Paper 4

Identification of Errors Committed by Chemistry Teachers in Using Technical Terms During Classroom Instruction

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Abstract

During chemistry instruction, some technical terms are required to communicate the content of the lesson. These terms are very important because students who cannot use them effectively are not considered competent during assessment. Unfortunately, very few studies have focused on errors which teachers commit while using such terms during the teaching and learning process, and the likely impact of such on students' learning. Therefore, this study adopted a qualitative approach to identify and analyse chemistry teachers' errors in the use of some technical terms and how such practice is likely not to support students' learning. Eighteen Chemistry teachers were selected from some secondary schools that were drawn from three randomly selected local governments in Ibadan metropolis using random and purposive sampling. The data sources for the study were teachers' lesson notes and written notes/contents on the boards. The data were analysed through thematic analysis using chemistry language proficiency rubric for teachers (CLPRT). The wrong technical terms used found in the study were classified into the following themes: symbolic representation, scientific terms, diagrammatic representation and everyday words. Based on these findings, it was recommended that chemistry teachers should be sensitized on how errors in the use of chemistry technical terms could lead to students' misconceptions.

Introduction

Scientific texts are regularly multimodal, containing pictures, charts and diagrams. The utilization of pictures and outlines in science is useful for creating, imagining and imparting logical thoughts

(Treagust, Won & McClure, 2018). Rees, Kind and Newton (2018) argued that learning the language of science is similar to learning a second language. During science teaching, the teacher combines everyday language and science language. Hence science is often communicated through a hybrid language. The peculiarity of students in Nigeria is that they are strangers to everyday (English) and science languages. Yet students are expected to develop linguistic competence in both languages so as to participate in subject specific discourse. This is because the competence in the hybrid language is associated with conceptual understanding.

In the course of teaching chemistry at the senior secondary school, the teacher makes use of scientific text to depict chemical concepts so as to aid meaningful learning. For instance, the significance of an arrow in a chemical equation is different from that of the arrows in a change of state diagram. The former depicts a chemical change while the later a physical change. Hence, the same symbol has a distinct meaning in different contexts. This shows that the usage of scientific texts which are considered technical terms in chemistry can result in conceptual misunderstanding instead of clarification if it is not properly used.

Therefore, during science instruction, the language of communication must be precise and accurate. According to Harlen (1993), communication is an outward extension of thought that helps in the process of rearranging the thinking of the receiver. Students later communicate what they have learnt from teacher's communication through pictures, diagrams, maps, charts, graphs, models and language during classroom assessment. Chemistry teachers at the secondary school level teach chemical ideas by utilizing words, signs and images. This comprises diagrams, graphs, charts, numerical images, chemical symbols (like Na for sodium, C for Carbon) and formulae (for instance, NaCl for sodium chloride) and chemical equations (for example, $2Na + Cl_2 \rightarrow 2NaCl$).

Parkinson (1994) noted that students regularly become confused when the word they are familiar with in everyday usage has another meaning in chemistry classroom. For example "salt" is a specialized term in chemistry that alludes to a chemical compound formed when a metallic ion joins with a non-metallic ion. For instance; $Na^+ + Cl^- \rightarrow NaCl$, (where Na^+ is the metallic ion, Cl^- is the non-metallic ion and NaCl is the salt). In regular use, a salt alludes to a substance used to prepare and preserve food to most learners. This is just an example of difficulties teachers have while using technical terms for chemistry teaching.

Evidence from the West African Examinations Council (WAEC, 2019) Chief Examiner's report for Chemistry revealed that the poor performance of students, were partly due to lack of adequate

knowledge of chemical concepts, inability to recognize redox reaction, inability to draw correct and workable diagram for the preparation of chlorine gas in the laboratory, inability to write the correct formula of a compound and wrong use of symbols to represent ions. The Chief Examiner advised that students should learn to use the appropriate technical terms, write and balance chemical equations correctly, explain concepts using the appropriate technical terms and familiarize with ions and their symbols.

