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# TEACHERS' PROBLEMS OF TEACHING OF OXIDATION-REDUCTION REACTIONS IN HIGH SCHOOLS

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**Abstract:**
The study explored how teachers taught redox reactions to senior high school students. Within a case-study research design, six chemistry teachers with a minimum of 7 and a maximum of 12 years teaching experiences from three schools were interviewed. The results revealed four themes; inhibition of instruction, weak instructional strategy, inability to teach concepts, and teachers' professional development. It was found that teachers employed weak instructional strategies such as expository and out of class group assignments in teaching redox reactions. The study recommends that chemistry educators and researchers should design and develop subject-specific pedagogical content knowledge for teaching redox reactions.

**Keywords:** chemistry teachers, instructional strategy, redox reactions, teaching

## 1. Introduction

Electrochemistry is one other chemical concept given attention in high school chemistry. The areas of concentration under electrochemistry at the high school level, as pertained in Ghana, were oxidation-reduction processes, balancing of redox equations, redox titrations, electrochemical cells, electrolytic cells, and corrosion of metals (Ministry of Education [MOE], 2010). The area for this study was oxidation-reduction process. As an interesting area, a number of research works have identified students'

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difficulties and alternative conceptions in learning electrochemistry (Adu-Gyamfi, Ampiah, & Agyei, 2015; Bong & Lee, 2016; De Jong & Treagust, 2002; Walanda, Napttupulu, & Mallaburn, 2017). Some students' alternative conceptions identified by Bong and Lee (2016) are associated with identifying the cathode and anode, analysing reactions in electrolysis, and writing chemical equations. Also, some students had conceptual difficulties in understanding oxidation and reduction half reactions and the role of salt bridge in electrolysis (Walanda et al., 2017). From Adu-Gyamfi et al. (2015), students' alternative conceptions and conceptual difficulties exist in the introduction of $H_2O$, $H^+$, and $OH^-$ in balancing redox reactions. Bong and Lee (2016) attributed the students' alternative conceptions and other conceptual difficulties to lack of basic knowledge in electrochemistry, challenge with language, and rote learning.

Various approaches to teaching have been observed to have effects on students' performance in redox reactions (Anderson, Mitchell, & Osgood, 2005; Hunt, Sorey, Balandova, & Palmquist, 2010; Majerich & Schmuckler, 2008; Own, 2005; Purtadi & Sari, n.d.; Udo, 2011). Notwithstanding how important redox reaction is in chemistry education and the instructional strategies used in teaching, research findings have revealed that there are difficulties associated with the teaching of the concept. It was observed by De Jong, Acampo, and Verdonk (1995) that chemistry teachers have a difficulty in helping students to accept the electron model as the concept for explaining and identifying redox reactions. In addition, Osterlund and Ekborg (2009) observed that considering the number of months the electronic model of explaining and identifying redox reactions was taught in their study, very few students were able to adopt the concept in explaining the situations of redox reactions. This is an indication that we need to look at the chemistry of redox reactions in the context of how best to teach the concept.

In Ghana, students' performance in redox reactions in senior high school examination is a source of concern in the Chemistry Chief Examiner's reports. This is because students usually show weak performance in test items in the area of redox reactions (West Africa Examination Council, 2004; 2005; 2006; 2007; 2008; 2009; 2011; 2012; 2013). One thing is certain that, the Chief Examiner's reports could not identify the nature of the problem relating to students' weak performance in redox reactions and what actually is/are contributing to the problem. It was therefore necessary to explore the nature of the problem with the teaching of redox reactions in Ghanaian high schools. The purpose of the research, therefore, was to explore how teachers taught redox reactions to senior high schools (SHS) students in Ghana. In working towards achieving this purpose, the research question raised was: 'What do teachers find problematic in teaching redox reactions?'

Many research works around the world in the area of redox reactions have adopted different methods and techniques of teaching. In some cases the methods and techniques are compared (Anderson et al., 2005; Gray & Madden, 2009; Hunt, Sorey, Balandova, & Palmquist, 2010; Majerich & Schmuckler, 2008; Own, 2005; Purtadi & Sari, n.d.; Udo, 2011). For instance, the study of Gray and Madden (2009) used the 5E model of Bybee to investigate the reduction of iron (III) to iron (II) by a natural bacterial anaerobic mineral respiration. The results show that students' understanding was enhanced. From Hunt et al. (2010), the salt bridge in regular galvanic cell battery facilitated the redox reactions between the anode and cathode plates. The two plates are made of two dissimilar metals, acting as a solution for the ions involved. The anode oxidises to release electrons to the cathode, which undergoes reduction by accepting the electrons from the anode thereby providing flow of current. Hunt and his colleagues propounded that, the use of hands-on experiments enables students to conceptualise the electron transfer model of redox reactions (Hunt et al., 2010).

