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Students' Perceptions of the Pedagogical Content Knowledge of Chemistry Teachers on the Concept of Hybridization

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Abstract: Students' perceptions of their teachers have been reported in literature to influence their interest, attitudes and motivation to learn and also influence their understanding of concepts in a subject. To improve the understanding of concepts in topics taught in our schools, there is the need for students to have a positive perception of their teachers and their pedagogical content knowledge, PCK. Thus, the study investigated Senior High School students' perception of their chemistry teachers' pedagogical content knowledge in hybridization. A mixed method was adopted using the sequential exploratory mixed approach design. Purposive sampling was used to sample six (6) Senior High Schools for the study. Simple random sampling was used to sample hundred and twenty (120) students to respond to students' questionnaire for the study, out of which convenient sampling was also used to select 24 students for the interview. A self-constructed questionnaire and a semi-structured interview were the main data collection instruments. The data was analyzed by employing descriptive statistics and content analysis. The findings revealed that, the overall mean of student's perception of their teachers' PCK in teaching concepts of hybridization was negative (M = 2.702, SD = 0.898). The results also reveal that, the students' perception on assessment methods (M=3.01, SD = 0.816) was rated above the criterion mean of 3.0, implying the PCK of the teacher was positive. However, the student's perception on teacher illustrations and demonstrations (M=2.70, *SD* = 0.947)), teaching methodology (M=2.91, SD =0.906), teaching and learning materials (M = 2.62, *SD* = 0.910) and students learning interest (M=2.27, SD =0.912) were negative below the criterion mean of 3.0. Because of this, teachers should use student-centered methodologies, teaching and learning materials, illustrations and demonstrations, and an understanding of their students while teaching abstract concepts like hybridization to ensure that their students learn in a meaningful way.

Keywords: Concept of Hybridization, Enacted PCK, Pedagogical Content Knowledge, Sequential Explanatory Mixed Method, Students Perception

1. Introduction

Hybridization is one of the concepts in the senior high school chemistry curriculum for Ghanaian students. The concept has been reported in literature as abstract and hence difficult for students to learn and understand [1-4]. The chemistry syllabus for Ghanaian senior high schools generally aims to; "*Use appropriate numeric, symbolic, nomenclature and graphic modes of representation and appropriate units of measurement; produce, analyze, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; make the subject interesting and motivating through designing hands – on* *activities to enhance students understanding of the subject, encourage investigative approach to the teaching and learning of chemistry… and make chemistry lessons, problem-solving in nature*" [5]. Therefore, students need to understand the concept of hybridization of atomic orbitals, formation of hybrid orbitals (sp^3, sp^2 and sp), bonds (sigma and pi bonds) and shapes of molecular compounds in the first year. In addition, students are expected to be able to: explain the term hybridization, describe the formation of sp^3, sp^2 and sp hybrid orbitals, understand how sigma and pi bonds are formed and illustrate the shapes of given molecular compounds [5]. Using student centered teaching techniques and school-based assessment on these chemical concepts, students are to go through brainstorming, discussions, sketches and illustrations and project works [5] to achieve these objectives related to the concept of hybridization.

Pedagogical Content Knowledge (PCK) is one of the important components of knowledge that a teacher requires to plan a lesson, select appropriate teaching techniques, and instructional materials, and assess to address the needs of learners during instructions [6]. In addition, Abell [7] and Kind [8] believe that, the PCK of a teacher influences their practice and is able to differentiate good teaching and good teachers from bad teaching practices. This knowledge that teachers must possess to teach and promote meaningful learning is called Pedagogical Content Knowledge (PCK) as defined by Kind [8]. Boesdorfer [9] added that, the PCK of a teacher is the knowledge, skills and experiences that they possess to convert content knowledge of a concept during classroom instruction and employ other strategies to assist and enhance understanding among learners.

PCK was originally defined as "*the ways of representing and formulating [a] subject to make it comprehensible to others... including an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions of students of different ages and backgrounds*" [10]. Pedagogical content knowledge is the knowledge and ability to take subject matter (content knowledge) and transform it into a lesson from which students, all students, can successfully learn [10]. "*The attraction of PCK lies in its ability to tell us something of the unique professional experience that constitutes teaching*" [8]. It has the ability to help us understand what constitutes good science teaching and good science teachers, and has helped in teacher education by developing and improving the performance of both novice and practicing teachers [7, 8]. Thus, the training and development of science educators for our classrooms requires an understanding of science teachers PCK and how they are constantly evaluated (assessed) to meet the current trends in teacher education. Most of the research work on PCK have concentrated on the teacher without taking into consideration what the students perceive about their teachers PCK. That is, students need to understand and examine their teachers teaching because they directly interact with them during classroom instructions daily.

Students' perception about their teachers PCK is the enacted pedagogical content knowledge of the teacher that they acquire and understand during classroom instruction when they observe their teachers [11]. Also, Adediwura and Tayo [12] added that, during instruction students need to note and remember the teaching strategies, teaching and learning materials, assessment and behavior of teachers in class to assist in data collection about their perception about their teachers PCK in hybridization.

1.1. Research Problem

The perception of students about their teachers PCK is one of the research areas that can be considered in relation to learning the concept of hybridization. According to Asiedu – Addo et al., [13], student's perception of their teachers influences their interest, attitude and motivation to learn and also influence their performance in a subject. To improve instructional quality in our schools, there is the need for students to have a positive perception of their teachers PCK. This will help teachers to identify their weakness and shortfalls in a concept and devise approaches to improve their practice based on what the students perceive [14]. Based on this, Ali and Shah [11] believe that, to measure the PCK of teachers, the perception of students needs to be considered to help the teachers develop and improve their PCK to promote meaningful learning without limiting it to only the perception of teachers. Halim et al., [15] added that, the knowledge students acquire during classroom instruction is influenced by their teachers PCK which can therefore be perceived by students. They added that, to understand the PCK of teachers in hybridization, there is the need to understand what students perceive about their teachers' PCK. This can therefore help to develop and modify the PCK of teachers based on students' perception to promote meaningful teaching and learning.

Evidences from numerous researchers [1-4, 16] and the researchers' personal experiences revealed that Senior High School students in the study area and in Ghana at large have generally poor understanding of the concept of hybridization. These research works have not highlighted the views of what the students have about their teachers teaching. Also, most of the research work on PCK have concentrated on the teacher without taking into consideration what the students perceive about their teachers PCK with limited research. Students' perception of teachers' PCK is a major contributing factor to teachers' development and in students' understanding of all concepts [11, 14, 15, 17-20], there is the need to know what students think about their teachers' PCK in this important concept of hybridization. Hence, this study seeks to explore Senior High School students' perception about the pedagogical content knowledge of chemistry teachers in teaching the concept of hybridization.

1.2. Research Question

The study seeks to answer the question: What are senior high school students' perception of their chemistry teachers PCK?