It will be improper and unscientific to attribute students' difficulty in using scientific terms in the Chief Examiners' report solely to teachers' errors while using the terms in the classroom. This is because it is not impossible that the use of technical terms by a chemistry teacher is error free and the students will still fail to represent matters accurately due to other factors which this study does not consider. Nevertheless, teachers' use of wrong terms which the students may copy from contribute significantly to the problem observed by the Chief Examiner.

Unfortunately, research on the teachers' wrong use of technical terms in chemistry has not gained the same popularity as those focused on the use of teaching strategy, influence of teacher and students factor on various chemistry concepts. Irrespective of the chemistry concept, and the strategy adopted by the teacher to teach, there are technical terms will always be used. For this is imperative to identify the errors which teachers commit while using the technical terms. During classroom teaching, there are many documents teachers use, but the most important of them is the lesson note. It contains all that the teacher intends to teach and how the teacher intends to teach them. A look into the lesson note of the teacher, can provide information of what the learners are likely to learn, just like the mothers' diet determine the nutrient in the breast milk. Any error committed in the teachers' lesson note will be transferred to the students. Apart from the lesson notes, the blackboard is very important because it is the medium from which the students copy the lesson content. Writing on the chalkboard is a very different skill from writing on paper because if the teacher makes any mistake, the students copy the same faithfully (Stones, 2003). Unfortunately, teachers' error on the board has become a widespread phenomenon and Stones (2003) stressed the urgent need to systematically study this phenomenon. Anything written on the board is harmful if it is factually or pedagogically rubbish. Therefore, this study identified and classified the errors which teacher commits while using technical terms in the chemistry classroom and in their lesson notes.

Research Questions

1. What are the categories of errors which teachers commit when they use technical terms during chemistry lessons?
2. What are the examples in each of the categories of errors identified?

METHODOLOGY

This study adopted the phenomenological approach of qualitative research. This is suitable because the study focused on exploring, describing and explaining the teachers' errors while using technical terms during chemistry instruction. The population of the study is all chemistry teachers in senior secondary schools in Ibadan metropolis. Eighteen chemistry teachers that formed the study sample were selected through multiple stage sampling procedures. At stage one, three Local Government areas in Ibadan were selected, using the simple random sampling techniques, the three Local Government areas selected were: Akinyele, Ibadan North, and Ibadan North West Local Governments. In each of the Gocal Governments, six schools were purposively selected. The criteria for selection were that the chemistry teachers must be professionally qualified and had teaching experience that was not less than five years. The justification for the criteria is to eliminate errors that could be traced to inexperience and qualification.

The Chemistry Language Proficiency Coding Guide (CLPCG) was used to analyze the data collected. CLPCG was adapted from Omilani (2015) Misconceptions Coding Guide. The Omilani (2015) Misconceptions Coding Guides had ten themes and it was used to analyse the errors of students in volumetric and qualitative analysis. The development of CLPCG was done iteratively in the first stage; data sources outside the population were analyzed with four themes generated from Omilani (2015) misconception coding guide. The emerging themes were wrong symbolic representations, inaccurate use of scientific terms, quasi diagrammatic representations, and use of everyday words. At the second stage during validation all areas of overlap of the themes were resolved and adequate distinctions were made. Wrong symbolic representations are errors related to wrong chemical formulas, and other symbols used in chemistry. Quasi diagrammatic representations involve diagrams that are not correct because they are not workable. For instance, drawing of laboratory preparation of substances without putting cork on a reaction that is meant to take place in a closed system. Inaccurate use of scientific terms for example using efflorescence

to describe a phenomenon that is effervescence. Use of everyday words involves not using the appropriate and accepted chemical language. For example, effervescence of gases is more acceptable than stating that gases are released.

Two independent raters used the CLPCG on the same lesson note of a chemistry teacher who is not part of the study population and the data obtained were analyzed using Scott-pi and an inter-rater reliability of 0.521 was obtained. A value considered moderate. The researcher observed chemistry lessons of the eighteen teachers for three weeks depending on the timetable. During each of the lesson, a picture of the lesson note and the board were taken. There was no teacher who did not enjoy at least a visit per week. The research assistants and the researchers met every week to analyse the images on weekly basis. At the end of the three weeks the result were analyse as described.

