Senior High School Students' Perception of Difficult Chemistry Topics

Abstract

This study investigated students' perceptions of difficult chemistry topics. The sample was sixty (60) SHS Form 2 chemistry students. It was found that only five out of the twenty-three topics (21.7%) were perceived to be easy by the students, whiles 78.3% were perceived to be difficult. The topics perceived as easy were basic safety laboratory practices, the particle nature of matter, atomic structure, chemical bonding and hybridisation, and the shapes of molecules. However, the topics perceived to be difficult for the students were: amount of substance and the C-12 scale; solutions, stoichiometry, and chemical equations; nuclear chemistry; enthalpy changes and bond enthalpies; periodic chemistry; rate of chemical reactions; transition metal chemistry; acids, bases, and the concepts of PH and POH; electrochemical cells; solubility; organic chemistry; redox reactions, and balancing redox reactions; chemical equilibrium; hydrolysis of salts; and acid-base titration and redox titration. The study found that students have a low perception of chemistry (M = 3.30, SD = 0.61). However, it was found that students held positive perceptions on the dimensions of value of chemistry, gender, and interest in chemistry. The students held negative perceptions in fear of chemistry and the characteristics of chemistry dimensions. There was no significant difference in perceptions of difficult chemistry topics between males (M = 3.025, SD = 0.36) and females (M = 2.98, SD = 0.417), t (58) = 0.356, p = 0.723. Again, there was no significant difference in the perception of students towards chemistry between males (M = 3.22, SD = 0.60) and females (M = 3.54, SD = 0.61), t (58) = -1.83, p = 0.07. Teachers can use interactive learning approaches and inquiry-based learning to involve students in fostering curiosity and exploration. Chemistry teachers can utilise technology tools such as interactive simulations, virtual labs, and multimedia resources to enhance learners' understanding of abstract chemistry concepts.

Keywords: *chemistry, perceived topic difficulty, perception of chemistry, senior high school, levels of representation.*

1. BACKGROUND

Chemistry plays an important role in the development of a country (Emendu&Emendu, 2017; Samuel et al., 2010). Udogu (2010) described chemistry as a body of knowledge that stands in a central position among the basic sciences. Knowledge of chemistry plays a significant role in transforming the environment, improving quality of life, and understanding the environment in which we live (Samuel, Harcourt, & Harcourt, 2010).However,because chemistry topics are related to the structure of matter, it proves to be a difficult subject for students to understand. One reason is that, Chemistry curricula commonly incorporate many abstract concepts (Taber, 2002), which are significant since future chemical concepts or theories cannot be easily understood if the learner does not understand the underlying concepts (Coll &Treagust, 2001a; Nicoll, 2001). Ogembo (2012) agreed that the background of the students, and negative perceptions toward chemistry, are the major causes of students' poor performance in chemistry.

2. STATEMENT OF THE PROBLEM

Students perceive chemistry as abstract, difficult to learn, and unrelated to the world (De Vos et al., 2002; Osborne & Collins, 2001). Chemistry is perceived as difficult because of its specialised language, mathematical and abstract conceptual nature, and the amount of content to be learned (Gabel, 1999). This is exacerbated by the requirement for quick transmission of thought across the macroscopic, sub-microscopic, and symbolic levels (Johnstone, 1999; Gafoor & Shilna, 2013). Real understanding of chemistry demands meaningful teaching (Sirhan, 2007). Research found evidence of misconceptions, rote learning, and certain areas of basic chemistry that are still not understood(Sirhan, 2007).