1.3. Literature Review

1.3.1. Pedagogical Content Knowledge of Chemistry Teachers

The concept of PCK is based on the idea of Shulman in 1986 who defined PCK as "*the ways of representing and formulating [a] subject to make it comprehensible to others... including] an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions of students of different ages and backgrounds*" [10]. Shulman [21] revealed that, a teacher's PCK is the regular (major) topics in a subject, the ideas that are mostly represented in the content, the different analogies and illustrations employed and how the content is formulated and represented by making it understandable to the students in the classroom. Hence, knowledge of subject - matter, effective instructional techniques and social competence have been reported by [20, 22] as what students perceive as their teachers PCK. Hence, Shulman [21] added that, for effective teaching, PCK is required by a teacher and that: content, learners and learning, contexts of schooling, educational philosophies, goals and objectives and pedagogical content knowledge are the seven components of knowledge of a teacher for teaching. He concluded that, "*PCK of a teacher represents the blending of content and pedagogy into how particular topics, problems, or issues are understood, organized, represented, and adapted to the diverse interests and abilities of learners and presented for instruction"* [21].

1.3.2. Perception of Students About Their Teachers PCK in Hybridization

Students' perception about their teachers PCK is the enacted pedagogical content knowledge of the teacher that students acquire and understand during classroom instruction when they observe their teachers [11]. Thus, students' ability to take note of and remember the instructional techniques, instructional resources, assessment strategies employed by their teachers including their behavior during instruction which according to Adediwura and Tayo [12] assist in data collection about their perception about their teachers PCK.

After Shulman's conceptualization of PCK, several researchers have developed models to investigate into what the PCK of teachers entails. Research have revealed the various components of teachers PCK perceived by students in these studies. Some of these works adopted PCK models proposed by [10, 21, 23 - 28], among others. Also, there have not been any agreed instrument for measuring PCK (components) of teachers from students' perspective, although Jang et al., [29] developed an instrument for measuring students' perception of their teachers PCK. Though some studies adopted Jang et al., [29] instrument, others developed their own instruments in measuring students' perception of their teachers PCK.

Kumi and Wonu [19] employed subject matter knowledge (SMK), instructional representation and strategies (IRS), instructional objectives and context (IOC) and knowledge of students understanding (KSU) to study the perception of students on Mathematics teachers PCK. The findings revealed a positive student's perception of teachers PCK in teaching mathematics and its impact on their academic achievement. Also, Ali and Shah [11] employed knowledge of physics curriculum, students' difficulties, teaching strategies and assessment in physics to investigate the PCK of physics teachers in students' perspectives. The study reveals that teachers had high level of PCK of students learning difficulties, curriculum, assessment and teaching strategies. The study further reveals that, teachers did not consider the differences in students' intelligent levels during instruction, the use of limited examples by teachers which were limited to their daily life experiences and teachers employing teacher centered methods (lecture) of teaching as perceived by students. Sofianidis and Kallery [14] assessed the perception of students of their physics teachers PCK by taking into account subject matter knowledge (SMK), instructional representation and strategies (IRS), instructional objectives and context (IOC) and knowledge of students understanding (KSU). Halim et al., [15] measured the perception of students about their science teachers PCK using subject matter knowledge, knowledge of teaching strategies, knowledge of concept representation, knowledge of teaching context, knowledge of students and knowledge of assessment in learning science. Their study focused on the perception of students on their teachers PCK based on how different achieving abilities of learners had different views of teachers PCK in assisting their learning and understanding. The findings reveal that, teachers should be alert to students' needs such as being sensitive to students' reactions and preparing additional materials. PCK of science teachers should be different for high and low achieving students and knowledge of students understanding plays a critical role in shaping teachers PCK. A study by Ajayi and Otoide [30] focused on the perception of students on the instructional strategies used by science teachers in senior secondary schools. The results reveal that, science teachers frequently employ teacher -centered and discipline -centered teaching approaches for their lessons in secondary schools. The study also reported that, science teachers did not frequently employ student – centered teaching methods during instruction.

The findings from the above studies reveal that, what students view/perceive as their teachers PCK have benefited researchers, teachers and stakeholders in education to understand the effect of the instructional and contextual perception of students on their learning and academic performance. Thus, a teacher with a strong content knowledge and also employing effective instructional strategies as perceived by students according to Tuan et al., [20]. Perception of students about their classroom experiences and teachers have an influence on their lives and attitude towards the subject which is sometimes revealed in their examination results and classroom participation. Hence given students an opportunity to assess their teacher's instructional behaviour during and after instruction provides a positive representation of teachers' behaviour from student's perspectives [31]. Maulana et al., [32] reported in their study that, students' perception of teacher's classroom behaviour has an impact on their performance compared to when external assessors or teachers observe their own behaviors.

Therefore, in this study, teacher illustrations and demonstrations, teaching methodology, teaching and learning materials, assessment methods and students learning interests are the components of teachers PCK that will form the conceptual framework for the study. Thus, these five components of teachers PCK above would be used as a guide to understand the perception of senior high school students on their teachers PCK in teaching the concept of hybridization in chemistry.

2. Research Methodology

2.1. Design

Based on the pragmatists paradigm, the study adopted the sequential exploratory mixed-method design. The mixed-method approach according to Creswell [33] enabled the study to gather, analyze, and integrate qualitative and quantitative data of the research.

2.2. Sample Procedure

First year senior high school chemistry students in the Upper West Region of Ghana were the target population. A total of 120 Senior High School first year chemistry students were sampled using a multistage sampling technique.

Senior high schools which offer chemistry as an elective subject were first selected. With this, purposive sampling technique was used to sample 20 senior high schools that offer chemistry as an elective subject from 32 senior high schools in the Upper West Region of Ghana. The Purposive sampling procedure was used because some of the senior high schools do not offer chemistry as an elective subject in their programme of instruction. Secondly, purposive sampling was employed in selecting six category B senior high schools based on the Ghana Education Service classification of schools. Thirdly, in selecting intact classes for the study, simple random sampling was used to select six intact classes, one from each of the six category B senior high schools. Finally, twenty-four (24) students comprising four (4) students from each of the six intact classes were conveniently selected to take part in the interview.

2.3. Research Instruments

Two instruments were used to collect data: A Questionnaire and Semi-structured interviews.

2.3.1. Questionnaire

A closed-ended questionnaire of 53 items on a four-point Likert scale ranging from strongly disagree to strongly agree was used to collect data. The questionnaire consisted of five subscales: teacher illustrations and demonstrations (13 items), teaching methodology (10 items), teaching and learning materials (11 items), teachers' assessment for student learning (10 items) and student learning interest (9 items). The questionnaire solicited responses from students on the PCK of their teachers on the concept of hybridization.

The questionnaire was piloted with 40 SHS students. This was done to determine the reliability and then to ensure that the items were without ambiguity and students understood the items. The Cronbach's Alpha Reliability coefficient was used to determine the reliability of the Questionnaire. The reliability was found to be 0.786 suggesting that the questionnaire was reliable.

2.3.2. Semi-Structured Interview

The Semi-structured interview items were self-constructed. To ensure trustworthiness of the interview data, the interview protocol was given to experts to make inputs and pilot tested. The interview transcripts were read to the students to ensure that the responses were exactly what they intended to say. Twenty- four (24) students from the sample were interviewed.

2.4. Data Collection Procedure

An introductory letter was obtained from the Department of Science Education of C. K. Tedam University of Technology and Applied Sciences and was used to seek permission to carry out the study in the sampled Senior High Schools. The Students Questionnaire was personally administered to the respondents to ensure high accessibility and response rate by the researcher on their perception about their teachers PCK in hybridization. The SHS 1 chemistry students sampled were instructed on the purpose of the study and the importance of reading all instructions before responding to the items. Semi-structured interview was conducted to solicit and validate the responses from student's questionnaire on their teachers PCK in hybridization. The interview was face to face and lasted between 30-60 minutes. The interview was recorded and transcribed verbatim.