The work of Gray and Madden (2009); Hunt et al. (2010) and others cited in this research work may have used one sample real life situation to develop the concept of redox reactions to students; they may not have catered for all situations and the theoretical basis for such reactions. Chemistry teachers around the world may or may not be using the teaching approaches used by these researchers in teaching their respective students. This is because the difficulties in teaching and learning of redox reactions seem to exist and common among high school students.

Notwithstanding the number of learning theories in the domain of constructivism, they all consider the student as an active participant of the teaching and learning process (Landcare Research, 2002; Ross & Nisbett, 1991). Students' meaning making is built upon mental structures from experience relating to the new information. The previously built mental structures serves as the content for follow up meaning making. Consequently, to all forms of constructivism, students' previous knowledge and experiences are very necessary for further meaning making (Ernest, 2010).

An effective instruction is dependent upon teachers' decision making with respect to teachers' knowledge of the content, subject pedagogy, and the nature of students in the class. Constructivist instruction is to provide students with optimum levels of instruction but not 'direct' or 'minimal' instruction (Taber, 2011). Teachers' view of nature of knowledge influences the selection and use of instructional strategies. It is, therefore, important for teachers to appreciate whether knowledge is independent to us or not. From Hein (1991), constructivist learning theories believed that knowledge is not independent of students and that students have to construct meaning for themselves as they learn. Teachers should understand the world, organise it in the possible rational way and present it to students for them to manipulate the objects of the world.

Hendriks, Luyten, Scheerens, Sleegers, and Steen (2010); Richardson (2003) found that teachers' deep and strong content knowledge is a necessary tool in a constructivist classroom. However, teachers' instructional strategies, learning to learn and reflection on the strategies are equally important in constructivist lessons (Hendriks et al., 2010). This is because those teachers could provide students with opportunities to develop deep understanding of concepts, internalise the concepts, understand the nature of development of knowledge, and develop complex cognitive structures for connections to other bodies of knowledge.

Torre, Daley, Sebastian, and Elnicki (2006) viewed behaviourist instruction as most important in instructing students when an educational intervention is aimed at change in behaviour. That is behavioural instruction strategies stress students' mastery of prerequisite steps ahead of the subsequent steps. In the behaviourist learning environment, teachers mainly arrange the environment to obtain feedback from students. Osborne (1993) explained that as much as over reliance on didactic teaching and learning strategies is not good enough for all students so as over reliance on constructivist strategies, such as co-operative and discussion-based activities for meaning making, could not be good enough for all students. Student motivation and preferred learning strategies differ from student to student and therefore it is not appropriate to centre teachers' teaching strategies on only one learning theory. Such teaching and learning processes could satisfy the need of some group of students whereas others suffer.

> *"In general, high quality constructivist teaching requires more support, more access to resources, more careful design and attention to detail, more progress monitoring, and more carefully craft guidance than traditional instructor-led teaching" (Wilson, 2010, p. 5). Tetzlaff (2009) reiterated that constructivist learning theory does not eliminate teachers entirely from assisting students. That is the traditional role of teachers as information presenters should give way to teachers' role as facilitators in the teaching and learning process (by asking questions, making suggestions, and explaining concepts) in the perspective of constructivism. Though students are responsible for their meaning making under constructivism, teachers are to create opportunities to facilitate student learning."*
>
> (Taber, 2011; Tetzlaff, 2009)

According to Tetzlaff (2009), an introduction of teachers' intervention into constructivist learning environment is very necessary in order to prevent students from developing misunderstanding of the new material and to ensure that students work towards the lesson objectives. In constructivism, the role of teachers is to facilitate the teaching and learning process (Brown, 2005; Wilson, 2010). The constructivist learning theories provide teachers at all levels of education, as well as all subjects/courses, with sound theoretical basis for selection of instructional strategies (Taber, 2011). There was, therefore, the need to explore the teaching of redox reactions to come to terms with the problems thereof, and how best chemistry educators and researchers could help to solve any problem hindering students' conceptual understanding of redox reactions. This is because the planners of the chemistry syllabus recommended that teachers should avoid rote learning and drill-oriented methods in teaching but to use participatory teaching and learning approaches. The participatory approaches would help students to develop cognitively (MOE, 2010).