Conceptual understanding in chemistry is the ability to explain chemical phenomena through the use of macroscopic, molecular, and symbolic levels of representation (Johnstone, 1993; Wu et al., 2001; Gafoor & Shilna, 2013). When relationships are formed among these three levels of representation, students understand chemistry better (Sanger, Phelps, &Fienhold, 2000). At the macroscopic or phenomenal level, properties can be seen and measured. At the sub-microscopic level, the molecular structures of the particles cannot be seen. The symbolic level is how a chemical formula represents a substance. However, students have difficulties creating links across these levels (Gafoor & Shilna, 2013). The degree to which a student can comprehend a topic is referred to as topic or concept difficulty. Topic difficulty ranges from the least difficult, where the learner progresses in the concept from rote to meaningful learning (Novak, 2002; Grove & Bretz, 2012), to the most difficult, where the learner encounters challenges in learning the concept meaningfully (Oladejo et al., 2023). According to Cañas and Novak (2014), concept difficulty refers to the ease or difficulty of attaining an understanding of the concept.

Research found that students perceive organic chemistry as a difficult topic (Halford, 2016; Hanson, 2016; Nartey & Hanson, 2017; Childs & Sheehan, 2009; Jimoh, 2004; Johnstone, 2006). For example, Hanson (2016) reported that Ghanaian students do not understand the nature of matter and cannot connect the three representational levels of matter.According to Hanson (2017), most students cannot understand these levels of thought well and thus form a weak foundation for further study of organic chemistry concepts. Adu-Gyamfi et al. (2013) also found that Ghanaian senior high school students performpoorly in naming and writing of the structure of organic compounds. Similar studies revealed that senior high school students perceived the classification of organic compounds as difficult to understand (Davis, 2010; Donkoh, 2017). Therefore, this study intends to discover the chemistry topics in the Ghanaian Senior High School chemistry syllabus that students perceive as difficult to learn and comprehend. The study seeks to answer the following questions:

1. What are students perceived difficult topics in chemistry?
2. What is the perception of students towards chemistry?
3. Is there any significant difference in perceived difficult chemistry topics between males and females?
4. Is there any significant difference in perceptions of chemistry between males and females?

3. RESEARCH HYPOTHESIS

- $H_0$1: There are no significant differences in the students' perceived difficult chemistry topics between males and females.
- $H_0$2: There is no significant difference in perception of chemistry between males and females.

4. LITERATURE REVIEW

4.1. Chemistry topic difficulty

Proper understanding of the concepts of various topics in chemistry is a requirement for the good performance of students in examinations, which guarantees the realisation of learning objectives.

Chemistry students should be able to investigate and verify scientific information and communicate scientific ideas as part of their academic experience. These essential elements of a high school chemistry curriculum will help students make informed decisions about relevant scientific issues (ACS, 2012).

The knowledge gained from learning chemistry translates to the development of skills needed for the technological advancement of any nation. An individual's understanding is a predisposition to his or her perception. Perception is a cognitive activity in learning and a mental process that involves an individual's ability to discern the concept and reason toward the accepted view point (Agogo et al., 2013).

Students' perceptions of difficult chemistry topics have attracted serious attention***.*** For instance, Jimoh (2010) discovered that students perceive the particulate nature of matter, chemical combination, gaseous state and gas laws, energy level of atoms, qualitative and quantitative analysis, rate of chemical reactions, chemical equations, non-metals and their compounds, thermochemistry, and nuclear chemistry as difficult topics in secondary school chemistry. Agogo and Onda (2014) identified mass-volume relationships, reactivity series, hydrocarbons, and organic chemistry as perceivedly difficult topics. According to Agogo and Onda (2014), the reasons for topic difficulties were the abstract nature of chemistry concepts, inadequate practical activities, a lack of instructional materials, poor knowledge of mathematical aspects of chemistry, language problems, a lack of textbooks, poor teachers' understanding of concepts, and an overcrowded classroom. Uchegbu et al. (2016) also found that students perceived gas laws, mass-volume relationships, hydrocarbons, and alkanols as difficult topics in senior high school chemistry. Omiko (2017) identified students' difficulties in nuclear chemistry, metals and non-metals and their compounds, rates of chemical reactions, qualitative analysis, and acid-base reactions. Gongdenet al. (2011) found that students perceive chemical reactions, balancing of redox reactions, electrode potential and electrochemical cells, laws of electrolysis, chemical equilibrium, solubility, and IUPAC nomenclature of organic compounds as difficult.