2.5. Data Analysis

Data was analyzed using SPSS version 25. Descriptive statistics such as means and standard deviations were used to analyze the data. Students' perceptions were interpreted as either very positive, positive, negative or very negative based on the categories of man scores.

Table 1. *Mean Range of Students Perception.*

Mean Range	Response	Mode Interpretation
3.6-4.0	strongly agree (SA)	Very positive
3.0-3.5	Agree (A)	Positive
2.1 – 2.9	Disagree (D)	Negative
1.0-2.0	Strongly disagree (SD)	very negative

The interview data was analyzed using content analysis. According to Leedy and Ormrod [34], content analysis is "*a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases*". The data was coded and categories into themes based on students' perception about their teachers PCK on the concept of hybridization. The results were presented in tables.

3. Results

3.1. Demographic Data of Students

Table 2. *Sex and age groups of participants.*

Variable	Frequency	Percent (%)
GENDER		
Male	74	61.7%
Female	46	38.3%
Total	120	100%
AGE		
15 – 16 years	17	14.2%
17 – 18 years	79	65.8%
19 and above	24	20.0%
Total	120	100%

The study sampled 120 chemistry students from six senior high schools in the Upper West Region of Ghana to obtain the data to answer the research questions. Out of the 120 chemistry students, 72 of them were males representing 62% whiles 46 were females representing 38% as presented in Table 2. Also, the ages of the students ranged from a minimum of 15 years to a maximum of 20 years. It also revealed that 17 students out of 120 students were between the ages of 15 and 16 years. It further revealed that 79 students were also between the ages of 17 and 18 years whilst 24 students were 19 years and above. This therefore revealed that most of the students were between the ages of 17 and 18 years.

3.2. Students' Perception About Their Teacher's Use of Illustrations and Demonstrations in Teaching the Concept of Hybridization

The students' perception on how the teacher's illustrations and demonstrations helped them understand the concept of hybridization is presented in Table 3.

Table 3. *Student's perception of teachers on teacher illustrations and demonstrations.*

Statement	Mean	Std. Deviation
The teacher used illustrations, charts and models to explain the sigma and pi bonds formed in Ethene.	2.93	0.954
The conceptual explanation and illustrations by the teacher on the formation of sigma bonds was easily understood.	2.92	0.885
The conceptual explanation and illustrations by the teacher on the formation of pi bonds was easily understood.	2.83	0.901
The conceptual explanation of the formation of Ethyne (HC=CH) showing the sigma bond in the molecule was difficult to understand.	2.73	0.985
The conceptual explanation of the formation of Ethyne showing the pi bonds in the molecule was difficult to understand.	2.68	0.898
The chemistry teacher's explanation about the difference in bond strength between the pi bond and sigma bond was not understood.	2.25	0.919
The conceptual explanation of the formation of a triple bond consisting of one sigma bond and two pi bonds in Ethyne was well understood	2.52	0.961
The teachers' explanations about the difference in reactivity between sigma bond and pi bonds was well understood.	2.86	0.892
The teacher's use of cardboard cut outs with illustrations to show how an sp^3 hybrid orbital overlaps with an s-orbital forms a sigma bond was well comprehended.	2.91	1.021
The teacher explained with illustrations that, an sp^3 hybrid orbital overlap with an sp^3 hybrid orbital to form a sigma bond but not a pi bond.	2.46	0.978
The teachers use of illustrations and demonstrations to explain CO_2 as a linear molecule with C being sp hybridized was not understood	2.48	0.961
The teachers' explanations with illustrations on H_2O not a linear molecule was well understood.	2.73	1.029
The teacher's explanations with illustrations of the CO molecule with one sigma bond and two pi bonds were confusing to me.	2.80	0.922
Overall mean	2.70	0.947

(From researchers' data, 2021).

The perception of students on the knowledge of teacher illustrations and demonstration in teaching the concept of hybridization was negative (M = 2.70, SD = 0.922). This indicated that students had negative perception about their teachers' use of illustrations and demonstrations in teaching the concept of hybridization. The findings show that the students disagreed that the illustrations and demonstrations employed by the teachers influenced their understanding. This means that students involved in the study had a negative perception of their teachers PCK on the use of illustrations and demonstration in teaching the concept of hybridization.

The results revealed that the students disagreed that the chemistry teachers used illustrations, charts and models to explain how sigma and pi bonds are formed during the teaching and learning process (M = 2.93, SD = 0.954). In addition, the students disagreed that the conceptual explanation and illustrations by the teacher helped them to understand the formation of sigma bonds (M = 2.92, SD = 0.885) and pi bonds (M = 2.83, SD = 0.901). Also, the students disagreed that they had a difficulty in understanding the conceptual explanation by teachers in the formation of ethyne showing sigma bonds (M = 2.73, SD = 0.985) and pi bonds (M = 2.68, SD = 0.898).

Also, the study explored to find out how the chemistry teachers' explanation about the difference in bond strength between pi bond and sigma bond was understood by students. The results reveal that, students disagreed the chemistry teacher's explanation about the difference in bond strength between the pi bond and sigma bond was not understood (M = 2.25, SD = 0.919). The chemistry teachers' explanations about the difference in reactivity between sigma bond and pi bond was one of the statements that responses were solicited from students. The students disagreed that they understood the difference in reactivity between sigma bond and pi bond from the teachers' explanations (M = 2.86, SD = 0.892). In addition, students disagreed they had an understanding about the explanation given by the teacher on the formation of a triple bond in ethyne consisting of one sigma bond and two pi bonds (M = 2.52, SD = 0.961).

Furthermore, the study solicited for responses from students on the use of cardboard cut-outs with illustrations on students understanding of the concept's hybridization. The students disagreed that the cardboard cut-outs with illustrations the teachers used helped them to understand the formation of a sigma bond when an sp^3 hybrid orbital overlaps with an s – orbital (M = 2.91, SD = 1.021). In addition, students disagreed to the statement, the teacher explained with illustrations that, an sp^3 hybrid orbital overlap with an sp^3 hybrid orbital to form a sigma bond but not a pi (π) bond (M = 2.46, SD = 0.978).

The study also explored how the chemistry teacher used illustrations and demonstrations to explain CO_2 as a linear molecule with the central C being sp hybridized. The students disagreed that the teachers use of illustrations and demonstrations to explain CO_2 as a linear molecule with C being sp hybridized was not understood (M = 2.48, SD = 0.961). Also, students disagreed they understood the concept H_2O not a linear molecule with the teachers' explanations with illustrations (M = 2.73, SD = 1.029).

Finally, the study found out how teachers' explanations with illustration of the CO molecule helped students to understand the concept. The students disagreed that the teachers' explanations with illustration of the CO molecule were confusing to them (M = 2.80, SD = 0.922),

3.3. Students' Perception About the Teaching Methodology Employed by Their Teachers in Teaching the Concept of Hybridization

The students' perception on how the teaching methodology employed by teachers helped them understand the concept of hybridization is presented in Table 4.