## 2. Participants and Methods

The design for the research was a case-study research design, as part of a Design-Based Research approach, used to explore the teaching of high school redox reactions. The case-study became necessary as there was the need to understand WAEC chief examiner's persistent lamentations on students' weak performance in redox reactions. The case-study employed only qualitative methods to collect and analyse data, relating to the views of chemistry teachers that made teachers ineffective in teaching of redox reactions at the senior high school level.

Senior high school (SHS) education in Ghana was a post-junior high school education. SHS was considered terminal education for the entry into the world of work and tertiary education (Ministry of Education, Youth and Sports, 2004). SHS education was structured into three years as SHS 1, 2, and 3 for all subjects including chemistry (MOE, 2010). The teaching of chemistry was allotted six periods (of 40 minutes) per week. Of the six periods, there should be two periods of practical lessons and four periods of theory. The work under each year was structured into sections (which consist of a fairy homogenous body of knowledge within chemistry). Each section consisted of a number of units. A unit comprised a more related and homogenous body of knowledge (MOE, 2010).

From MOE (2010), the sections covered at SHS 1 were introduction to chemistry, atomic structure, chemical bonds, conservation of matter and stoichiometry, and states of matter. For SHS 2, the sections were energy and energy changes, inorganic chemistry, chemical kinetics and equilibrium, acids and bases, redox reactions and electrochemistry, and chemistry of organic compounds. And for SHS 3, the sections were chemistry, industry and environment, and basic biochemistry. For the purposes of this research, the section, redox reactions and electrochemistry was selected. The units under redox reactions and electrochemistry were oxidation-reduction processes and oxidising-reducing agents, balancing redox equations, redox titrations, electrochemical cells, electrolytic cells, and corrosion of metals (MOE, 2010, pp. iv-v).

MOE (2010) recommended that students taking chemistry, like all other subjects, should be proficient in English Language and attained high level of achievement in junior high school Integrated Science, with chemistry as an aspect. Chemistry teachers were expected to use teaching and learning approaches that would help students apply knowledge acquired in solving problems to cover these units.

### 2.1 Participants

The study was carried out in high schools in Mampong Municipality, Sekyere Central, and Kwabre East Districts of the Ashanti Region of Ghana. In the three district assemblies, there were 15 SHS. The 15 schools were stratified into science elective schools and non-science elective schools. The elective science schools offered students the General Science Programme where students learn Biology, Chemistry, Physics, and Elective-Mathematics whereas the non-science elective schools offered students General Programmes, such as General Arts and Visual Arts. In the General Programmes, schools offered students Integrated Science as a core-subject.

Of the 15 schools, seven offered elective science as a programme and eight did not offer science as an elective programme. Three schools were randomly selected from the seven schools that offered elective science to students. All the teachers teaching chemistry in each school were involved in the research. A total of six teachers were available for the research. This is because there were two science teachers teaching chemistry in each school at the time of the research. The teachers could be described as experienced teachers as they had been teaching high school chemistry for a minimum of 7 and a maximum of 12 years. The six teachers were involved in the interview sessions on how teachers teach redox reactions to students at the SHS level and the problems thereof.

### 2.2 Research Instrument

The teachers were interviewed at one stage or the other during the period of the research. The interview scheme was a semi-structured interview protocol type where all the teachers responded to the same set of basic questions as:

1. Do you teach redox reactions to your students?
2. How often do you teach your students redox reactions?
3. Explain how you teach redox reactions to your students.
4. What should be the best way for the teaching of redox reactions?
5. Are there any identifiable challenges associated with the teaching of redox reactions?
6. Explain how these identifiable challenges could affect the teaching of redox reactions.
7. Explain what should be done to reduce the effects of these identifiable challenges on teaching of redox reactions.

Giving the teachers the opportunity to respond to the same set of basic questions meant that any form of biasness could have been minimised. The views of the teachers on the teaching of redox reactions were further compared within a broad-based issues. New issues that evolved however in the cause of the interviews were further investigated as the author*1* moved from one teacher to another.