4.2. Levels of representations in chemistry

According to the American Chemical Society (ACS), to promote scientific literacy, the chemistry curriculum should expose and engage learners in activities that involve problem solving and critical thinking (ACS, 2012). However, acharacteristic of chemistry is the constant interplay between the macroscopic and microscopic levels of thought (Bradley & Brand, 1985).The view that the interplay between macroscopic and microscopic worlds is a source of difficulty for many chemistry learners (Sirhan, 2007). Students should acquire an appreciation for the interactions of matter at the macroscopic level, the atomic level (ACS, 2012).

There are three levels of chemical representation — macroscopic, symbolic and submicroscopic — that are directly related to each other (Johnstone, 1982). The macroscopic level is the observable chemical phenomena that can include experiences from students' everyday lives, such as colour changes, observing new products being formed and others disappearing. In order to communicate about these macroscopic phenomena, chemists commonly use the symbolic level of representation that includes pictorial, algebraic, physical and computational forms such as chemical equations, graphs, reaction mechanisms, analogies and model kits (Treagust et al. 2003). The submicroscopic level of representation, based on the particulate theory of matter, is used to explain the macroscopic phenomena in terms of the movement of particles such as electrons, molecules, and atoms. These submicroscopic entities are real but they are too small to be observed, so chemists describe their characteristics and behaviour using symbolic representations to construct mental images (Treagust et al. 2003).

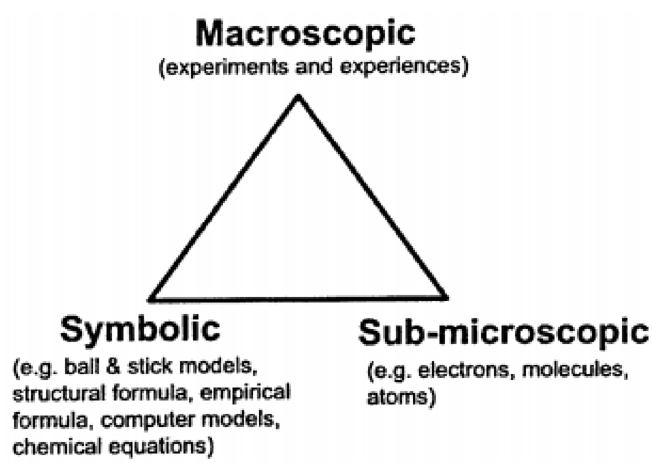

Fig.1 Johnstone's Levels of chemical representations: Adopted from Treagust, Chittleborough and Mamiala (2003).

Johnstone (1991) suggested that one reason science was difficult for students was that it involved what he termed 'multilevel thought'. Students are expected to think about very different concepts immediately (cited in Taber, 2013). Johnstone (1991) posits that learners are usually asked to make sense of teaching about three levels of thought: the macro, the sub-micro and the symbolic levels (Taber, 2013). Johnstone illustrated his point with a triangle with the three apices labelled as macro, sub-micro, and 'symbolic'. According to Johnstone, rather than teaching being focused at one apex, or even along one side of the triangle, it often happened inside the triangle where students were expected to cope with all three 'levels' immediately (Taber, 2013).

Explanations ofthe macroscopic observable chemical phenomena rely on the symbolic and submicroscopic level of representations. The ability of students to understand the role of each level of chemical representation and the ability to transfer from one level to another is an important aspect of generating understandable explanations (Treagust et al., 2003). At the microscopic level, chemical phenomena are explained by the arrangement and motion of molecules, atoms, or subatomic particles. Chemistry at the symbolic level is represented by symbols, numbers, formulas, equations, and structures. Understanding microscopic and symbolic representations is especially difficult for students because these representations are invisible and abstract, while students' thinking relies heavily on sensory information (Wu et al. 2001).