Table 4. *Student's perception of teachers on teaching methodology.*

STATEMENT	Mean	Std. Deviation
The teacher employs a variety of teaching techniques to help me grasp the concept of hybridization.	2.91	0.917
The brainstorming method used to introduce the concept hybridization helped me to explain the concept hybridization.	2.99	0.884
The discussion method employed by the teacher helped me to learn and accept varied views from colleagues on the concept hybridization.	2.84	0.850
The teacher Demonstrated using sketches to help me understand the shapes of molecular orbitals.	3.08	0.894
The teacher's marker board illustrations on the p-p orbital overlap helped me to understand how pi bonds are formed.	2.98	0.879
The marker board illustrations by the teacher on the shapes of molecules helped me to understand the concept of hybridization.	2.83	0.929
The teacher's marker board illustrations on the s-s, s-p, p-p, sp-s, sp2-s, and other orbital overlaps helped me understand formation of sigma bonds.	2.82	0.917
The demonstrations by the teacher using the models helped me to understand the shapes of the molecules.	2.86	0.901
The hands–on activity method with the cardboard cut outs the teacher used to explain the formation of sigma bonds was well understood.	2.87	0.898
The hands–on activity method with the cardboard cut outs the teacher used to explain the formation of pi bonds was well understood.	2.89	0.986
Overall mean	2.91	0.906

(From researchers' data, 2021).

The overall perception of students on the knowledge of teaching methodology employed in teaching the concept of hybridization was negative (M = 2.91, *SD* = 0.906). This indicated that students had negative perception about their teachers' employing different teaching methods in teaching the concept of hybridization. The findings shows that the students disagreed that the teaching methods employed by their teachers influenced their understanding. This means that students involved in the study had a negative perception of their teachers PCK on teaching methodology in teaching the concept of hybridization.

The results examined students' responses on the variety of teaching techniques employed by the teacher to teach the concept hybridization. The students disagreed that the teachers employed a variety of instructional techniques to help them grasp the concept of hybridization (M = 2.91, SD = 0.917). Hence the students had a negative perception about the different instructional techniques employed by their teachers in teaching the concept of hybridization. Also, students' responses were solicited on some of the instructional techniques employed by their teachers in the classroom. The students agreed that, the brainstorming method used to introduce the concept hybridization helped them to explain the concept hybridization (M = 2.99, SD = 0.884). Hence, the students had a positive perception about their teachers using the brainstorming teaching technique to introduce the lesson and how it helped them to explain the concept of hybridization. In addition, the students disagreed that the discussion method employed by the teacher helped them to learn and accept varied views from colleagues on the concept of hybridization (M = 2.84, SD = 0.850). Hence, the students had a negative perception about the discussion technique employed by their teachers to assist them to learn and accept varied views from their colleagues.

Also, the students agreed that the teacher demonstrations using sketches helped them to understand the shapes of molecular orbitals (M = 3.08, SD = 0.894). Hence, the students had a positive perception about how the demonstrations with sketches employed by their teachers helped them to understand the concept of shapes of molecules. The students perceive that their teacher's marker board illustrations and demonstrations helped them to understand some concepts in hybridization. The students agreed that the teacher's marker board illustrations on the p-p orbital overlap helped them to understand how pi bonds are formed (M = 2.98, SD = 0.879). Hence, the students had a positive perception on how the marker board illustrations the teacher employed to explain the overlap of p-p orbitals during the formation of pi bonds was understood.

Furthermore, students disagreed that, the marker board illustrations by the teacher on the shapes of molecules helped them to understand the concept hybridization (M = 2.83, SD = 0.929). Also, students disagreed that, the teacher's marker board illustrations on the s-s, s-p, p-p, sp-s, sp^2-s and other orbital overlaps helped them understand the formation of sigma bonds (M = 2.82, SD =0.917). In addition, students disagreed that they understood the shapes of molecules when the teacher used models to demonstrate the concepts (M = 2.86, SD=0.901). Hence, the students had a negative perception about the models their teachers employed to demonstrate the concepts of shapes of molecules helped them to understand.

The study also sought the opinions of chemistry students on how the hands-on activities employed by the teacher helped them to understand some concepts. From the results the students disagreed that the hands-on activity method with cardboard cut-outs helped them to understand the formation of sigma bonds (M = 2.87, SD = 0.898) and pi bonds (M = 2.89, SD = 0.986). Hence, the students had a negative perception about how the hands-on activity techniques with cardboard cut-outs helped them to understand sigma and pi bonds formation.

Majority of the learners revealed that, their teachers used discussion, brainstorming and questioning to introduce the concept of hybridization. In addition, majority of the students also agreed that, the methods used to introduce the lesson motivated their interest in the lesson.

3.4. Students' Perception About the Teaching and Learning Materials Employed by Their Teachers in Teaching the Concept of Hybridization

The students' perception on teaching and learning materials employed by teachers to teach the concept of hybridization is presented in Table 5.

Table 5. *Student's perception of teachers on Teaching and Learning materials used.*

STATEMENT	Mean	Std. Deviation
The models/ cardboards used by the teacher on the concept hybridization helped me to understand the concept.	2.88	0.871
The Charts, models and illustrations used by the teacher did not help me to understand the concept shapes of molecules in hybridisation.	2.33	0.963
The cardboard cut-outs the teacher used to explain orbital overlap (s-s, s-p and p-p) helped me to understand the formation of sigma bonds.	2.66	0.874
The cardboard cut-outs the teacher used helped me to draw the orbital overlap of s-s, s-p and p-p orbital overlap.	2.88	0.927
The cardboard cut-outs and illustrations the teacher used helped me to develop my drawing skills on orbitals and the shapes of molecules.	2.88	0.945
The charts and models did not help me to understand how the atomic orbitals overlap in a molecule.	2.18	0.889
The teacher did not use any material to explain the concept.	1.98	1.000
The Teaching and Learning materials the teacher used motivated me to learn the concept hybridisation.	2.88	0.903
The teaching and learning materials also aroused my interest in the topic hybridisation.	2.89	0.776
The teaching and learning materials used by the teacher sustained my interest in the topic hybridisation.	2.91	0.830
The teacher used a cardboard to demonstrate pi and sigma bond formation in Ethyne and Ethene without guiding us to draw the structures in our note books.	2.43	1.034
Overall mean	2.62	0.910

(From researchers' data, 2021).

The overall mean on the perception of students on the knowledge of teachers on the use of teaching and learning materials in teaching the concept of hybridization was negative (M = 2.62, *SD* = 0.910). This indicated that students had negative perception about their teachers' employing different teaching and learning resources in teaching the concept of hybridization. The findings show that, most of the students disagreed that the teaching and learning materials employed by the teachers influenced their understanding. This means that students involved in the study had a negative perception of their teachers PCK on the use of teaching and learning materials in teaching the concept of hybridization.

From the results the students disagreed that the models/ cardboards the teacher used to teach the concept of hybridization helped them to understand (M = 2.88, SD = 0.871). Thus, the students had negative perception about how the models and cardboards employed by teachers in the class helped them to understand the concept of hybridization. Also, the students disagreed that the charts, models and illustrations used by the teacher did not help them to understand the shapes of molecules (M = 2.33, SD = 0.963). Hence, students had a negative perception about how the charts, models and illustrations employed by their teachers helped them to understand the shapes of molecules.

