

ASSESSMENT OF PEDAGOGICAL KNOWLEDGE EFFICACY AND APPLICATIONS AMONG SECONDARY SCHOOL CHEMISTRY TEACHERS IN NIGERIA

BY

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Abstract

This study assess the pedagogical knowledge efficacy and applications among secondary school in kwara state, Nigeria. A mixed research design was adopted to conduct the study. Related literature was reviewed after the conceptual framework based on the major variable of the study. The population of the study comprises of all the chemistry teachers in secondary school in kwara state. Based on the data estimate collected from Kwara State Ministry of Education, out of an average number of 118 schools in Ilorin, four Senior Secondary Schools were purposively selected and 40 Chemistry teachers were then randomly selected for the study. Data collected were based on the research questions and were analyzed using both descriptive and inferential statistic. The finding from the study revealed that majority of chemistry teachers have adequate knowledge about the instructional strategies while few still have contrary view about it. Further finding shows that some chemistry teachers still don't possess efficacy when exposed to observation protocol. The study concluded that chemistry teachers possess adequate knowledge of the pedagogical knowledge and knowledge of assessment of chemistry students while some still had contrary view about the knowledge of assessment, despite the fact that Pedagogical content knowledge plays important role in classroom instruction.

Keywords: Pedagogical knowledge, content knowledge, pedagogical content knowledge, efficacy, content representation

Introduction

The most important aspect of every educational program is teacher, from the primary school level of education to the highest level of education, since teachers are responsible for putting educational activities into practice. Hence, the achievement of any nation depends mainly on the quality of its teachers. According to Ani, et.al. (2013), teachers education includes solid pedagogical theory, professional skills, and instructional abilities. In line with this submission, science teachers were trained in the institution to become science teachers and they should possess adequate pedagogical content knowledge to be effective science teachers. According to Ahmed and shogbesan (2023) asserted that educators' pedagogical content knowledge (PCK) is crucial to the development of effective teaching practises and the implementation of effective curriculum. Science educators PCK is very important in the development of effective teaching practices and they will be able to implement the curriculum especially the chemistry teachers that Okorie and Akubuilu (2013) attributed causes of students' poor performance in Chemistry to teachers' inadequate knowledge of teaching curriculum on which students learning is based, as well as teachers' lack of adequate knowledge of the subject matter and instructional strategies.

Science plays a very important role in the development of many nations. It is essential that science teachers possess basic knowledge for teaching. Science has also been viewed as the pursuit and application of knowledge in order to have a better understanding of both natural and social world based on systematic methodology evidences (O'Hanion, 2015). According to Abimbola (2013), science is a body of knowledge, a way or method of investigating and a way of thinking in the pursuit of understanding of nature. Olorundare (2014) also defined science as assessing, amending and enhancing activities which deal with ideas relating to natural phenomena and how they can be interpreted. Science was defined by Bradford (2017) as an organised and rational approach aimed at finding out means by which everything in the confinement of the universe works. It is also described as a body of knowledge acquired and synthesised by

ways of determining the nature of all things in the universe. According to Ivowi (2003), the development of any nation depends basically on the level of scientific and the technological literacy possessed by the citizenry. Science and its application have become important for sustainable development in all nations' economy. There are two major branches of science; pure and applied sciences. Pure sciences include Biology, Physics and Chemistry (Infoplease, 2013; Helmentine, 2015). Chemistry is a branch of science which deals with the study of the structures, composition, properties and reaction of matter in different forms. Bagley (2017) defined Chemistry as the study of matter, its properties, how and why substances combine or separate to form other substances, and how substances interact with energy. In the study of Chemistry, it has been observed that matter changes its forms. Therefore, there is the need to understand the basic principles involved in the formation of new substances (American Chemical Society, 2015).

Chemistry teaching is supposed to be students-centered to enhance understanding of the concept. This can be achieved using proper methods and instructional media in teaching students when students are willing to learn (Adesoji & Olatubosun, 2008). In line with submission chemistry teachers should have adequate pedagogical knowledge about chemistry teaching at secondary school. Students are curious in nature; they ought to participate actively in the learning process as they constantly equip, test, speculate and build their individual ideas and understanding that becomes functioning, significant and valuable to them. Owing to the position of Chemistry in relation with other science subjects such as Physics and Biology at Senior School level and also as a prerequisite for admission requirement to study courses such as medicine, agricultural science and engineering, students are expected to perform well. These disciplines require a credit pass in Chemistry (Bamidele & Adekola, 2017) at secondary school level. Consequently, there is the need to put in place all necessary requirements for the effective teaching and learning of Chemistry in order to achieve a positive outcome. The teaching of chemistry by chemistry teachers should have adequate knowledge about pedagogical practices to be use for teaching of chemistry.