The interactions between these levels are important characteristics of chemistry learning and necessary for comprehending chemical concepts. Therefore, if students possess difficulties at one level, it may influence the other (Sirhan, 2007). According to Johnstone (1991), the nature of chemistry concepts and the way the concepts are represented (macroscopic, microscopic, or representational) make chemistry difficult to learn. Thus, the effectiveness of chemistry teaching depends on the teacher's ability to communicate and explain abstract and complex chemical concepts, and on the students' ability to understand the explanations (Treagust et al. 2003). Chemistry teachers must present new information at an appropriate level for the learner, make use of relevant explanatory artefacts, build on the knowledge and concepts that students already understand (Treagust and Harrison, 1999, cited in Treagust et al., 2003).

5. METHODOLOGY

5.1. Design and Approach

The study adopted a quantitative approach, using a cross-sectional survey design. Survey research is ‘the collection of information from a sample of individuals through their responses to questions’ (Check & Schutt, 2012, p. 160). This type of research allows for a variety of methods to recruit participants, collect data, and utilise various methods of instrumentation (Ponto, 2015).

5.2. Sample and Sampling Techniques

The goal of sampling strategies in survey research is to obtain a sample that is representative of the population of interest (Ponto, 2015). The target population was all senior high school chemistry students in the Kassena-Nankana municipality. The sample consisted of sixty (60) form 2 chemistry students offering general science (39), home economics (6) and agricultural science (15). Three senior high schools that offer a general science programme were purposively selected. Thirty (30) SHS Form 2 science students were selected from each school by using the random sampling technique.

5.3. Instruments

Two instruments were used to collect data. These are the difficult chemistry topics questionnaire (DCTQ), and the chemistry perception questionnaire (CPQ).The difficult chemistry topics questionnaire (DCTQ) was developed by the researcher. The questionnaire consisted of twenty-three (23) chemistry topics drawn from the Ghanaian SHS form 2 chemistry syllabus. Students were required to indicate the level of difficulty on a five-point Likert scale. The options are very difficult (1), difficult (2), neutral (3), easy (2), and very easy (5). Thus, higher scores indicate that the topic is not difficult, and low scores indicate that the topic is difficult. The reliability of the DCTQ was determined by calculating the Cronbach alpha reliability coefficient, which was 0.71.The Chemistry Perception Questionnaire (CPQ) used in this study was adapted from Wells (2003). The CPQ consisted of 23 items on a five-point Likert scale, with options ranging from strongly agree, agree, neutral, disagree, and strongly disagree. The CPQ has five subscales: value of chemistry, gender, interest in chemistry, fear of chemistry, and characteristics of chemistry. Characteristics of chemistry are the perception of inherent characteristics of chemistry. Interest is the perception of one's ability in chemistry. Fear of chemistry is the perception of anxiety concerning chemistry. Gender is the perception that one's gender influences one's ability to learn chemistry. The value of chemistry is the perception that chemistry is important for individuals or society. The development of the CPQ instrument involved experts in establishing both content and construct validity. Cronbach's alpha reliability of the CPQ was calculated to be 0.81 (Wells, 2003).

5.4. Data Analysis

The data was a**nalys**ed using SPSS version 26. Both descriptive and inferential statistics were used to analyse the data. Descriptive statistics, such as means and standard deviations, were used to analyse the data from the DCTQ and the CPQ. Also, inferential statistics were used to compare means of students' chemistry perceptions and topic difficulty by gender. Students' perceptions were categorised and interpreted as either positive perception, moderate perception, or negative perception based on the mean score categories. Also, chemistry topic difficulty was organised as difficult, somewhat difficult, and not difficult (Table 1). The results were presented in tables and graphs.

