole Questionnaire (TKPMQ) was a closed-ended questionnaire. TKPMQ was structured on a five-point Likert-type scale as strongly agree, agree, uncertain, disagree and strongly disagree. There were 18 items from which, Items 1- 3 were on the general background information of teachers and Items 4 – 18 on the perceptions of teachers. TKPMQ was prepared by the researchers based on literature to ensure instrument validity. To further ensure face validity, TKPMQ was scrutinized by two chemistry teachers from senior high schools out of the pilot testing zone. Their suggestions were used to improve TKPMQ. For instrument reliability, a pilot test was conducted on eight teachers from two schools selected from the target population. For the reason that the schools for the pilot testing were considered to possess similar characteristic with the schools that were selected for the main study. The pilot testing helped to expose ambiguous statements, poorly worded items that might not be understood by the teachers, unclear choices and duplicate items on the questionnaire. Thereafter, the internal consistency of the questionnaire was checked using a reliability coefficient, Cronbach's alpha. The calculated Cronbach's alpha reliability coefficient for TKPMQ was 0.7.

Teachers' In-depth knowledge into the Nature of Mole Interview Guide (TINMIG) was constructed by the researchers. The items constructed were based on the researchers' personal teaching experience and literature on teaching and learning of other concepts. The reason was to ensure that TINMIG was valid. TINMIG was semi-structured with the purpose to find out challenges facing the teaching of mole concept in high school and to solicit views on how the mole concept should be taught to students. There were 12 items on TINMIG. Items 1-9 were the main interview items on teaching mole concept. The TINMIG was used before and after lesson observation on mole concept. Items 10-12 were asked after the lesson on mole concept. TINMIG was given to two colleague researchers and two SHS teachers to judge the content and for cross checking to test for honesty and clarity. Internal validity of TINMIG was ensured through credibility where the researchers offered teachers opportunity to add further information to what they had stated earlier. The validity and reliability of TINMIG was also checked by recording the teachers' responses and after transcription, the chemistry teachers were encouraged to compare the transcript with the views they held. This helped to also ensure trustworthiness of the interview. The reliability was also determined by practicing interviewer neutrality, where the interviewer ensures rigour by not adding to the responses from the teachers. Reliability was further ensured by consistent coding of the responses.

Feedback on Mole Concept Instruction Observation Checklist (FMIOC) was constructed by the researchers based on the responses of the teachers during the interviews. FMIOC was constructed on present/absent scale. The purpose of observation checklist was to confirm what teachers professed to do and to what they actually practice in lessons on mole concept. To ensure validity, the observation outcome was not predicted before conducting the lesson observation. The outcomes of the lesson observation were not being overstated or understated by the researchers. For reliability, the researcher observed an aspect of the lesson at a time.

2.3 Data Collection Procedures

The researchers embarked on two to three times visit to some of the schools, before the completed questionnaires were received. The collection of data using TKPMQ with schools A, B C and D lasted for 2 weeks. The 32 teachers responded to TKPMQ achieving a response rate of 100%. Another 2 weeks were used to conduct interview with the teachers using TINMIG as a guide in Schools A, B, and C. A minimum of one hour for each interview section. This was done to give the teachers enough time to adequately respond to the questions asked by the interviewer. Rapport was established between the interviewer and the teacher before the interview began. The responses were recorded to encourage triangulation and teachers were given the chance to give more information for better summary and adequacy of the analysis. The interviews were in two parts; before a lesson on mole concept and after the lesson. The interview before the lesson was proceeded by lesson observation to confirm the responses of the teachers on how mole concept is to be taught to students and another, after the lesson observation.

2.4 Data Processing and Analysis

The research question was answered using means, percentages, standard deviations, and themes. For each item, the mean scores on the Likert scale were calculated. The five-point Likert-type scale was reduced to Agree, Uncertain, and Disagree. That is a mean of 5.00 – 3.50 indicated Agree, 3.49-2.50 was Uncertain, and 2.49- 1.00 was Disagree. The outcomes of the interviews and observations were open-coded and constantly compared and themes generated.