Literature Review

The poor performance of Senior School science students has been attributed to teachers' low level or lack of Pedagogical Content Knowledge (Gess-Newsome, 1999); hence, teachers need to make science comprehensible and interesting for their students. To do this, teachers need to change and develop their PCK (Shulman, 1986), since PCK is a distinctive body of knowledge necessary for classroom teaching (Kind, 2009). It has been a challenge for students to have a clear knowledge of certain chemistry concepts due to instructional methods used by teachers to teach these concepts like mole concepts (Lamidi et.al 2015). The teaching of students, according to the present day standards for students to achieve the characteristics of the 21st century learning skills, requires that teachers need to understand the subject matter deeply so that they can help students create useful cognitive maps, relate one idea to another and address misconceptions held by the students. There is the need for teachers to represent ideas using content representation in planning their lesson. Teachers are also expected to be acquainted with the interconnection across disciplines with the day- to- day life. This kind of understanding provides the basis of PCK that enables one to make ideas accessible to others (Shulman, 1987). The original conceptualization of PCK did not consider the 'doing' of teachers, as Shulman (2015) believed he had been inattentive to the role of 'pedagogical culture' or the lived settings in which teaching, learning, and development occurs. For PCK to be meaningful and effective, it had to be mindfully situated within the culture of science teaching and learning and the settings in which teaching, learning, and development occurs (Shulman, 2015). Is therefore important to carry out research on pedagogical knowledge efficacy and application among secondary school in Nigeria.

Despite the position of chemistry in relation with other science subjects, findings from several studies have revealed the causes of dwindling academic performance of Chemistry students at the Senior School level in Nigeria. The situation is due to the abstract nature of Chemistry (Samba & Eriba, 2012), schools, students and teachers- related factors Nwagbo, 2006; Mailumo, Agogo & Kpagh, 2007; Ugwu, 2008; Rand, 2012; Okorie & Akubuilu, 2013; Okebukola, 2016; Ojukwu, 2016; Concept difficulty (Agwai, 2008) is also one of the reasons amounting to poor performance of secondary school students in Chemistry. Majority of the aforementioned studies have showed that most of the causes of dwindling students' performance are due to the ineffectiveness of the teachers. Ojukwu's (2016) finding revealed that lack of qualified teachers, ineffective methods of teaching, lack of teaching experience, the non-use of instructional media had been identified and perceived as the causes of poor performance of students in

Chemistry. Okorie and Akubuilu (2013) attributed causes of students' poor performance in Chemistry to teachers' inadequate knowledge of teaching curriculum on which students learning is based, as well as teachers' lack of adequate knowledge of the subject matter and instructional strategies. Chemistry teacher must have adequate pedagogical content knowledge in teaching concepts in chemistry for students' proper understanding. The poor learning outcome in mole concept is as a results of a number of problems such as teachers lack of subject matter expertise, their lack of pedagogical knowledge understanding, and students' misconceptions of the mole concepts, among many others (Yaayin,2018; Nweshi et.al., 2020; Adu-gyamfi & Vorsah, 2022).

According to Gates (2015), having an effective teacher is the single, most essential in-school factor that has influence on students' achievement. In line with submission of (Gate 2015), to be effective teacher, they should have solid pedagogical content knowledge. In order to provide solution to ineffectiveness in teaching on the part of teachers, Shulman (1986) brought up the concept of pedagogical content knowledge (PCK) as a distinctive type of knowledge for teaching which creates a content domain understandable for learners (Shulman, 1986; Shulman, 1987). An effective teacher is required to improve their knowledge with reference to all aspects of pedagogical content knowledge and the topics they teach (Magnusson, Krajcik& Borko, 1999). PCK is hybrid of both content knowledge and pedagogical knowledge. The content knowledge is about knowledge of what to teach while pedagogical knowledge deals with knowledge of how to teach what you know or the subject matter. The pedagogical knowledge is very important in chemistry teaching because of nature of the subject itself, because most students feel that the subject is abstract and it is not easy to understand, but if the teachers uses better instructional strategies most of the problem will be solved. Hence there is need to carry out study on pedagogical knowledge efficacy and application among chemistry teacher at secondary schools in Nigeria. Several research has been conducted on PCK and using various PCK models to assess teachers pedagogical and content knowledge in different concepts in chemistry (Widhiyanti et. al.,(2017), Arrigo et. al. (2022). As a result of this, Loughran et al. (2013) recommended that teachers should be encouraged to use CoRe and PaP-eRs so as to improve their thinking about teaching for positive outcome in the teaching and learning processes. If the problem of poor understanding of chemistry concepts by the student still persist there is need to assess the pedagogical knowledge efficacy and application of among secondary school chemistry teachers in Nigeria.