Table 1: Categories of topic difficulty and chemistry perception

Variable	Mean score	Interpretation
	1.00-2.90	Negative
Perception	3.00-3.50	Moderate
	3.60-5.00	Positive
	1.00-2.90	Difficult
Topic difficulty	3.00-3.50	Somewhat difficult
	3.60-5.00	Not difficult

5.5. Data Collection procedures

Permission was sought from school authorities to conduct the study. The researchers ensured a friendly atmosphere so that the respondents felt relaxed. This was achieved with the help of the school chemistry teachers. The purpose of the study was explained to the students, which was also indicated on the questionnaire. They were told that participation is strictly voluntary. The data collection process took one week.

6. RESULTS AND DISCUSSION

6.1. Demographic characteristics of participants

Table 2 shows the sex and age distribution of the students. Most of the students (73.3%) were males, while 26.7% of them were females. Ninety percent of the students age between 16-20 years.

Table 2: Sex and age distribution of respondents

Sex	**frequency**	**Percent**
Male	44	73.3
Female	16	26.7
Total	60	100
Age		
15-15	5	8.3
16-20	54	90
21-25	1	1.7
Total	**60**	**100**

6.2. Research question 1: What are students' perceptions of difficult chemistry topics?

Table 3 presents the descriptive statistics of perceived difficult topics in chemistry. It was found that only five out of the twenty-three topics (21.7%) were perceived to be easy by the students. The remaining topics (78.3%) were perceived to be difficult. Among the topics perceived not to be difficult were basic safety laboratory practices (M = 4.22, SD = 1.14), particle nature of matter (M = 4.10, SD = 0.99), atomic structure (M = 4.00, SD = 0.99), chemical bonding (M = 3.57, SD = 1.11), and hybridisation and shapes of molecules (M = 3.47, SD = 1.13). The topics perceived by students as difficult include: amount of substance and the C-12 scale; solutions; stoichiometry and chemical equations; nuclear chemistry; enthalpy changes and bond enthalpies; periodic chemistry; rate of reactions; transition chemistry; acids, bases, and the concepts of PH and POH; electrochemical cells; solubility, organic chemistry, redox titration, redox reactions, chemical equilibrium, balancing redox reactions, hydrolysis of salts, and acid-base titration.

Table 3: Descriptive statistics of perceived difficult chemistry topics

sn	Statement	N	M	SD
1	Basic safety laboratory practices	60	4.22	1.14
2	The particle nature of matter	60	4.10	0.99
3	Atomic structure	60	4.00	0.99
4	Chemical bonding	60	3.57	1.11
5	Hybridisation and shapes of molecules	60	3.47	1.13
6	Amount of substance and the C-12 Scale	60	3.33	1.22
7	Solutions	60	3.25	1.11
8	Stoichiometry and chemical equations	60	3.22	1.06
9	Nuclear Chemistry	60	3.18	0.85
10	Enthalpy Changes and bond enthalpies	60	3.15	1.05
11	Periodic Chemistry	60	3.02	0.95
12	Rate of reactions	60	2.88	1.09
13	Transition Chemistry	60	2.72	0.98
14	Acids, bases and concept of PH and POH	60	2.70	1.05
15	Electrochemical cells	60	2.64	1.11
16	Solubility	60	2.63	1.19
17	Organic chemistry	59	2.63	1.14
18	Redox titration	60	2.60	1.04
19	Redox reactions	60	2.54	1.22
20	Chemical equilibrium	60	2.42	1.08
21	Balancing redox reactions	60	2.42	1.20
22	Hydrolysis of salts	60	2.38	1.11
23	Acid-Base titration	60	2.27	1.06
	Overall mean	**60**	**3.01**	**0.37**