3. Results

The research question examined, in part, the perceptions of chemistry teachers in teaching mole concept in senior high schools. To achieve teachers' perceptions on the mole concept, Items 4-18 on TKMPQ were used. The mean perceived scores on teaching of the mole concept are presented in Table 1.

Table 1: Teachers' Perception on Mole Concept (N = 32)

Item	n	%	M	SD
4	26	81.25	3.91	1.20
5	26	81.25	4.00	1.16
6	26	81.25	4.13	1.04
7	22	68.75	3.59	1.16
8	15	46.88	3.47	1.24
9	26	81.25	3.97	1.03
10	26	81.25	4.16	1.14
11	24	75.00	3.88	1.21
12	29	92.63	4.31	0.82
13	12	37.50	3.44	1.13
14	8	25.00	2.44	1.16
15	7	21.88	2.56	1.11
16	10	31.25	3.31	0.97
17	13	40.63	3.00	1.19
18	31	96.88	4.63	0.55
Overall mean			**3.65**	**0.38**

Where:
N = the total number of teachers who participated in the study
n = the total number of teachers who agreed to each item
M = the perceived mean score
SD = Standard deviation

From Table 1, the results show that, there were three aspects to the teachers' perception of the mole concept. That is, teachers agreed, disagreed or uncertain on some statements relating to mole concept. Amongst all the statements that teachers agreed to, Item 18 obtained the highest frequency and mean. That is, of the 32 teachers, an overwhelming majority (96.88%) with highest mean of 4.63 (SD = 0.55) agreed that *mole concept can be understood better if teachers teach with adequate teaching and learning materials (resources)*. This implies that, only 3.12%, being an individual teacher disagreed to the statement. Hence, it is perceived by teachers that they could help enhance students' conceptual understanding of the mole concept if they (teachers) use adequate teaching and learning resources in teaching it. On Item 12, of the 32 teachers, majority (92.63%) with means of 4.31 (SD = 0.82) agreed that *mole concept is a concept which involves practical work*. That is, only 7.37%, being two teachers disagreed to the statement. This implies that, the teachers perceived that, teachers should teach the mole concept through practical activities, possibly in the laboratory where the concept could be made real to students. With respect to Items 4, 5, 6, 9, and 10, the results show that an equal proportion of teachers (81.25%) agreed to the statements on the mole concept. On Item 4, teachers, respectively with means of 3.91 (SD = 1.20) agreed that, *mole concept is a concept which has to do with molecules and atoms*. That is, only 18.75% of the teachers disagreed to the statement. Hence, the teachers perceived that the mole concept is about the molecules and atoms of substances. On Item 5, teachers with a mean of 4.00 (SD = 1.16) agreed that, *they most of the time consider mole as the unit of the amount of substance*. That is, only 18.75% of the teachers disagreed to the statement. Hence, the teachers perceived that, the mole is only the unit of the amount of substance. On Item 6, teachers with a mean of 4.13 (SD = 1.04) agreed that, *they have enough scientific conception about mole concept and as such, they have clear knowledge of scientific language, chemical names and terms under the mole concept*. That is, only 18.75% teachers disagreed to the statement. This implies that the teachers perceived that, they have what it takes such as scientific language, chemical names and terms to present the mole concept to students. On Item 9, teachers with a mean of 3.97 (SD = 1.03) agreed that, *the mole concept requires students to incorporate information from other concepts*. This indicates that, once again only 18.75% of the teachers disagreed to the statement. Hence, the teachers perceived that, teaching mole concept requires that students incorporate information from other concepts. On Item 10, of the 32 teachers, (81.25%) with a mean of 4.16 (SD = 1.14) agreed that, *mole concept is a concept which requires mathematical knowledge for it understanding*. That is only 18.75% of teachers disagreed to the statement. Hence, the teachers perceived that, a good mathematical knowledge could help students to understand the mole concept. In addition, on Item 11, of the 32 teachers, 75.00% with a mean 3.88 (SD = 1.21) agreed that, *mole concept is brief and relates to the Avogadro's number and mass of substance in 12g of carbon-12*. That is 25% of the teachers disagreed to the statement. Hence, the teachers perceived the mole concept as a brief one, only relating to Avogadro's number and mass of a substance in 12g of carbon-12. On Item 7, 68.75% of the 32 teachers with a mean of 3.59 (SD = 1.16) agreed that, *applying the mole concept to stoichiometric calculations is very easy*. That is 31.25% disagreed to the statement. Hence, teachers perceived that an understanding of the mole concept could help students easily apply the concept to solving stoichiometric calculations.