Furthermore, the students disagreed that they understood the formation of sigma bonds when the teacher used the cardboard cut-outs to explain the orbital overlaps (M = 2.66, SD = 0.874). Hence, the students had a negative perception about how the cardboard cut-outs used by teachers to explain orbital overlap helped them to understand sigma bond formation. The students disagreed that the cardboard cut-outs the teacher used helped them to draw the orbital overlap of s-s, s-p and p-p orbital (M = 2.88, SD = 0.927). Hence, the students had a negative perception about how the cardboard cut-outs employed by their teachers helped them to draw and illustrate orbital overlaps.

The students disagreed that cardboard cut-outs and illustrations employed by the chemistry teacher helped them to develop their drawing skills on orbitals and the shapes of molecules (M = 2.88, SD = 0.945). Hence, the students had a negative perception about how the cardboard cut-outs and marker board illustrations employed by their teachers helped them develop their drawing skills. In addition, students disagreed that, the charts and models did not help them to understand how the atomic orbitals overlap in a molecule (M = 2.18, SD = 0.889). Hence the students perceive that, charts and models employed by their teachers to teach the concept of hybridization helped them to understand how atomic orbitals overlap in a molecule. The students disagreed that, their teachers did not use any material to explain the concept of hybridization (M = 1.98, SD = 1.000). Hence, the students think that, their teachers used different teaching and learning materials to teach the concept of hybridization.

The students disagreed that, the Teaching and Learning materials the teacher used motivated (M=2.88, SD= 0.903), aroused (M=2.89, SD=0.776) and sustained their interest (M= 2.91, SD = 0.83) to learn the concept of hybridization. Hence, the students perceive that the use of teaching and learning materials employed by their teachers in class motivated them to learn, aroused and sustained their interest in the concept of hybridization. Also, the students disagreed that, their teachers used a cardboard to demonstrate pi and sigma bond formation in Ethyne and Ethene without guiding them to draw the structures in their note books (M = 2.43, SD =1.034). Hence, the students perceive that, their teachers used cardboards to demonstrate the formation of pi and sigma bonds in ethyne and ethene but they were not assisted to draw the structures. This implies that, during demonstrations teachers should employ techniques to guide their students to help them understand the concepts.

Teaching and learning materials are very important during classroom instruction. The effective use of instructional materials in the classroom by teachers can help to reduce the learning difficulties experienced by students. Cardboards, cardboard cut-outs, balloons, animations, picture, analogy, illustrations etc. are some of the materials that can be used to effectively teach the topic hybridization for promoting meaningful learning in students. Students revealed that, their teachers used cardboards, cardboard cut-outs, molecular model kit, flash cards among others to teach the concept of hybridization. They had this to say about the TLMs their teachers employed in teaching the concept of hybridization:

Student 018 "use of gari and beans, flash cards (cardboards)"

Student 016 "Cardboard cut into s and p orbitals; those round things (molecular model kits)"

Student 008 "Cardboards cut outs of s and p orbitals, used some of us as materials"

Student 003 "cardboard cut into s and p shapes, cardboard illustrations"

3.5. Students' Perception About the Assessment Methods Employed by Their Teachers in Teaching the Concept of Hybridization

The students' perception on how the teacher's assessment techniques helped them understand the concept of hybridization is presented in Table 6.

Table 6. *Student's Perception of teachers on Assessment for Student learning.*

STATEMENTS	Mean	Std. Deviation
The written assessment the teacher used helped me to correct my learning difficulties in during and after the lesson.	2.78	0.939
The illustrations the teacher always ask us to do in class motivated me to always practice after class.	3.01	0.794
The teacher provided hands-on activities for us to learn the concept hybridisation.	2.79	0.943
The oral (questioning) assessment method used by the teacher did not help me to understand the concept hybridisation.	2.31	0.877
The class assignment that the teacher assigned us allowed me to practice more on the concept of hybridisation.	3.18	0.756
The teacher asked many questions about hybridisation to help me understand the concept.	3.18	0.860
The teacher gave all students in the classroom a chance to answer questions.	3.13	0.755
The teacher provided us the opportunity to think and respond to questions.	3.25	0.748
My teacher encourages all of us to participate in all classroom discussions.	3.18	0.778
My teacher asks us a lot of questions in class to ensure that we understand the concept of hybridisation.	3.26	0.716
Overall mean	3.01	0.816

(From researchers' data, 2021).

The overall mean on the perception of students on the knowledge of teachers' assessment in teaching the concept of hybridization was positive (M = 3.01, *SD* = 0.816). This indicated that students had a positive perception about assessment methods their teachers employed in teaching the concept of hybridization. The findings shows that the students agreed that the assessment methods employed by the teachers influenced their understanding. This means that students involved in the study had a positive perception of their teachers PCK on assessment in teaching the concept of hybridization.

The findings revealed that, the students agreed that their teachers asks them a lot of questions in class to ensure they understood the concept of hybridization (M = 3.26, SD = 0.716). Hence, the students think that they understand the concept of hybridization better if their teachers ask a lot of questions during instruction.

Also, students agreed that, the teacher provided them the opportunity to think and respond to questions asked during instruction (M=3.25, SD = 0.748). Thus, majority of the students perceive that, teachers should always provide them the opportunity to think critically before they respond to questions in class during instruction. In addition, students agreed that, the class assignment that the teacher assigned them allowed them to practice on the concept of hybridization (M = 3.18, SD = 0.756). Hence, majority of the students perceive that, teachers need to constantly give them assignments for them to practice the concept taught after class. This will improve their conceptual understanding and improve their performance.

Students agreed that, the teacher asked many questions on the concept of hybridization to help them understand the concept (M = 3.18, SD = 0.860). Thus, the students perceived that, during classroom instruction, teachers need to ask students different kinds of questions on the concept taught to enhance their conceptual understanding. Furthermore, the students agreed that, their teachers encourage all of them to participate in all classroom discussions (M = 3.18, SD = 0.778). This implies that, teachers should encourage and motivate students to participate fully in classroom activities as perceived by the students.

The students agreed that, their teachers gave all of them in the classroom the opportunity to answer questions (M = 3.13, SD = 0.755). Hence, majority of the students perceived that their teachers gave them all the opportunities in the classroom to answer questions. The students agreed that, the illustrations the teacher always asks them to do in class motivated them to practice after class (M = 3.01, SD = 0.794). Thus, the students perceive that teacher illustrations on the markerboard and also guiding them to illustrate the concepts in their books motivated them to understand and also practice concepts taught after class.

The students also disagreed that the teacher provided hands – on activities for them to learn the concept of hybridization (M = 2.79, SD = 0.943). Hence, the students had a negative perception about the hands-on activities employed by their teachers during instruction to enhance their learning of the concept of hybridization. In addition, students disagreed that, the written assessment the teacher used helped them to correct their learning difficulties during and after the lesson (M = 2.70, SD = 0.939). Hence, the students had a negative perception about the written assessment used by their teachers during instruction to help them overcome their learning difficulties in learning the concept of hybridization. There is therefore the need for teachers to employ varied assessment techniques during classroom instruction.

Again, the students disagreed that, the oral (questioning) assessment method used by the teacher did not help them to understand the concept of hybridization (M = 2.31, SD = 0.877). Hence the students had a negative perception and that, teachers should not rely on only one method of assessment (such as oral) is assessing students in the classroom but employ other student-centered assessments techniques to promote meaningful learning.