RESULTS

Research Question 1

What are the categories of errors which teachers commit when they use technical terms during chemistry lessons?

The errors found in the data sources were categorized into four. These are: wrong symbolic representations, inaccurate use of scientific terms, quasi diagrammatic representations, and use of everyday words.

Wrong Symbolic Representation

The symbolic representation of a chemical reaction involves the chemical equation in the form of symbols and formulae, wherein the reactant entities are given on the left-hand side and the product entities on the right-hand side. A plus sign is also written between the entities on both the reactants and the product side. An arrow is always pointing towards the products, and shows the direction of the reaction. The teachers in this study used some symbols inappropriately which tended to confuse students. The following symbolic representations were used wrongly; KmnO4, NaoH, $CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$, H_2SO4.

Inaccurate Use of Scientific Terms

This involves writing symbols, terms and units wrongly. The typical example given by Omilani (2015) while referring to this category among students is writing residue instead of using precipitate. Residues are recovered from the filter after filtration while precipitate are formed after chemical reactions. The teachers in this study used the following scientific term wrongly: mol/dm^3

Quasi Diagrammatic Representation

This has to do with the diagram used in representing chemistry reactions, structural formula and representation, graphical representation, and scientific illustrations.

Use of Everyday Language

The utilization of everyday words has to do with utilizing familiar common words in place of scientific terms which are suitable and acknowledged chemical language. For example, using melt instead of dissolve, strong as concentration, burn as decompose. This can be solved by carefully defining terms and by selecting appropriate scientific vocabulary. The following terms were used by the teacher inaccurately: Reaction between Calcium oxide and water, reaction between acid and base ratio.

Research Question 2

What are the examples in each of the categories of errors identified?

Symbolic representation

a. Incorrect utilisation of a chemical formula in the lesson note.

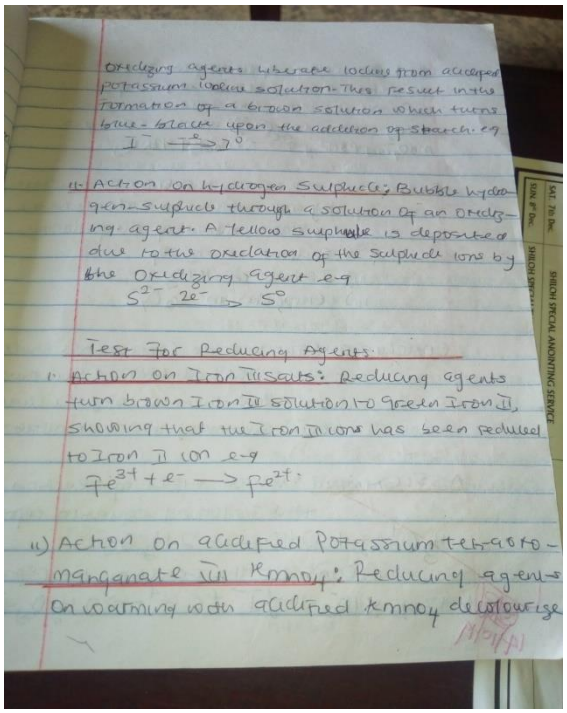

Figure 1: Wrong Chemical Formulae in the teachers' lesson note.

Figure 1 explains the action of acidified potassium tetraoxomanganateVII (KMnO4) on IronII as a test for reducing agent. The teacher wrote Kmno4 instead of KMnO4. The compound potassium tetraoxomanganateVII is made up of Potassium (K), Manganese (Mn) and Oxygen (O). The mno in the formulae makes the symbol to mean something different from the compound name. Therefore, inappropriate use of this chemical formula makes it unclear thereby misguiding the students on the correct term to use. Omilani (2015) misconception coding guide showed that the error was categorised as an inaccurate particulate representation (IPR) because the chemical components that made up the compound were inaccurate. A similar error was seen in figure II the Co2 written at the lower part of the board does not mean Carbon(IV) Oxide.