In another perspective, the results from Table 1 show that, majority of the teachers disagreed on only one statement on the mole concept under Item 14. This is because, of the 32 teachers, 75.00% with mean of 2.44 (SD = 1.16) disagreed that, *the mole concept has a narrow scope*. This indicates that 25% of the teachers were in agreement that the mole concept has a narrow scope. This implies that teachers really know that the mole concept is a broad area of teaching and learning under chemistry.

Additionally, there were five instances that teachers involved in the study were uncertain on the perceived nature of teaching and learning of mole concept in senior high schools. On Item 8, of the 32 teachers, 53.12% with a mean of 3.47 (SD = 1.24) failed to agree or disagree to the statement that, *mole concept is well introduced in an explicit way in textbooks*. This indicates that less than half of the teachers were either in agreement or disagreement to the statement. Hence, teachers were uncertain whether the mole concept is explicitly introduced in chemistry (and science) textbooks. On Item 13, 62.5% of the teachers with a moderate mean of 3.44 (SD = 1.13) failed to agree or disagree that, *the mole concept is easy to teach*. This indicates that 37.5% of teachers either agreed or disagreed to the statement. This implies that mole concept is neither difficult nor less difficult to teach by teachers involved in this study. On Item 16, of the 32 teachers, 68.75% with mean of

3.31(SD = 0.97) were uncertain that, *mole concept is the concept whose teaching resources are easy to find and use*. That is, 31.25% of the teachers failed to agree or disagree that teaching and learning resources were readily available for teaching mole concept to SHS students. Also, on Item 17, of the 32 teachers 59.37% with mean of 3.00 (SD = 1.19) were uncertain that, *mole concept can become understandable when one had adequate historical or evolutional knowledge about it*. That is, 40.63% either agreed or disagreed to the statement. Hence, teachers were uncertain whether historical or evolutional knowledge in mole concept can facilitate student learning of it. On Item 15, the results show that 78.12% of the teachers with mean of 2.56 (SD = 1.11) were uncertain that, *they used few periods to complete lessons on mole concept*. Only 21.88% of the teachers either agreed or disagreed to the statement. This implies that, the mole concept though very broad, teachers were not sure of having the required period of time for completion of lessons on the concept. From Table 1, the overall mean of 3.65 (SD=0.54) on teacher's perception about the nature of mole concept, shows that teachers even though were uncertain on some of the items on the nature of the mole concept, they have moderate positive perception about the nature of the teaching of mole concept.

The research question further examined what teachers professed to practice in teaching mole concept and what actually happened in their lessons. To achieve this, some lessons on mole concept were observed from both experienced and novice teachers. Five themes emerged from the interviews and observations as:

Teaching and Learning Resources: are materials and equipment needed to facilitate students' learning of mole concept. Teaching mole concept was faced with lack of adequate teaching and learning resources. These resources were information communication and technology-based and conventional laboratory materials. Examples are animations, hypermedia, interactive boards, models, crate of eggs, and ice board. A teacher with 8 years teaching experience stated that;

> *"There is no teaching learning materials or models available and as such, students are hardly involved in the mole concept lesson"* (School A, Teacher).

Another teacher with 2 years teaching experience explained initially that, personally there are no challenges in teaching mole concept in relation to their school, but later expounded that;

> *"Mole concept is difficult because of the lack of practice, and this mole concept lack practical items in teaching it as the equipment are not there. But I still try to teach it any way"* (School C, teacher).