Students interview responses on the assessment techniques employed by their teachers in teaching the concept of hybridization in chemistry reveal that, their teachers employed written exercises, oral questions, written quizzes (tests), assignments, demonstrations and students' illustrations on the marker board. Also, majority of the students also added that, the methods mentioned were student friendly and appropriate in measuring the concept of hybridization. Furthermore, the students were asked about how the assessment methods employed by the teacher helped them to understand the concept of hybridization. They said:

Student 003: "it helped me to contribute to classroom discussions, practice before and after class, learn from my mates and also accept the views from my mates in class"

Student 015: "using demonstrations helped me to understand some of the concepts in class, to read aloud before coming to class, and it motivates me to take part in classroom discussions"

Student 020: "how he assessed us using the exercises and oral questions helped me to understand; the exercises helped me to always learn to score high marks; the answers given by my mates through oral questions helped me to learn from them; demonstrations helped me to reflect and draw the shapes on my own"

Student 009: "it helped me to understand the formation of pi and sigma bonds, shapes of molecules and determine the bond angles of molecules. To explain to a colleague for more clarification (understanding)"

Student 022: "reflecting back to the demonstrations helps to understand and answer the questions and also helped me to assist/teach my colleagues"

The views of the students on the teacher classroom assessment reveal that, teachers need to select student-centered assessment techniques to enhance conceptual understanding of a concept. Thus, oral questions and students' illustrations on the marker board used by some of the teachers during the lesson as observed by the researcher allows students to read and practice previous concepts before and after a lesson.

3.6. Students' Perception About Students Learning Interest in Learning the Concept of Hybridization

The students' perception on how the teacher's understanding of student's learning interest helped them understand the concept of hybridization is presented in Table 7.

Table 7. *Students' perception of teachers on students learning interest.*

STATEMENT	Mean	Std. Deviation
The many questions teacher asks us helped us to understand the concept of hybridization in the classroom.	2.97	0.934
The teacher gave us no encouragement to participate in all classroom discussions.	1.90	0.911
When I was having difficulty sketching the shapes of some of the molecules, the chemistry teacher did not assist me.	2.10	0.929
I didn't have enough time to write the summary notes on the marker board since the teacher didn't give me enough time.	2.26	0.845
We didn't have enough time to complete the exercises since the teacher didn't give us enough time.	2.21	0.907
The teacher does not allow us to participate in the lesson.	1.93	0.900
Teacher did not give students individual attention.	2.10	0.864
After class, I don't always put what the teacher has taught me into practice.	2.63	0.916
I have a difficulty in explaining the types of hybrid orbitals.	2.37	1.012
Overall mean	2.72	0.912

(From researchers' data, 2021)

The overall mean on the perception of students on the knowledge of teachers on students understanding in teaching the concept of hybridization was negative (M = 2.27, *SD* = 0.912). The findings shows that the students disagreed that the knowledge of teachers on students understanding influenced their understanding. This means that students involved in the study had a negative perception of their teachers PCK on student learning interest in the concept of hybridization.

From the results students disagreed that, the many questions their teachers asked helped them to understand the concept of hybridization in the classroom (M = 2.97, SD = 0.934). Hence the students perceive that teachers should ask many and different questions during classroom instruction to help them understand the concept. The students disagreed that after class, they don't always put what they are taught by their teachers into practice (M = 2.63, SD = 0.916). Thus, students had a negative perception by revealing that after class they don't always practice what they are taught in class. This could affect students conceptual understanding and performance in a concept.

Also, the students disagreed that, they have a difficulty in explaining the types of hybrid orbitals in the concept of hybridization (M = 2.37, SD = 1.012). Thus, the students perceive that, they had a difficulty in explaining the types of hybrid orbitals in hybridization. This could increase the difficulty the students encounter in learning the concept of hybridization since understanding the formation of hybridization influences students conceptual understanding of the concept. In addition, students disagreed that they didn't have enough time to write the summary notes on the marker board since the teacher didn't give them enough time (M = 2.26, SD = 0.845). Hence, most of the students said that their teacher did not give them enough time to write summary notes on the marker board. This implies that, teachers need to give their students enough time to write summary notes to facilitate revision and promote conceptual understanding.

The students disagreed that they didn't have enough time to complete the exercises since their teachers didn't give them enough time (M = 2.21, SD = 0.907). Hence, the students revealed that their teacher did not give them enough time to complete the exercise given to them during instruction. This implies that, teachers need to give their students enough time to complete their class exercises and also take note of the number of questions given to students by also taking into consideration the different categories of students in the class. The students disagreed that, their teachers did not give them individual attention in class (M = 2.10, SD = 0.864). Hence, teachers need to always attend to students during instructions to help identify their learning difficulties and provide them with the necessary assistants to overcome their challenges in class.

The students disagreed that their teachers do not allow them to participate in the lesson. Hence, the students perceive that their teachers allow them to participate in the lesson during instruction (M = 1.93, SD = 0.900). Therefore, teachers involving students in their lessons helps them to identify students' difficulties and misconceptions and thus assist them to understand the concepts better. The students disagreed that the teacher gave them no encouragement to participate in all classroom discussions (M = 1.90, SD = 0.911). Hence, the students said their teachers encourage them to participate in classroom discussions.

Views of students on the learning challenges/ difficulties they encountered during the teaching and learning process. Students' responses from the interview reveal that, they experienced some difficulties in learning the concept of hybridization. This includes the topic is difficult to understand and confusing, difficulty in drawing the diagrams, drawing the shapes of molecules are difficult. They said that:

Student 008: "*the topic is confusing; the topic is difficult to understand; more than one question on a concept which makes understanding difficult"*

Student B002: "It is difficult to understand the topic' 'The topic is confusing' 'I don't understand the formation of bonds (pi and sigma)' 'I can't draw the shapes of molecules"

Student D013: "It is full of drawings and it's been taught well but it is difficult to understand the shapes of molecules and I find it difficult to understand"

Student B013: "I find it difficult to understand the topic and exactly what is talking about' 'I do not understand how orbitals are mixed to form new orbital" 'I cannot draw shapes of molecules' 'I cannot remember what I am taught"

'The topic is confusing"

Student 021: "the method and some of the procedures were confusing to me; I did not understand the concept of hybridisation, formation of sp, sp^2 and sp^3 orbitals, shapes of molecules and formation of bonds; I had difficulty in drawing the diagrams; I don't understand when I read the notes; I do not always read before and after class"

Though majority of the students interviewed revealed their difficulty in understanding the concept of hybridization, some agreed that, their teachers were able to identify their learning challenges and helped them to overcome the challenge. They were also asked about how their teachers helped them overcome their learning challenge in hybridization. They added that:

Student 002: "the teacher helped me to read and write; encouraged me to take part in classroom discussions and always takes his time to demonstrate to us in class"

Student 010: "the oral questions the teacher asked in class, written exercises given by the teacher and demonstrating some of the concepts using the TLMs helped me to understand the concept"

Student 019: "constant practice/revision of questions; using videos, shapes and demonstrations helped me to reflect back to answer questions"

Student 023: "the teacher takes his time to explain the concept; the teacher gives us more examples to try on our own; the teacher calling some of us in class to draw some shapes on the board"

Student 009: "the teacher used some of my mates to demonstrate in front of the class; he asked some of us to illustrate on the marker board; he advices us to read and practice after class; he asks us questions in class to enhance our understanding; he uses more examples in the classroom discussions"

Student 015: "by repeating himself and going over it and also taken his time to explain the concept of hybridisation to the understanding of his students, and also give us trial questions to try"

It is observed from the students' responses that, teachers need to select and use teaching and learning materials, classroom illustrations and demonstrations, student-centered teaching methods, assessment strategies to help address the numerous challenges students experience during classroom instruction. Teachers need to also motivate students to always practice what they are taught in class before and after class and also take into consideration the needs of the students to promote meaningful learning.