### 2.3 Validity and reliability of interview instrument

To ensure content validity of the items on the semi-structured interview protocols, they were shown to two experts in instructional design and chemistry education. The suggestions from the experts were used to improve the quality of the items. Internal validity of the interviews was ensured through credibility where the researcher offered teachers opportunity to add further information to what they had stated earlier. For the external validity of the interviews, there will be transferability of data. That is sufficient data on the interviews will be provided in the current research for readers and users.

For the reliability in the interviews, the same basic items in the same sequence were used in the protocols. In addition, the interviews were dialogue in nature. The teachers were given sufficient time to organise their thought before responding to any item.

### 2.4 Data Collection Procedure

During the first week of the research, the teachers were interviewed. Where there was the need for follow up interviews, it was conducted to ensure the validity of the views of the teachers in the second week of the research. The teachers' views on the teaching of redox reactions were analysed to explore the nature of the teaching of high school redox reactions and the problems thereof.

### 2.5 Data Analysis

The research question was answered by transcribing the views of the teachers respectively on the teaching and the problems teachers encountered in the teaching of redox reactions at the SHS level. The researcher then made meaning out of teachers' explanations given. From the meanings so constructed from teachers' explanations, themes were deduced, analysed, and discussed thereafter.

## 3. Results

The research question sought to explore teachers' problems of the teaching of redox reactions to their students; leading to four factors. The four factors were:

a) inhibition of instruction (which was any issue that prevent effective instruction of the concept);
b) weak instructional strategy (which was any instruction that did not involve students collaborative learning in making meaning);
c) inability to teach concepts (which was any demand the teaching of redox reactions placed on the shoulders of teachers); and
d) teachers' professional development (which was any internal and external training that enhanced teachers' best practices).

### 3.1 Inhibition of instruction

On issues preventing effective instruction, the inhibitors were found as length of content; quality of students; and teacher's knowledge of concept and instructional strategies. From the number of years, the teachers have taught chemistry at the SHS level, it was obvious that they were not new to the senior high school chemistry in general and the redox reaction in particular. This is because two of the teachers had taught for 7 years, one for 9 years, two for 10 years, and the other, for 12 years. The teachers easily outlined the major aspects of redox reaction they usually taught as if they were copying from the actual chemistry syllabus (MOE, 2010; 2012).

- *"Definitions of oxidation and reduction reactions using addition/removal of oxygen and hydrogen, oxidation number, and transfer of electrons;*
- *Examples of redox reactions such as combustion and displacement reactions;*
- *Reducing and oxidising agents;*
- *Half reactions;*
- *Balancing of redox equations in both acidic and basic media;*
- *Redox titrations;*
- *Electropotentials;*
- *Electrolytic cells;*
- *Electrolysis; and*

- *Corrosion of metals*." (Kyei, Teacher, School C)

The quality of students was identified to be a major factor that may or may not prolong the time for teaching redox reactions at the SHS level. It was found that in a class where majority of students were good (high-achievers) and they could work extra hard, teachers usually spent a few weeks to complete the redox reaction outline.

Out of the six teachers, four indicated they spent a lot of time in teaching redox reactions to students in a class which could be described as a weak one (low-achievers). For instance, Asare explained that,

> "*…it takes long time to teach redox especially if the class is slow… it can take half of the term and the problem can be solved by taking it earlier with such students*". (Teacher, School A)

Also, two of the teachers interviewed felt that students' previous knowledge and experience determined the time for teaching the concept. For instance, Berko indicated that,

> "*…the foundation of the students prolongs the time period for the teaching. In one instant I used the whole term as I have to take care of what the students should have learnt before redox as well*". (Teacher, School B)

In addition to these, the teachers acknowledged that their own knowledge of the content and appropriate instructional strategy influenced the time taken to complete the teaching of redox reactions. Kyei, for instance, summed it all up as,

> "*…if I know my subject matter very well and weaknesses of my students, I can easily select a strategy that will suit them. This will help to manage the number of weeks the topic will cover*". (Teacher, School C)

### 3.2 Instructional strategies

It was generally accepted by the teachers that their instructional strategy was very important in teaching redox reactions as four of them talked about teacher-led strategies and two talked about practical lessons and ability grouping. The selection of a particular instructional strategy was linked to students' characteristics. According to Sekyere,

> "*…teaching methods is important here but I need to understand and appreciate first the strength and weakness of my students ahead of the concept*." (Teacher, School C)

The number of instructional strategies identified were categorised as formal and informal. These were expository, questions and answers, reading assignments, practical lessons, problem-solving, ability groups, and "I do-you do-we do". Four of the teachers who used teacher-led strategies agreed that the concept of redox reactions (using addition and removal of oxygen or hydrogen, oxidation number, and transfer of electrons) was usually taught to students using the expository (lecture) method. The expository method was not only used as the instructional strategy at the introductory stage of redox reaction but also used in presenting almost all the theoretical aspects of the concept by the teachers. These expository strategies were interspersed with reading assignments and "questions and answers" sessions.