From School B, an extract of an interaction with teacher after a lesson on mole concept is:

Researcher: *How long have you been teaching chemistry?*
Teacher B: *7 years.*

Researcher: *Unlike your colleagues in other schools, you do not have a challenge with teaching and learning resources?*

Teacher B: *Oh madam! You made me smile.*

Researcher: *Why?*

Teacher B: *It is a challenge everywhere but we try to manage it.*

Researcher: *How do you manage to deliver your lessons?*

Teacher B: *I try to use group activity and demonstration that hardly benefit individual differences as seen in this lesson.*

Time Allocation: is the time period allotted for teaching chemistry. Time only came up as issue in two of the selected schools. Mole concept is broad and requires a lot of periods in teaching and learning it but there was no sufficient time for teachers to do so. Most of the teachers complained that they are not able to complete lesson on chemistry (for example, mole concept) because the concept entailed a lot. From School B, a teacher stated that;

"The mole concept requires enough research and time in teaching it" (School B, teacher).

From School C, the teacher had no issue with the time but indicated that it was difficult to achieve the lesson objectives as the lesson started late.

"Time is not the problem. I didn't achieve all the objectives because the class was late".

Pre-requisite Knowledge: is lack of prior knowledge by students and teachers' in-depth knowledge about mole concept. Research has showed that having enough knowledge in a form of prior knowledge about mole concept is the key for understanding the concept (Goh, 2002). The teachers from the three schools attributed some of their problems in teaching, in part, to pre-requisite knowledge in diverse forms. For instance, an extract of an interaction with Teacher A is:

Researcher: *Did you say another problem is students' knowledge?*

Teacher A: *Yes.*

Researcher: *Can you explain further?*

Teacher A: *Yeah. Most of the students have no knowledge of mole concept.*

Researcher: *Yes; but that is the reason they are in school?*

Teacher A: *I meant that students do not have background knowledge relating to the mole concept for me to build on.*

From School B, the teacher was keen about teacher's knowledge in mole concept and how the teacher prepares to teach any aspect of the concept. The teacher indicated that;

"*Before he teaches, he will first tell students to read on mole concept before he starts to teach it*" (School B, teacher).

From School C, the teacher indicated that;

"*I expect the students to remember previous lessons on mole and I will read further on stoichiometry to have more control over the difficult aspects of the concept*" (School C, teacher).

Nature of Concept: explains how teachers perceive mole concept. The teachers in their attempt to talk about the problems facing the teaching and learning of mole concept identified the nature of the concept as one of the problems. The nature of the mole concept was identified to be abstract and mathematical. One of the teachers mentioned that;

"The shared difficulties are in some calculations aspect of mole. For instance, if you are asked to write equation and find the amount of compound in the reaction" (School B, teacher).

From School C, the teacher explained that;

"*Another issue is students solving problems on mole concept. Problems involve calculations and students usually do not like calculations. … the problem to be solved covers more than one area on mole*" (School C, teacher).

From School A, the teacher explained that;

"*When you teach mole, you expect your students to be able to solve problems on it. But students complain it is difficult and too abstract*" (School A, teacher).

Issues of Attitude: is the mind-set teachers and students have about teaching and learning of mole concept. Attitudes of teachers and their students toward mole concept is additional problem facing the teaching and learning of the concept. For example, a teacher complained that;

"Students have made up their mind not to understand lessons on mole concept (School A, teacher).

Aside the interviews, lessons were observed on mole concept based on the responses given during the interviews. From School A, the teacher taught lessons on introduction to mole, molar mass, and concentration.

Concerning lesson delivery, the teacher said that;

> *"I will deliver lesson by using crate of eggs and salts to introduce the mole concept to them, after which I will teach the other aspect as it is in the textbook. I will also solve more questions with the students"* (School A, teacher).

However, this was found to be absent in the lesson. That is the teacher neither used the crate of eggs and salt nor solve more questions with students.

From School B, the teacher taught molar mass, Avogadro's number, concentration, and molar mass. Prior to the lesson delivery, the teacher explained that;

> *"I will deliver lesson by narrating story to bring students understanding in mole concept"* (School B, teacher).

Unfortunately, this was absent in the lesson delivered. That is the concept was never related to any everyday experiences.

From school C, the teacher taught lesson on the introductory aspects of the mole. Prior to the lesson, the teacher declared that;

> *"Mole concept had to do with measurement and so in teaching, I will ask my students if they had once measured anything and from there, I will tell them that mole concept also has to do with measurement. From there, I will start the lesson"* (School C, teacher).

However, this was absent in the lesson and the teacher never used any resources throughout the lesson delivery to make the concept real to students.