Table 8. *Summary of the means of student's perception about teacher PCK in hybridization.*

PCK variables	Mean	Standard deviation	Remarks
Teacher illustrations and demonstrations	2.70	0.947	Negative
Teaching methodology	2.91	0.906	Negative
Teaching and learning materials	2.62	0.910	Negative
Assessment methods	3.01	0.816	Positive
Students learning interest	2.27	0.912	Negative
Overall mean	2.702	0.898	Negative

The results in Table 8 reveal that, the overall mean of student's perception of their teachers PCK in teaching the concept of hybridization was negative (M = 2.702, SD = 0.898). The results also reveal that, the student's perception on assessment methods was rated above the criterion mean of 3.0, implying the PCK of the teacher on assessment methods is positive. However, the student's perception on teacher illustrations and demonstrations, teaching methodology, teaching and learning materials and students learning interest were negative and below the reference mean of 3.0. Furthermore, among the PCK components measured in the study, students' perception on assessment methods had the highest mean (M=3.01, SD = 0.816), followed by teaching methodology (M=2.91, SD =0.906) with students learning interest having the least (M=2.27, SD =0.912). Therefore, the means of the student's perception of assessment methods greater than the other PCK components implies that, the teachers had positive perception on classroom assessment which has an influence on their learning. The teacher with a negative perception on students learning interest could also affect students learning if a teacher does not take into consideration the different groups of learners during instructions.

4. Discussion

The study investigated the perception of senior high school students about their teachers PCK in teaching the concept of hybridization in chemistry. The study reveals that, the overall mean of student's perception of their teachers PCK in teaching the concept of hybridization was negative (M = 2.702, SD = 0.898). The results also reveal that, the student's perception of assessment methods was rated above the criterion mean of 3.0, implying the PCK of the teacher on assessment was positive. However, the student's perception on teacher illustrations and demonstrations, teaching methodology, teaching and learning materials and students learning interest were below 3.0, which are negative. Furthermore, among the PCK components measured in the study, students' perception on assessment methods had the highest mean (M=3.01, SD = 0.816), followed by teaching methodology (M=2.91, SD =0.906) with students learning interest having the least (M=2.27, SD =0.912). Therefore, the mean of student's perception of assessment methods is greater than the other PCK components implies that, the teachers had more knowledge on classroom assessment which had an influence on their learning. The teacher with a low mean on students learning interest could also affect students learning if teacher does not take into consideration the different groups of learners during instructions.

4.1. Teacher Illustrations and Demonstrations

The findings reveal that, students had a negative perception (M=2.70, SD=0.947) about their teacher's use of illustrations and demonstrations in teaching the concept of hybridization. This implies that, the illustrations, demonstrations, charts, models employed by the teacher to explain the various concepts in hybridization influenced students understanding. The above findings reveal that the use of illustrations and demonstrations helped students to understand the concept of hybridization. Also, the student's exposure to the illustrations and demonstrations employed by the teacher enhanced students' perception in learning and their conceptual understanding in the concept. The findings agree with the study by Sweeder and Jeffery [35] that, a well and properly planned classroom illustration and demonstration plays an important role in developing a deep and rich understanding of chemical concepts. The findings of the study is confirmed by Mthethwa-Kunene et al., [36] who revealed that topic specific instructional techniques were employed by teachers in diverse forms including context – based teaching, illustrations, peer teaching and analogies, however, they were unable to use models, individual or cooperative strategies to guide students conceptual understanding. hey recommended the use of necessary instructional materials in teaching abstract concepts.

4.2. Teaching Methodology

The findings reveal that, students had a negative perception (M=2.91, SD=0.906) about the teaching methodology employed by their teacher's in teaching the concept of hybridization. Thus, most of the students disagreed that the teaching methods employed by the teachers helped them to understand the concept.

From the study, the students perceived that their teachers employed a variety of teaching techniques to help them grasp the concept of hybridization; their teachers employed the brainstorming teaching technique to introduce the lesson and helped them to explain the concept of hybridization; teachers need to use the discussion technique to assist them to learn and accept varied views from their colleagues; they understood the concept of shapes of molecules when their teachers' employed demonstrations with sketches; the marker board illustrations the teacher employed to explain overlap of p-p orbitals during the formation of pi bonds was understood; the models their teachers employed to demonstrate the concepts of shapes of molecules helped them to understand and the hands-on activity techniques with cardboard cut-outs helped them to understand the formation of sigma and pi bonds. The findings are compatible with that of Mishra and Koehler [37] that a teacher who understands his teaching methodology uses it to identify how students learn and make meaning from what they learn in the classroom [37].

The findings also contradict with Ali and Shah [11] that during physics class, students perceived they only listen carefully to their teachers because they mostly employ the lecture method. With this, Holtman et al., [38] added that, teachers need to adopt student – centered teaching methods to teach in other to enhance the conceptual understanding of students. Based on this, the chemistry syllabus [5] also recommended brainstorming, demonstrations, discussions, hand-on activities among others which majority of students perceived were employed by their teachers in teaching the concept of hybridization.

4.3. Teaching and Learning Materials

The study reveals that, students had negative perception (M=2.62, SD=0.910) about the teaching and learning materials employed by their teacher's in teaching the concept of hybridization. Thus, most of the students disagreed that the teaching and learning materials employed by the teachers helped them to understand the concept. The students perceived that, charts, models and illustrations employed by their teachers helped them to understand the shapes of molecules; the cardboard cut-outs used by teachers to explain orbital overlap helped them to understand sigma bond formation., the cardboard cut-outs employed by their teachers helped them to draw and illustrate orbital overlaps; the cardboard cut-outs and marker board illustrations employed by their teachers helped them develop their drawing skills; the use of teaching and learning materials employed by their teachers in class motivated them to learn, aroused and sustained their interest in the concept of hybridization; the charts and models employed by their teachers to teach the concept of hybridization helped them to understand how atomic orbitals overlap in a molecule.; their teachers used different teaching and learning materials to teach the concept of hybridization; their teachers used cardboards to demonstrate the formation of pi and sigma bonds in ethyne and ethene but they were not guided to draw the structures. This implies that, during demonstrations teachers should employ techniques to guide their students to help them understand the concepts.

The findings are also supported by the study by Mthethwa-Kunene et al., [36] that, teachers reinforced the understanding of the students in the concept of genetics by employing contextual -base teaching, illustrations, and drawings, cooperative teaching, and analogies while others used teaching and learning materials and inquiry-based learning. However, the findings of the study also supports the findings of Bagheri et al., [39], that when teachers engages students less in instructional approaches and not using instructional materials [40] like models, computer simulations among others to explain scientific concepts affects students conceptual understanding.