Similar to the findings of this study, Kindu et al. (2016) reported that students perceive chemical bonding, thermodynamics, chemical equilibrium, and reaction kinetics as difficult. Adu-Gyamfi et al. (2017) reported that students have difficulties with the IUPAC naming of organic compounds. Similar studies revealed that high school students perceived the classification of organic compounds and petroleum as difficult to understand (Davis, 2010; Donkoh, 2017). Jimoh (2010) found that senior high school chemistry students perceive the particulate nature of matter, chemical combination, gas laws, energy level of atoms, qualitative and quantitative analysis, rate of chemical reactions, chemical equations, non-metals and their compounds, thermochemistry, and nuclear chemistry as difficult topics. In a similar study, Agogo and Onda (2014) reported that students perceive mass-volume relationships, reactivity series, ionic theory, and organic chemistry as difficult topics. Also, Uchegbuet al. (2016) found that students perceived gas laws, mass volume relationships, hydrocarbons, and alkanols as difficult topics. Omiko (2017) found that students have difficulties in nuclear chemistry, metals and their compounds, non-metals and their compounds, rates of chemical reactions, qualitative analysis, and acid-base reactions. Again, Gongden andLohdip (2011) found that students perceive chemical reactions, balancing of redox reactions, electrode potential and electrochemical cells, laws of electrolysis, chemical equilibrium, solubility, and IUPAC nomenclature of organic compounds as difficult. Nartey and Hanson (2017) reported that almost half of the student sampled saw organic chemistry as a difficult topic.

6.3. Research question 2: What is the perception of students towards chemistry?

Table 4 presents the descriptive statistics of students' perceptions of chemistry.

Table 4: Descriptive statistics of students' perception of chemistry

sn	Statement	*N*	*M*	*SD*
1	Chemistry is useful for solving problems of everyday life	60	3.97	0.94
2	Chemistry positively impacts society	60	3.97	0.92
3	Everyone should know some chemistry	60	3.82	1.03
4	Chemistry is easier for males	60	3.65	1.29
5	Males are better at chemistry than females	60	3.57	1.28
6	Chemistry is interesting to me	60	3.53	1.20
7	I do not like chemistry	60	3.52	1.17
8	Only Chemists need to know chemistry	60	3.50	1.17
9	I cannot do chemistry	60	3.42	1.27
10	Chemistry is mainly for males.	60	3.40	1.32
11	I do not have enough math background to do well in chemistry	60	3.37	1.31
12	Chemistry makes me nervous	60	3.30	1.32
13	Chemistry is more difficult for females.	60	3.28	1.45
14	I get anxiety just thinking about chemistry	60	3.27	1.25
15	Chemistry is boring to me	60	3.25	1.37
16	Just hearing the word chemistry scares me	60	3.08	1.41

17	Chemistry has too much math	60	3.07	1.40
18	Chemistry has too much memorisation	60	3.07	1.22
19	Chemistry requires the learning of too many unrelated facts	60	2.88	1.25
20	Chemistry is too abstract	60	2.87	1.17
21	Chemistry has too many concepts or ideas	60	2.82	1.23
22	You must have a scientific mind to do well in chemistry	60	2.78	1.19
23	Chemistry is too difficult	60	2.73	1.36
	Overall mean	**60**	**3.30**	**0.61**

It was found that students have a low perception of chemistry (M = 3.30, SD = 0.61). However, on the sub-scales or dimensions, it was found that students held positive perceptions of the value of chemistry (M = 3.81, SD = 0.721), gender (M = 3.48, SD = 1.04), and interest (M = 3.43, SD = 0.93). The students held negative perceptions of fear of chemistry (M = 3.14, SD = 0.93) and characteristics of chemistry (M = 2.88, SD = 0.686). Table 5 shows the descriptive statistics of the perception dimensions.

Table 5: Descriptive statistics of the dimensions of perception of chemistry

Dimension	*N*	*M*	*SD*
Value of Chemistry	60	3.81	0.721
Gender	60	3.48	1.041
Interest in Chemistry	60	3.43	0.941
Fear of Chemistry	60	3.14	0.938
Characteristics of Chemistry	60	2.88	0.686

6.4. Research question 3: Is there any significant difference in perceived difficulty topics in chemistry between males and females?