4. Discussion

Teachers perceive that, adequate teaching and learning resources are needed for teaching and learning of the mole concept. These adequate teaching and learning resources are very necessary to enhance the understanding of abstract and difficult concept such as the mole. Some examples of these teaching and learning resources aside the traditional ones include, models, animations, audio-visuals, but teachers hardly employed them in teaching mole concept. The chemistry teachers involved in this study may have perceived positively to the use of teaching and learning resources for teaching mole concept but factors, such as lack of training and motivation of teachers, lack of technical support staff, and lack of funds could have affective how teachers effectively use the resources in teaching chemistry (Achimugu, 2016). The finding that teachers perceive the teaching of the mole concept to be aided by the use of teaching and learning resources may not be new as literature on science and science-related courses has affirmed the assumption that science is practical in nature and require an effective use of teaching and learning resources. Adequate teaching and learning resources could influence teachers' selection and usage of instructional strategies to enhance conceptual understanding in mole concept. The practical activities could make the concept less difficult as mole concept cannot be said to be at macroscopic, microscopic or symbolic level of representation by teachers in another study (Pekdağ & Azizoğlu, 2013). The finding that teachers perceive the mole as just the unit of the amount of substance could be a contributing factor to the difficulty of students in learning the mole concept. This is because if a teacher teaching the mole concept considers it only as the unit of the amount of substance instead of its broad picture, then transferring the true concept of mole to students could be a problem, compounding the difficulties students have in learning the concept. This confirms the report of Taber (2011) that, students usually make meaning of chemical concepts in the way that they were taught. Hence, if students have difficulties in the mole concept as reported by WAEC (2015; 2016; 2017), then teachers' conceptual understanding of the concept could be a contributing factor. Teachers have what it takes to present the mole concept to students could be seen as contradictory as teachers most at times see the mole as just the unit of the amount of substance. Teachers' continuous comprehension of the mole concept as a brief concept or the unit of the amount substance should be a serious concern to chemistry educators, researchers, and policy makers. This is because from literature, the mole concept is one of the important concepts underpinning many other concepts, such as stoichiometry without which students are bound to face conceptual difficulties in learning chemistry (Shadreck & Enunuwe, 2018). This goes further to confirm that students can only learn what their teachers understand and teacher difficulties in the mole concept are likely to be transferred to students (Chavan, 2013). If teachers are uncertain about an explicit introduction of the mole concept in textbooks, then the question to be raised is about the kinds of textbook being used as references on teaching and learning of mole concept. If not, the chemistry curriculum (MOESS, 2010) recommends the concept to be explicitly introduced to students at SHS1 under the Avogadro's number. The mole concept requires mathematical knowledge for its understanding. Teachers have come across several calculations on mole concept and as such are aware of the mathematical nature of the concept. Many teachers, therefore, place much importance on mole concept as a concept which is mathematical and involves several problem solving that could be difficult to students (De Quadros et al., 2011).

It is expected that the teachers could have perceived the mole concept to be difficult or not as they have been teaching it over the years, but they are uncertain. This disconfirms the findings of Shehu (2015) where teachers are sure of the difficulty associated with the mole concept. If teachers are uncertain on the level of difficult in a particular chemical concept, then how will they be in the position to select the most appropriate instructional strategies to help enhance the conceptual understanding of students on mole concept? Chemistry educators and researchers could further investigate reasons behind the teachers' inability to describe the level of difficult of teaching and learning of mole concept as the current study could not investigate that. There is uncertainty among teachers in relation to availability of teaching and learning resources though they perceive that teaching and learning resources could help enhance students' conceptual understanding of mole concept. The teachers could be described as not resourceful as they are uncertain about the availability of teaching and learning resources. It is, therefore, recommended that chemistry educators, from teacher education institutions, should prepare pre-service teachers so that they would be able to select and use the most appropriate teaching and learning resources in addition to appropriate instructional strategies for teaching mole concept.