One of the teachers, on the other hand, explained that all aspects of redox reactions should be taught through practical activities. However, where materials and equipment were not available for practical lessons, strategies other than the expository method could be used. He indicated that one of such strategies was the use of ability groups. The following was an extract of an interaction with Kyei:

> "Researcher: *Do you also use lecture in teaching redox reaction?*
> Kyei: *No; I use ability groups.*
> Researcher: *What is ability group?*
> Kyei: *I try to identify the students who are good and mixed them with weak ones.*
> Researcher: *What happens next?*
> Kyei: *They do peer teaching after each lesson.*
> Researcher: *Why peer teaching?*
> Kyei: *This is because some students learn better with their colleagues teaching them*."
> (Teacher, School C)

Amakye on his part used the strategy he has termed "I do-you do-we do". In this strategy, he first solved a given problem, gave students another problem to solve, and then solved a final one together with the students. He described the strategy as purely problem-solving. According to him,

> "*…usually my students are excited about how redox is presented to them and individual students are willing to be first to solve the next problem*". (Teacher, School A)

### 3.3 Inability to teach concepts

The teachers interviewed noted that the teaching of redox reactions at the SHS level placed some demands on teachers. This made the teaching of redox reactions difficult. Redox reaction was an important area for high school chemistry examination conducted by WAEC. Questions could be set on the theoretical aspect or the practical aspect, especially in redox titration. Hence, the demand for teachers to teach the concept at all cost. The WAEC questions usually restricted students to the use of transfer of electron and oxidation number models which seemed difficult to teach to most students. The following was an extract of an interaction with Asare:

> "Researcher: *Why are you saying that the demands of WAEC make teaching of redox difficult?*

Asare: *WAEC questions on redox are standard as it calls for students thinking.*
Researcher: *But that is good?*
Asare: *Yes: but WAEC most at times ask questions on the transfer of electrons and oxidation number.*
Researcher: *But the two are both models of redox reactions?*
Asare: *Yes; but the oxidation number and transfer of electrons are usually difficult to teach to most students and you know that demands extra work from the teacher*."

(Teacher, School A)

Another difficulty of teaching students was in the area of predicting redox reaction by inspection. The teachers linked the students' inability to predict redox reactions to lack of knowledge of mapping, lack of mathematical knowledge, and difficulty in calculating and comparing oxidation state of the atoms. For instance, Amakye explained that, the difficulty he faced in teaching redox reaction was "*teaching students to predict redox reaction by mathematical inspection*". (Teacher, School A)

Berko added that,

"*…the difficulty I face in teaching redox is the students' inability to calculate and compare the oxidation numbers of atoms involved in a reaction… as no matter what I do they go back to their old ways of calculating oxidation numbers*."

(Teacher, School B)

Three of the teachers identified that, there was a difficulty in teaching the concept of balancing redox reactions using the ion-electron method. This method was reported to be used whenever the reaction occurred in acidic or basic medium. These redox reactions involved the oxoanions like $Cr_2O_7^{2-}$. The difficulty was partly associated with the fact that students usually got confused with balancing in acidic medium and balancing in basic medium. The following was an extract in relation to balancing of redox reactions:

"Researcher: *Which other aspect of redox reaction is difficult to teach?*
Kyei: *Balancing of redox reactions.*
Researcher: *You said "balancing of redox"?*
Kyei: *Yes; especially balancing in acidic and basic medium.*
Researcher: *Why is it difficult to teach?*
Kyei: *The rules for balancing in acidic medium confuse students with the rules for balancing in basic medium*." (Teacher, School C)

According to Sekyere,

"*…the difficulty with teaching balancing redox is the students' inability to identify whether a given redox reaction is in acidic medium or basic medium*".