4.4. Assessment Methods

The study reveals that, students had positive perception

(M=3.01, SD=0.816) about assessment methods employed by their teacher's in teaching the concept of hybridization. Thus, the students agreed that the assessment techniques employed by the teachers helped them to understand the concept. Also, the students said that, they can understand the concept of hybridization better if their teachers ask a lot of questions in class during instruction. In addition, students said that; teachers should always provide them the opportunity to think critically before they respond to questions in class during instruction. This finding confirms the findings of Adedoyin [41].

Also, the students said that, teachers need to constantly give them assignments for them to practice the concept taught after class. This will improve their conceptual understanding and improve their performance. Majority of the students added that, during classroom instruction, teachers need to ask them different kinds of questions on the concept taught to enhance their conceptual understanding. Majority of students said that; their teachers encouraged all of them to participate in all classroom activities. This implies that, teachers should encourage and motivate students to participate fully in classroom activities.

Furthermore, some students said that the teacher did not give all of them in the classroom the opportunity to answer questions. Some of the students added that their teachers did not employ hands-on activities during instruction to enhance their learning of the concept of hybridization. Some of the students said that written assessment used by their teachers during instruction could not help them overcome their learning difficulties in learning the concept of hybridization. There is therefore the need for teachers to employ varied assessment techniques during classroom instruction.

Majority of the students said that teacher illustrations on the markerboard and also guiding them to illustrate the concepts in their books motivated them to understand and also practice concepts taught after class. The students added that; teachers should not rely on only one method of assessment (such as oral) in assessing students in the classroom but employ other student-centered assessments techniques to promote meaningful learning.

4.5. Students' Learning Interest

The study revealed that, students had negative perception (M=2.27, SD=0.912) about the knowledge of teachers on students learning interest in teaching the concept of hybridization. Thus, the students disagreed on the knowledge of teachers on students learning interest in hybridization.

Majority of the students said that teachers should ask many and different questions during classroom instruction to help them understand the concept. Majority of students said that after class they don't always practice what they are taught in class. This could affect students conceptual understanding and performance in a concept. Also, majority of the students said that, they had a difficulty in explaining the types of hybrid orbitals in hybridisation. This could increase the difficulty the students encounter in learning the concept of hybridization since understanding the formation of hybridization influences students conceptual understanding of the concept. This was confirmed by some students in the statement:

"*the concept is difficult to understand, I have difficulty in explaining the formation of sp, sp^2 and sp^3 hybrid orbitals, the topic is confusing"* among others.

This finding was also confirmed by Abukari et al., [1] who reported that majority of students had a difficulty in explaining the formation of hybrid orbitals. Again, this finding confirms the work of Wu and Shah [42] who believe that, when the content knowledge of students in a concept in a topic is low and fragmented, they experience difficulty in understanding and affects their performance. Smart et al., [43] also added that, inadequate understanding of scientific concepts and less engagement from teachers affects students conceptual understanding. Usak et al., [44] revealed in their study that, primary student teachers had insufficient content knowledge in teaching the content phase transition of matter. The conceptual difficulty of students in the study was also confirmed by Abukari, M. A. et al., Hanson, R. et al. and Koomson, C. K. et al. in their study. [1, 16, 45]

In addition, some of the students said their teachers did not give them enough time to write summary notes on the marker board. Thus, teachers need to give their students enough time to write summary notes to facilitate revision and promote conceptual understanding. Some of the students also said that their teachers did not give them enough time to complete the exercises given to them during instruction. Hence, teachers need to give their students enough time to complete their class exercises and also take note of the number of questions given to students by also taking into consideration the different categories of students in the class. Majority of the students said that their teachers gave them attention in class during instructions. This helped identify their learning difficulties and helped them to overcome their challenges in class.

Majority of the students said that their teachers gave them the opportunity to participate in the lesson during instruction. This helped them to understand the concepts better. Majority of the students think that their teachers encourage them to participate in classroom discussions. The findings reveal that, teachers should be able to be aware of the needs of students during classroom instruction to help them overcome their learning difficulties.

5. Conclusion

The study investigated the perception of senior high school students about their teachers PCK in teaching the concept of hybridization in chemistry. The study findings reveal new insights into PCK literature on students' perception about their teachers PCK. The study also established empirical evidence that student's perception about their teachers PCK in teaching have an influence on teacher practice and students conceptual understanding in class. The study showed that teacher illustrations and demonstration employed by the teachers to teach the concept of hybridization enhanced students conceptual understanding in the formation of sigma and pi bonds, formation of triple bonds and H_2O not a linear molecule. This was influenced by conceptual explanations, illustrations, charts, models, demonstrations and cardboard cut-outs employed by the teachers. However, students' difficulty in understanding the formation of ethyne (showing sigma and pi bonds), differences in bond strength between sigma and pi bonds, CO_2 as a linear molecule and CO molecule was also revealed in the study.

The study showed that, students' perception about the teaching methodology employed by teachers was negative, however, it helped them to grasp, explain, understand, learn and accept varied views of students on the concept of hybridization. This was influenced by the teacher employing different teaching techniques such as brainstorming, demonstrations with sketches and models, marker board illustrations and hands-on activities with cardboard cut-outs as perceived by the students. The teaching and learning materials employed by the teachers in teaching the concept of hybridization as perceived by students was negative but helped them to understand the concept of hybridization, draw orbital overlap diagrams (s-s, s-p, p-p orbitals), develop their drawing skills, motivated them to learn, aroused and sustained their interest in the concept of hybridization. The students also perceive that, their teachers employed teaching and learning materials such as models, cardboard illustrations, cardboard cut-outs, charts and illustrations to teach the concept of hybridization.

The study showed that, written exercises, test, assignments, oral questions, demonstrations, hands-on classroom activities and students' illustrations on the marker board are some of the assessment techniques employed by teachers in teaching the concept of hybridization as perceived by students was positive. The assessment methods employed helped students to understand the concept, correct their learning difficulties, motivated them to always practice before and after class, gave all of them an opportunity to think and respond to questions, encouraged them to participate in all classroom discussions, learn from their colleagues, accept varied views of their mates and assist their colleagues in class. The study shows that, during instructions teachers should ask many and different questions in class, allow students to participate in the lesson and encourage students to participate in classroom discussion which influences students conceptual understanding in learning the concept of hybridization as perceived by students. However, students perceived that, they do not always practice what they are taught after class, teachers did not give them enough time to write summary notes on the marker board and also complete the exercise given to them and teachers did not provide them with adequate attention during instruction. This therefore affects students conceptual understanding and increases their learning difficulty which affects their performance.

6. Recommendation

The study therefore recommends that, teachers should motivate and encourage students to express their views about their teaching. Teachers should always ask their students about their teaching after class to inform their practice. Also, the use of teaching and learning materials should be encouraged and used in teaching abstract concepts by teachers to motivate, arouse and sustain students' interest to learn. If possible, teachers should be assisted and encouraged to improvise teaching and learning materials through in-service training workshops on improvisation. In addition, teachers should also learn and assisted on the use of TLMs in teaching a concept and how it can be employed in explaining concepts to students conceptual understanding.

Teachers need to adopt different assessment strategies in their lessons by encouraging and motivating students to participate in all classroom's activities. Teachers need to pay attention to their students during instruction to identify their learning difficulties and help them with the necessary assistance to overcome their challenge. Finally, schools and teachers need to adopt strategies that will help students to practice what they are taught in class to improve their conceptual understanding and performance.

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