Purpose of the Study

The primary purpose of this study was to assess teachers' pedagogical knowledge efficacy and application among Secondary School Chemistry teachers in Nigeria. The study specifically:

- i. determined chemistry teachers' knowledge of instructional strategies used for teaching Chemistry;
- ii. evaluated the knowledge of assessment of Senior School Chemistry teachers in the teaching of Chemistry;
- iii. examined the Senior School Chemistry teachers' efficacy towards the teaching of Chemistry content

Research Questions

In this study, answers were sought to the following questions:

1. Do Secondary School Chemistry teachers demonstrate the knowledge of instructional strategies used for teaching Chemistry?
2. Do Secondary School Chemistry teachers possess knowledge of assessment in the teaching of Chemistry?
3. What is the Secondary School Chemistry teachers' efficacy towards the teaching of Chemistry content?

Methodology

This study is a mixed method research that involved gathering of both quantitative and qualitative data. The quantitative aspect of the research assess the teachers' pedagogical knowledge among chemistry teachers in secondary school in kwara state Nigeria while the efficacy of chemistry teachers was examined using observation protocol to observe the chemistry teachers in the classroom to show how effective the chemistry teachers are. The target population for this study was all Senior Secondary School Chemistry teachers in Ilorin. Based on the data estimate collected from Kwara State Ministry of Education, out of an average number of 118 schools in Ilorin, four Senior

Secondary Schools were purposively selected and 40 Chemistry teachers were then randomly selected for the study. Then 20 Chemistry teachers were randomly selected to examine the efficacy of pedagogical knowledge and application of instructional strategies in the classroom. An instrument was developed to elicit information from the respondents. Lastly, data collected were analysed using descriptive statistics.

Results

Research Question 1: Do Senior School Chemistry teachers demonstrate adequate knowledge of instructional strategies in the teaching of Chemistry?

Table 1: Percentage Analysis of Senior School Chemistry Teachers' Demonstration on the Knowledge of Instructional Strategies in the Teaching of Chemistry

S/N	Knowledge of Instructional Strategies for Teaching Chemistry	Agree (%)	Disagree (%)
1.	Experiment is best used to teach Chemistry concepts.	40(100%)	0 (0%)
2	Demonstration method facilitates conceptual understanding of chemical concepts.	39(97.5%)	1 (2.5%)
3.	Discussion method is the most effective method for teaching Chemistry concepts in the classroom.	28(70.0%)	12(30%)
4.	Innovative instructional strategies are suitable for teaching abstract concepts in Chemistry.	39(97.5%)	1(2.5%)
5.	Inquiry method is suitable for teaching chemical reaction.	31(77.5%)	9(22.5%)

Based on the responses provided in Table 1 by the teachers, about 97.5% of them possessed the requisite knowledge of instructional strategies for teaching chemistry contents which further showed high level of understanding of instructional strategies in chemistry teaching, while 2.5% of the teachers did not possess adequate knowledge of instructional strategies as shown in the listed statements in the table. In this case chemistry teachers should demonstrate adequate knowledge of instructional strategies by scoring 100% in their responses. The first item on knowledge of instructional strategies which says Experiment is best used to teach chemistry concepts shows that all the chemistry teachers possess adequate knowledge of instructional strategies on the first item the result also shows that 77.5% of chemistry teachers possess knowledge about inquiry method being suitable for teaching of chemical reaction while 22.5% still not possess knowledge about inquiry method being suitable for teaching chemical reaction. 30% of chemistry teachers still had contrary view about Discussion method as the most effective method for teaching chemistry concepts in the classroom.

Research Question 2: Do Senior School Chemistry Teachers possess knowledge of assessment in the teaching of Chemistry?