(Teacher, School C)

The basic mathematics, with respect to the calculation of the number of moles of the atoms, charges, and electron, was identified as another student challenge that made teachers ineffective in teaching of the balancing of redox reactions. For instance, Berko explained that,

"*teaching students to overcome their challenge in inspecting and balancing the number of moles of the species in the ionic equation. …especially balancing the charges*".
(Teacher, School B)

Two of the teachers, who commented on practical lessons as the appropriate instructional strategy for the teaching of redox reactions, identified another difficulty of teaching the concept. The difficulty was about inadequate materials and equipment in the high schools for the practical lessons.

"Researcher: *What challenge have you so far encountered in teaching redox reactions?*
Kyei: *Practicals; that is it, practicals.*
Researcher: *What about practicals?*
Kyei: *Inadequate materials and equipment such as reagents and salt bridge for teaching practicals.*
Researcher: *Have you inform your school administration about that?*
Kyei: *Yes off course but the usual complaint; no money.*
Researcher: *Does that mean you don't take your students through practicals?*
Kyei: *Not necessarily. There are times I have to improvised and at times I have to take my students to any of the sister schools where possible*." (Teacher, School C)

**3.4 Teachers' professional development**
The idea of professional development came up for discussion as the teachers lamented on the concept as difficult to teach. The teachers noted that, the few in-service training they had participated in were helpful but the concepts and skills acquired were not entirely used. This was due to lack of appropriate materials and equipment. The following was an extract from one of the teachers on in-service training:

"Researcher: *Do you usually receive support for teaching redox?*
Amakye: *What kind of support are you referring to?*
Researcher: *Training.*
Amakye: *Oh yes! I do attend in-service training organised by GES or GAST.*
Researcher: *How relevant are such trainings to you?*
Amakye: *They help a lot. I sometimes employed the ideas and skills from the training in teaching and at times not.*
Researcher: *Did you say "at times not"?*
Amakye: *Yes, because at times the ideas and skills are not new or can only be used when the need arises or there are no resources to help implement it*. (Teacher, School A)

Though the teachers were happy with the in-service training they had attended they were not happy with the frequency with which they had had the opportunity to attend. That is the number of times they had attended in-service training were so few. For instance, Kyei explained that,

"*I like the practical in-service training I attended. If it is done every month, I will be happy. But I have only attended in-service training on two occasions*".

(Teacher, School C)

Wireko added that,

"*I don't remember the last time I attended in-service training but the one I attended was good and I acquired some knowledge from it*".

(Teacher, School B)

The teachers teaching chemistry from each school were few and they hardly met to discuss issues relating to the teaching of chemistry. They only discussed issues bothering on science when they met at the departmental level to look at science in general. The following was an extract relating to the teachers' professional development at the school level:

"Researcher: *Aside external workshops or in-service trainings does your school organise workshops for you?*
Kyei: *Is like the ones we go for outside the school organised by GAST or GES. They are not usually organised.*
Researcher: *What about you and your colleague?*
Kyei: *Though we are just two, we hardly meet to discuss anything about the teaching of chemistry and our students' performance. But we meet as a department to discuss science in general.*
Researcher: *Why can't you and your colleague meet to review chemistry teaching and learning?*
Kyei: *Your guess is as good as mine.*
*Researcher: But you can acquire knowledge from that also?*
Kyei: *I will see my colleague and see if it will be possible*." (Teacher, School C)

## 4. Discussion

The results have shown that redox reaction is an elaborate area with a number of aspects. Though the area was elaborate there were other factors such as quality of students and teachers' knowledge of redox reaction and instructional strategy that may or may not prolong the time of completion. Students are the materials available for teachers to impact knowledge and that it is the teacher's responsibility to guide them to make meaning of redox reactions. This can be achieved when the teachers transform the concept of redox reaction to the level of students (Bond-Robinson, 2005; Mishra & Koehler, 2006). Hence, either the students are academically good or not, teachers have to deploy the best pedagogical content knowledge that will suit their students.

The results show that different teachers used various instructional strategies such as expository (lectures), questions and answers, teacher-led problem solving, group assignments, and reading assignments in teaching redox reactions. These instructional strategies were either teacher- or student-centered. The teachers used of various instructional strategies to teach redox reactions was based on the quality of students and the resources available to the teachers. The teachers appreciated that no one instructional strategy was good enough for all students (Landcare Research, 2002; Osborne, 1993) and that they needed to vary their instruction with respect to content, lesson objectives, and students' characteristics (Bednar, Cunningham, Duffy, & Perry, 1995; Cooperstein & Kocevar-Weidinger, 2004; Wilson & Peterson, 2006). This is an indication that no one instructional strategy is either right or wrong (Brown, 2005).