b. Inappropriate use of the chemical formula on the board

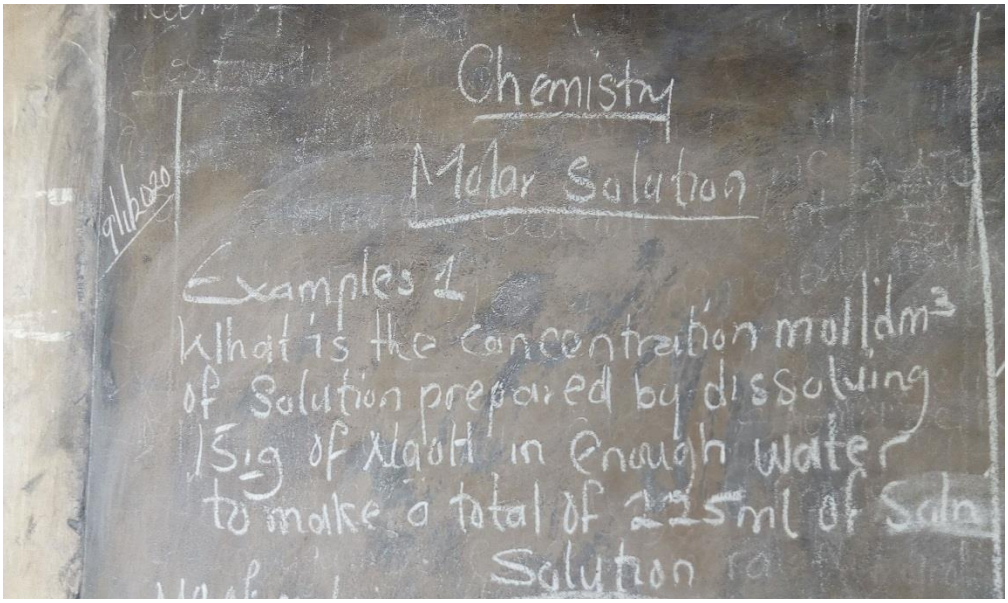

Figure 2: Wrong Chemical Formulae on the board

Figure 2 showed a question written on the board by a chemistry teacher. From the question, the chemical formula NaOH (sodium hydroxide) was inappropriately written as NaoH. The students in this classroom duplicated the same in their notes.