Table 2: Percentage Analysis of Senior School Chemistry Teachers' Knowledge Possession of Assessment in the Teaching of Chemistry

S/N	Knowledge of Assessment of Chemistry Teachers	Agree (%)	Disagree (%)
6	Questioning skill can be used to assess the knowledge of Senior Secondary School (SSS) students on Chemistry concepts.	40(100%)	0(0)

7	Assignment/ Home work can promote the facilitation of knowledge about Chemistry concepts in students.	39(97.5%)	1(2.5%)
8	Laboratory activities provide an effective platform to measure knowledge acquired by students	36(90%)	4(10%)
9	Classroom testing of students' knowledge of Chemistry concepts is an effective feedback mechanism for the Chemistry teacher.	38(95%)	2(5%)
10	There is need to assess Chemistry students on their ability to apply Chemistry knowledge.	38(95%)	2(5%)

Table 2 shows frequency and percentage distributions of teachers' response on their knowledge of assessment of chemistry, particularly the aspect of questioning skills. The results showed that 97.5% of the teachers had full grasp of how to assess chemistry contents while 2.5% of them had contrary views as indicated in their response. From the table the results shows that chemistry teachers possess adequate knowledge about Questioning skill which can be used to assess the knowledge of Senior Secondary School (SSS) students on Chemistry concepts. Also from the table 97.5% had knowledge about the use of Assignment/ Home work can promote the facilitation of knowledge about Chemistry concepts in students while 2.5 had contrary view. Only 90% of chemistry teachers possess knowledge about Laboratory activities provide an effective platform to measure knowledge acquired by students. It shows from the table that 90% of chemistry teachers understand that Classroom testing of students' knowledge of Chemistry concepts is an effective feedback mechanism for the Chemistry teacher, 10% had contrary view about this. 95% of chemistry teachers understand that there is need to assess Chemistry students on their ability to apply Chemistry knowledge to their society.

Research Question 3: What is the Senior School Chemistry teachers' efficacy towards the teaching of Chemistry content?

Table 3

Percentage Analysis of Senior School Chemistry Teachers' Efficacy towards the Teaching of Chemistry Content

S/N	Chemistry Teachers' Efficacy	Agree (%)	Disagree (%)
11	Pedagogical knowledge is always tasking when teaching Chemistry as a subject.	30(75)	9(22.5)
12.	It is somewhat difficult to teach Chemistry concepts using content representation.	27(67.5)	13(32.5)
13	Content knowledge is best displayed through laboratory activities in Chemistry.	36(90)	4(10.0)
14	Selection of appropriate instructional strategies can facilitate effective Chemistry knowledge acquisition by students.	38(95)	2(5.0)
15	Developing the right scientific approach to the teaching of Chemistry encourages students to learn Chemistry.	39(97.5)	1(2.5)

Chemistry teachers' efficacy is subject to how chemistry teachers can multi-tasks different techniques to bring about understanding for students and improve their performance in the subject. This can only be achieved if the combination of positive responses on the items or statements in Table 3 is ascertained. Therefore, 95% of chemistry teachers agreed with the statement which stated that selection of appropriate instructional strategies can facilitate effective chemistry

knowledge acquisition by students. This indicates that the chemistry teachers possessed knowledge of the ability to produce a desired outcome in the teaching of Chemistry, while 5% did not to possess the outlined skills as shown on Table 3. 75% of chemistry teachers agreed that Pedagogical knowledge is always tasking when teaching Chemistry as a subject while the remaining 22.5 disagreed while some of the chemistry teachers do not respond. 97.5% of chemistry teachers had right view on Developing the right scientific approach to the teaching of Chemistry encourages students to learn Chemistry.

Classroom Observation Protocol

S/N	ELEMENTS TO BE OBSERVED	TO BE EVIDENT TEACHER...	WHEN THE	Excellent (5 marks)	V.Good (4 marks)	Good (3 marks)	Fair (2 marks)	Poor (1 mark)
1.	Knowledge of Instructional Strategy for teaching Chemistry	1. Uses of appropriate activities in instruction 2. Uses of real-life examples and analogies in instruction 3. Utilizes different instructional strategies in presentation						
2.	Teacher efficacy	1. Developed the right scientific approach to teaching of Chemistry 2. Selection of appropriate instructional strategy 3. Displayed and effective content representation						

The Method used for the analysis of research question 3. The element to be observed by the teachers was analyzed using rating scale of observation protocol. The analysis was done by scoring each question observed by the teachers. The criteria for scoring in each of the evidence when the teacher exhibit it range between 1-5 marks. The number of scores obtained by each teacher on each question divided by maximum score of 30. The percentage is determined by the following equation:

$$\text{Percentage scores} = \frac{\text{Obtained score}}{\text{Obtainable score (30)}} \times 100\%$$