The use of these strategies were not structured enough and the strategies lacked student active involvement in lessons; student learning from small group members; two-way communication between student and teacher; presentation of solutions in class, and appraisal of fellow student's solutions to a given problem. The poor instructional strategies could make teachers have problems in teaching resulting in students' alternative conceptions and other conceptual difficulties in redox reactions (Adu-Gyamfi et al., 2015).

The instructional strategies of the teachers were dominated by teacher presentations but lack teacher supervision when it comes to group assignments out of the classroom. The strategies of the teachers could further be considered as one-sided and not selected to meet the needs of students at a particular time (Pain et al., 2011). That is the instructional strategies used by chemistry teachers lack the participatory approach recommended by the MOE (MOE, 2010; 2012); and hence these ineffectiveness in teaching. The strategies were weak and not structured, lack student centeredness and collaboration. Though the teachers claimed to select instructional strategies in relation to the quality of students but it could be seen that the instructional strategies are not varied by each teacher. The study has added to the literature that some teachers use combination of both constructivist and behaviourist instructional strategies in teaching unknowingly. This is in line with Osborne's (1993) idea that science can improve if instructional strategies from more than one ideology is used.

It could also be seen that the external examination requirements, which limited the students to the use of electron transfer (WAEC, 2008) was a challenge to teachers as the concept seem difficulty to teach to students. To be efficient in the area of chemical reactions is to be able to predict a given reaction and one other challenge facing the teaching of redox reaction was the difficulty in teaching students to predict a given reaction. Another result relating to the demands the teachers face in the teaching of redox reactions was to help students in the determination of the number of moles of atoms, charges, and electrons (WAEC, 2005). It becomes difficult for students to balance redox reactions in basic and acidic media using the ion-electron method if they cannot determine the number of moles of the atoms, charges, and electrons. It could be that teachers themselves have a difficulty in explaining the transfer of electron model (De Jong et al., 1995) or they cannot select the appropriate instructional strategy for teaching the concept. This is because a good number of students construct meaning of concepts in a similar way as they are taught by their teachers (Taber, 2011). Chemistry teachers are, therefore, encouraged to master the concept of redox reaction very well and select the most appropriate diagnostic instruction and cognitive conflict strategies (Ernest, 2010) for effective teaching of the concept using the transfer of electron and oxidation number models. This will help minimise the difficulty and enhance students' conception in redox reactions.

The results show that there were external bodies that organise professional development (in-service training) programmes for teachers teaching science-related subjects such as chemistry. These professional development programmes were beneficial to the teachers but were hardly petronised. This could be that the programmes were organised frequently but teachers failed to attend or that the programmes were not organised at all. The teachers' participation in the in-service training (professional development programme) was not continuous enough to influence the quality of their teaching (Hendriks et al., 2010) and it provided the teachers no opportunity to practice what they have learnt from it (Harwell, 2003). The reform-type of professional development programmes was absent in the school. This could be attributed to the fact that teachers hardly met to share views on the students' difficulties in chemistry and develop the best means to assist them. And there were no school-based programmes to provide teachers with the needed opportunities for interactions to facilitate teachers' professional development (Villegas-Reimers, 2003). The study has added to the call for reform-type of professional development programmes as it will help to address the challenges of individual schools and help improve students' conception in redox reactions and Chemistry Education in general. It is, therefore, recommended that chemistry educators in schools and colleges should meet formally and informally to share ideas and address challenges students face in learning chemical concepts.

## 5. Conclusions

In this research, how teachers teach redox reactions at the SHS level was explored to find that, which teachers find problematic in teaching redox reactions. The teachers' problems were associated with the length of the structure of redox reactions and the quality of students influencing the selection and use of instructional strategies. Other problem areas were teacher's knowledge of redox reactions, use of structured instructional strategies, demands of external examination bodies, and frequency of attending professional development programmes.

### 5.1 Recommendations

As students' characteristics was a problematic area in teaching, hence, teachers should be mindful of learner characteristics in relation to the chemistry concept in order to select and use the most appropriate instructional strategies for teaching. And as weak instructional strategies were used by teacher, chemistry educators and researchers should design and develop topic specific pedagogical content knowledge for teaching redox reactions in senior high schools.

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