Table 6 presents independent samples t-test of perceived topic difficulty by gender.

Table 6: Independent samples t-test of chemistry topic difficulty by gender

Sex	*N*	*M*	*SD*	*df*	*t*	*p*
Male	44	3.025	0.363	58	0.356	0.723
Female	16	2.98	0.417			

The results showed that there is no significant difference in perception of chemistry topic difficulty between males (M = 3.025, SD = 0.36) and females (M = 2.98, SD =

0.417), t (58) = 0.356, p = 0.723. Ajayi and Ogbeba (2017) reported that girls exhibit a more positive attitude towards chemistry than their male counterparts. Tinklin et al. (2001) found that there were more girls than boys who perceived more scientific concepts as difficult to learn. However, Musonda (1991) is of the view that there are no clear-cut differences based on gender in learners' perceptions of difficult topics.

6.5. Research 4: Is there any significant difference in perceptions of chemistry topics between males and females?

Table 7 presents an independent samples t-test of the perceptions of students towards chemistry by gender.

Table 7: Independent samples t-test of perception of chemistry by gender

Sex	*N*	*M*	*SD*	*df*	*t*	*p*
Male	44	3.22	0.60	58	-1.83	0.07
Female	16	3.54	0.61			

The results showed that there is no significant difference in students' perceptions of chemistry between males (M = 3.22, SD = 0.60) and females (M = 3.54, SD = 0.61), t (58) = -1.83, p = 0.07. However, several researchers found significant gender differences in interest in science (Krapp, 2002; Trumper, 2006; Elster, 2007). Logan and Skemp (2008) opined that these gender differences were most likely to be connected to pedagogical variables.

7. Conclusion and Recommendations

There are several strategies to improve the teaching and learning of chemistry in senior high schools and improve students' perceptions of chemistry. These strategies aim to enhance students' understanding, engagement, and retention of chemistry concepts. Chemistry teachers should encourage students to participate in the learning process by engaging in hands-on activities, experiments, and discussions. Chemistry teachers can use inquiry-based learning to foster curiosity and exploration. Chemistry teachers must encourage students to ask questions, investigate phenomena, and develop their own understanding of chemical principles

(American Chemical Society, 2012). Again, chemistry teachers can utilise technology tools such as interactive simulations, virtual labs, and multimedia resources.

Teachers must recognise that students have diverse learning styles, interests, and abilities. Teachers must differentiate instruction by providing different modes of learning, varied resources, and flexible assessments. The Ghana Education Service should support ongoing professional development for chemistry teachers to enhance their content knowledge, pedagogical skills, and familiarity with current research in chemistry education.

Students need to be provided with learning experiences to prepare them to grasp new materials by clarifying or correcting previously held concepts or by providing fundamental instruction on such concepts. It is important to consider the way learners acquire knowledge and to present materials that are consistent with the pattern of human learning. Chemistry teachers must link concepts so that the learner can make a coherent whole of the ideas. This allows for the development and learning of simple but meaningful concepts.

Chemistry teachers should use conceptual change teaching approaches to help eliminate misconceptions that students have about chemistry and topics they perceive to be difficult. Teachers should link the teaching of chemistry to the environment and context of students so that they do not see the subject as abstract. The Ghana Education Service and the National Council for Curriculum and Assessment (NaCCA) should provide infrastructure and apparatus for teaching chemistry at the senior high schools. The chemistry laboratory provides an excellent opportunity to relate the unseen microscopic world to the observable macroscopic world in which we live. Laboratory experiences promote teamwork, inquiry-based learning, hands-on activities, and exposure to standard laboratory equipment and technology (ACS, 2012).
To improve students' perceptions of chemistry, teachers should use hands-on laboratory activities and interactive multi-modal approaches in teaching chemistry. Teachers should use constructivist teaching approaches to improve students' understanding and change their perceptions of chemistry.

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