Discussion

Finding from the present study showed that majority of chemistry teachers demonstrate adequate knowledge of instructional strategies required. For example, all chemistry teachers sampled 40 (100%) agreed that using experiment is best method in teaching chemistry concepts. The combined knowledge of how teachers understand science and the instructional strategies used to teach science have become an important research interest (Gess-Newsom, 2015). This is also apparent from responses on item 19 where 39 (97.5%) agreed that innovative instructional strategies are suitable for teaching abstract concepts in chemistry. Because of the key role of teachers in the creation of significant learning is the question arises regarding how prepared biology teachers are to teach this important content (e.g., van Dijk 2009; Cofré et al. 2017; Deniz & Borgerding, 2018). it is therefore important to study which is the pedagogical content knowledge (PCK) of evolution that biology teachers display, this is, what knowledge do they have regarding how to teach and evaluate this subject, and which are the students’ learning difficulties (e.g., Cofré et al. 2016). In line with this submission, it is imperative to study teachers’ knowledge of instruction strategies of chemistry teachers. One of the limitations that prevents teachers from adequately teaching this content is the lack of training on teaching strategies to teach evolution (e.g., Romine et al., 2014; Sickel & Friedrichsen, 2013; Cofré et al. 2017) and to work with student preconceptions (Lucero et al., 2017; Parraguez et al. 2022).

It was also found out that 30% of the teachers disagreed with the statement that discussion method is most effective method for teaching Chemistry concepts in classroom. This implies that majority of the chemistry teacher possessed the knowledge of both components of topic and subject specific strategies. Teachers use of strategies can be influenced by their level o believes about a method or approach. This belief in turn influences the type of strategies they apply in the classroom. This implies that chemistry teachers should possess these two major components of teachers' knowledge on instructional strategies i.e. knowledge of subject- specific strategies e g demonstration or laboratory while knowledge of topic –specific teaching strategies includes representation, analogy, example and models. This finding from the study as regard instructional strategies is in agreement with the submission of Hodson (2001) who described teaching as multifaceted creativity where teachers are frequently required to amend their teaching strategies to ensure student learning. Teachers should make use of different teaching strategies. Another finding from the study revealed that the chemistry teachers sampled possessed adequate knowledge on what, when, and why of assessment during chemistry teaching. All chemistry teachers sampled 40(100%) agreed that questioning skill can be used to assess the students' knowledge of chemistry concepts. While, out of the 40 chemistry teachers sampled 36(90%) chemistry teachers agreed that laboratory activities provide an effective platform to measure knowledge acquired by the students. This indicates that 4(10%) of the teachers sampled still disagreed with the statement that activities of laboratory can provide platform to measure knowledge acquired by chemistry students. This implies that knowledge of assessment possessed by the chemistry teacher as one of component of pedagogical content knowledge is apparent among the teachers. This knowledge of assessment is important because the knowledge will help the teachers to determine what to assess, how to assess and the reason for the assessment. This is in agreement with submission of Magnusson et al. (1999) who modified Grossman model by adding the knowledge of assessment as important component of PCK. The teachers used the feedback from these assessments to update their teaching during classroom instruction. This goes with the submission of Atkin, Black and Coffey (2001), who indicated that identification of learning and performance goals and assessment of students' current level of understanding are the points to be considered in carrying out assessment.

Chemistry teachers' efficacy towards the teaching and learning of the subject represented the beliefs and assessments in terms of behaviour necessary for effective teaching. Finding from this study also revealed that out of 40 chemistry teachers, only 27 agreed with item 27 which states that it is difficult to teach chemistry concepts using content representation. This indicates that small percentage of chemistry teachers 13 (32.5%) disagree with item 27, this number of chemistry teachers did not find it difficult to use content representation (CoRe) when teaching chemistry concepts. Majority of respondents, 27(67.5%) found it difficult to use content representation to teach chemistry concepts. Thirty-six (36) chemistry teachers agreed that Content knowledge is best displayed through laboratory activities in teaching.

Conclusion

It can be concluded from the findings of this study that chemistry teachers possess adequate knowledge of the pedagogical knowledge and knowledge of assessment of chemistry students while some still had contrary view about the knowledge of assessment, despite the fact that Pedagogical content knowledge plays important role in classroom instruction. Some of chemistry teachers still do not have adequate knowledge about PCK. It shows that small percentages of chemistry teachers still had problem with content representation. Based on the finding from observation protocol few of the chemistry teachers score more than 50% of the score.

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