c. Unbalanced equation

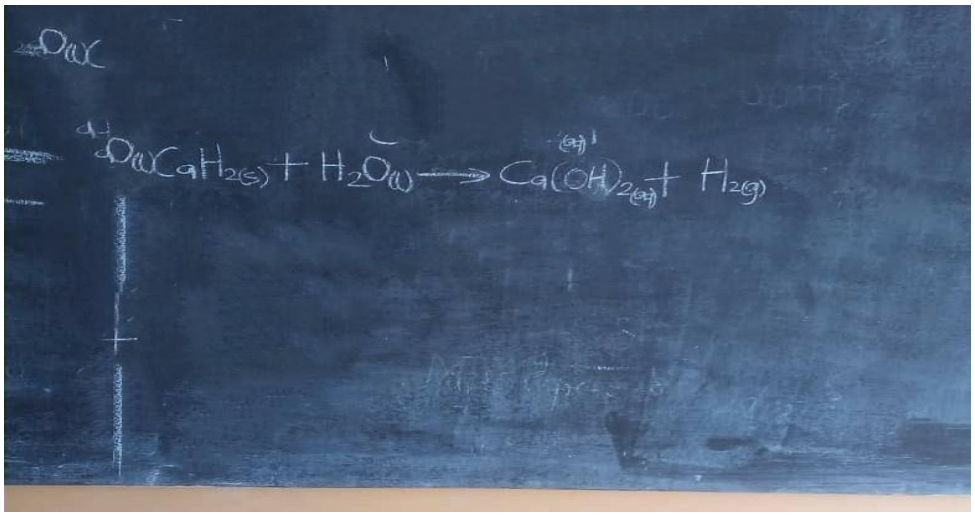

Figure 3: An unbalanced equation written on the board by the teacher

Figure 3 shows an unbalanced chemical equation of Calcium hydride reacting with water to produce calcium hydroxide and hydrogen gas. In chemistry, balanced equations are those whose coefficients bring about equivalent numbers of atoms for each element in reactants and products, such that law of conservation of mass is not violated. For a chemical equation to be balanced, the reactants should be equivalent to the product and this is one of the chemistry specialized terms which is exceptionally vital in the chemistry world. From the equation, it shows that Calcium hydride reacts with water to produce calcium hydroxide and hydrogen. However, the accurate equation is $CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$, which implies that one mole of CaH_2, and two moles of H_2O produce one mole of $Ca(OH)_2$ and two moles of hydrogen gas H_2 . In balancing the equation, the right coefficient and subscripts should be embedded. The subscript indicating the state of matter was not written. The $2H_2O$ produced is water in the gaseous state which is called steam.

Everyday Words

a. Incorrect use of everyday words in "Exothermic Reaction"

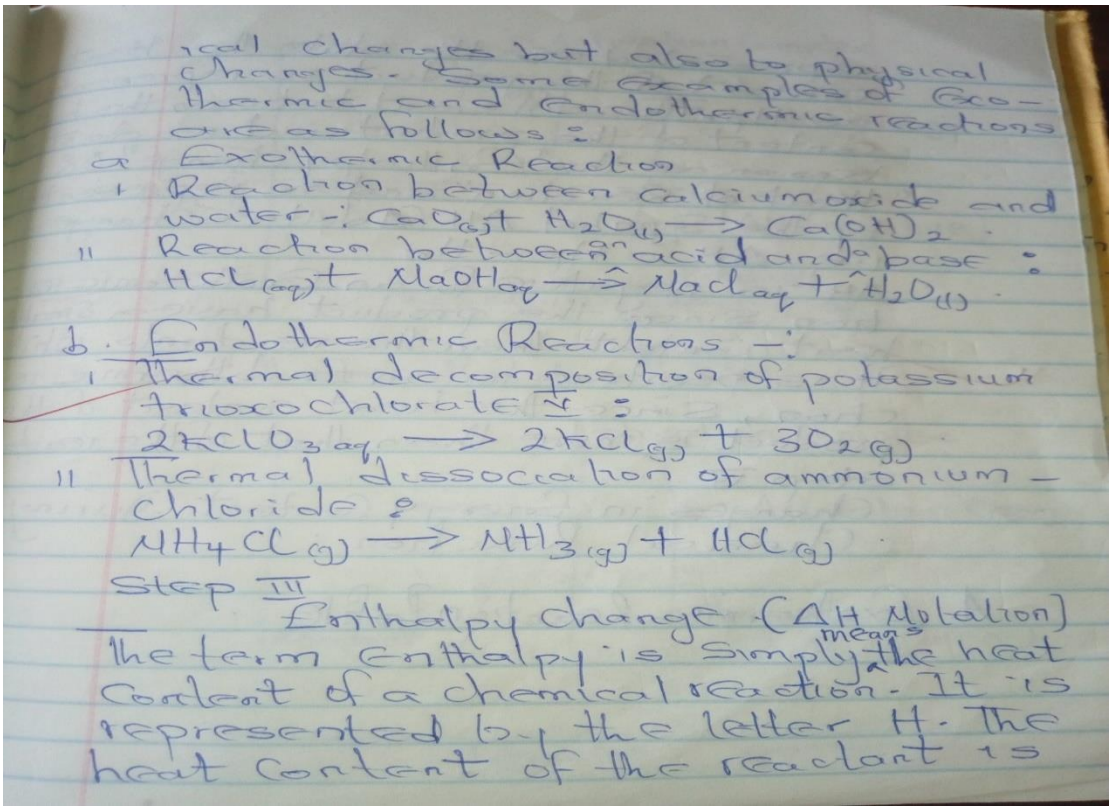

Figure 4: Wrong Everyday words usage in the teachers' lesson notes.