It is expected that teachers will perceive that learning mole concept need no historical or evolutional knowledge as it is a chemical concept needing chemistry and mathematical orientation to conceptualise it. This position of teachers could be another contributing factor of students' difficulties in learning mole concept. This is because if teachers are unable to clearly define the pre-requisite knowledge needed to understand mole concept, then it may be difficult for them to select the most appropriate instructional strategies to help their students make meaning of the concept (Lok, Yau, & Aw, 2017). It could also be that, the lack of the evolutional and historical knowledge about mole concept means more difficulties in understanding the mole concept. Teachers focus on only concepts in textbooks, which actually may not have enough information on the historical and evolutional knowledge on mole concept though required (Padilla & Garritz, 2014). And teachers transfer this insufficient knowledge in textbooks to students. The Ghana Education Service should organise seminars and workshops where experts could train chemistry teachers to appreciate that historical or evolutional knowledge in mole concept could facilitate students' conceptual understanding on the concept.

Additionally, it can be said then that unlike we are used to reading that there are few time allocations for teaching science-related concepts, the mole concept cannot be said to have sufficient or insufficient time for teaching and learning in the perspective of teachers involved in this study. This finding on time allocation is revealing. This is because time is one commodity affecting the effective teaching and learning of chemical concepts, such as mole concept. Teachers may find it challenging to complete mole concept if the time allocated to chemistry is insufficient. Teachers may not have time to spare to select instruction strategies that consume a lot of time in teaching and learning process but could help students to develop the correct conceptual understanding of the mole. Mole concept is broad in nature and more time periods had to be allotted in teaching it. Findings from the interviews and lesson observations show that teachers though are aware that adequate teaching and learning resources help students to understand mole concept but do not employ them in the teaching and learning of the mole concept. This is because there are inadequate teaching and learning resources available in their schools. In some of the schools, there are some resources, such as ice board available but hardly do the teachers use them in the teaching of mole concept. This, then becomes an attitudinal issue than availability. Teachers are, therefore, encouraged to use teaching and learning resources as they help students to conceptualise (Swan, 2005) chemistry. Previous knowledge and experiences of both teachers and students are important to fully conceptualise the mole and if students lack these, teachers cannot take advantage to help them confront any alternative conceptions. This because students can make meaning of mole concept from their previous experiences and teachers will have to take advantage that. If teachers fail to have in-depth knowledge in previous aspects of mole concept prior to new information, it will be difficult for teachers to help their students. Teachers are, therefore, encouraged to adequately prepare in the area of content to use their instructional strategies to deliver the content to students. Teachers (and their students) should appreciate the mathematical nature of mole concept, which has already been identified as abstract, being affected by language (Suchting, 1998). That is most aspects of mole concept involves problem solving and therefore, teachers should use mathematical approaches (Moss & Pabari, 2010) to help students overcome their difficulties. It is serious if teachers do not practice what they say with respect to the use of teaching and learning resources in their lesson. This is an indication that teachers normally tell best practices in theory but practice different things in reality (Ching, 2014). This attitude of the selected teachers is serious and may have contributed to students' difficulties in learning mole concept. Teachers practicing something different from what they profess to do could be that teachers just have theoretical knowledge about the adequate teaching and learning resources and how best to use them in an instruction but cannot practice it. This could also be attributed to the fact that there are inhibitors (Adu-Gyamfi, Ampiah, & Agyei, 2018) such as pre-requisite knowledge and nature of the concept, to the teaching of chemical concepts. Chemistry teachers are, therefore, encouraged to put into practice what they profess to implement in their classrooms to make lessons effective helping students to make meaning of chemical concepts.

5. Conclusion

The study, generally, revealed that chemistry teachers' perspective of the nature of the teaching of mole concept vary and that, their moderate positive perceptions of this nature of teaching of mole concept are full of uncertainties. Teachers' perspective and practice on teaching mole concept in highs schools are affected by problems such as teaching and learning resources, time allocation, pre-requisite knowledge, nature of concept, and issues of attitude. The study has added to the literature that chemistry teachers do not practice what they profess to and hence, contributing to students' difficulties in learning mole concept. Since teachers do not have positive attitudes toward their practice (as they practice something contrary to what they planned for), it is, therefore, recommended that Ministry of Education through Heads of senior high schools should monitor chemistry teachers to ensure that they effectively teach the concept to students by implementing their planned lessons.

Conflict of Interest Statement
The authors declare no conflicts of interests.

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