Figure 4 shows that teaching chemistry involves the teacher using both everyday language and chemistry language to communicate chemical ideas. The teacher must be skilled on how to combine the two languages. From the exothermic reaction explained, the acceptable scientific term for reaction between calcium oxide and water could be dissolution of pellets of Calcium oxide in water while reaction between acid and base ought to be called neutralization. Writing the appropriate name of the reaction will help the teacher to easily teach enthalpy of dissolution and neutralization or reinforce the same if it has been taught already. This is because the topic classifies and describes the type of heat of reaction according to the reaction type. Omilani (2015) misconception coding guide shows that the error was categorised as a non-scientific term (NST) with correct explanation.

Wrong Use Scientific Terms

a. Wrong utilisation of the unit "mol/dm^3"

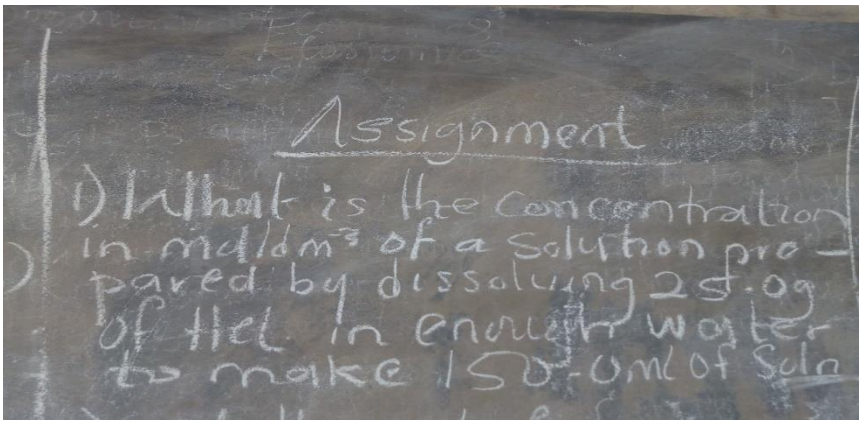

Figure 5: Wrong scientific terms written on the board

Figure 5 explains that the moles per cubic decimeter is a derived unit written as mol/dm^3 or moldm^{-3} used to express molar concentration (amount of the substance per unit volume of solution). The teacher above wrote mol/dm^{-3} rather than "mol/dm^3" as the unit of concentration of the solution. The unit written means moldm^3. Omilani (2015) misconception coding guide revealed that the

error can be categorised as an incorrect use of scientific terms because the concentration unit (mol/dm^3 or mol dm^{-3}) was written as mol/dm^{-3}.

b. Wrong use of Le Chatelier's principle

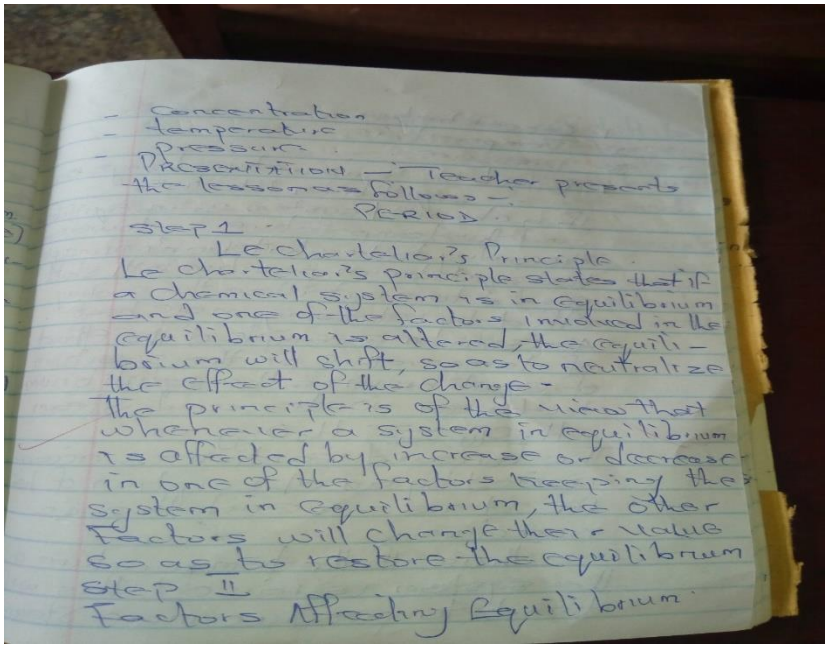

Figure 6: Wrong scientific terms in the teachers' lesson note.

Figure 6 explains that the idea Le Chatelier principle was utilized wrongly by the teacher as Le Charteliar's principle, which showed that the idea was wrongly spelt by the teacher while writing the lesson note. Omilani (2015) misconception coding guide shows that the error was categorised as an incorrect use of scientific terms.

Discussion

The findings of this study revealed that chemistry teachers commit errors when using chemistry technical terms in all the data sources examined in the study. It is important to consider the wrong use of chemistry technical terms found in the lesson notes might be an expression of the errors which teachers learnt while they were students. Teachers usually write lesson notes during the pre-instructional planning stage, and they are more relaxed during this stage and such errors may be considered as random. Hence, during the teaching and learning process, the teachers pass wrong use of technical terms to learners. The ones found on the board are usually as a result of the teacher reproducing exactly what they have in the lesson note or carelessly writing wrong chemistry

technical terms that they had written correctly in the lesson note. The classroom board exposes the learners to the error, whether the teacher has the right thing in the note or not. This is an indication that the teacher must consider the writing on the chalkboard as though they are writing on the learner's mind. The finding of this study is similar to that of Yates and Marek (2014) which revealed that students who had an accurate understanding of biological evolution before classroom instruction, ended up with misconception after teachers' instruction. Among other things, they attributed the misconceptions to teacher's instruction and they even described teachers as propagators of misconceptions. Unlike Yates and Mare (2014), this study did not determine students' pre and post instruction use of chemistry technical terms but it did identify precisely teachers' error that can lead to students' misconceptions. This finding of this study further amplifies the concern of Lightman and Saddler (1993) that if teachers do not give consideration to the prevalent misconceptions, and do not factor it in the implementation of instructional strategies, they may hold overly optimistic expectations of the effectiveness of their teaching. In the context of this study, they use incorrect technical term is already prevalent in students' responses in standard chemistry examination. Unfortunately, the instruction of teachers is not giving any consideration to prevent it, rather it is strengthening the same. The finding of this study is in agreement with the findings of Gupta (2018). Although Gupta focused on the eighth grade science students' errors; leading among the errors are spelling mistakes that gives science terminology a different meaning.

Conclusion

Based on the findings of this study it is concluded that many chemistry teachers' lesson notes and content written on the classroom board are laden with errors in the use of technical terms in chemistry which the students learn from.

Recommendations

The following recommendations are suggested based on the findings:

1. There is a need for the teachers to know how to use the language of teaching science and chemistry technical terms correctly. This will make teachers perceive teaching chemistry as a hybrid of the everyday language and, especially, technical chemistry terms. The peculiarity of the Nigerian child who is a second language user of the everyday language

must be given adequate consideration during this awareness because the everyday language, English in our context, is not like those who are the first language user.Hence, chemistry teachers are expected to be exposed to training, workshops, seminars and conferences to overhaul and improve their knowledge of chemistry and technical terms used for the teaching.

2. During the pre-service and in-service teacher training, especially the aspect of lesson notes preparation and use of chalkboard, the consequences of teachers' inappropriate use of technical language in chemistry on students' conceptual understanding must be emphasized.
3. Further research on how students make mistakes must be considered by chemistry educators. Chemistry educators must also give other aspects of language use in chemistry considerations.
4. In the course of a Chemistry lesson, correct usage of technical terms must be among the checklist of classroom reflection and any wrong use must be corrected in the subsequent lesson. Teachers should also check the written notes of the students to ensure that technical terms are not copied wrongly.

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