

Determination of Pre-Service Chemistry Teachers TSPCK in Mole Concept in Abubakar Tafawa Balewa University Bauchi State

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Abstract :- The study assessed the topic-specific pedagogical content knowledge (TSPCK) of pre-service chemistry teachers in Abubakar Tafawa Balewa University in Mole concept. The two research questions sought to determine the extent to which components of TSPCK were effectively transformed by the pre-service teachers. The research questions were drawn from the components of TSPCK in Mole concept. which are; The knowledge of the learner's component and Curricular Saliency. To answer the research questions, five (5) instruments were used for data collection. The instruments included; The TSPCK in Mole concept questionnaire, TSPCK in Mole concept scoring rubric, observation checklist, interview protocol and conceptual understanding test in Mole concept. The pre-service teachers were observed in the classroom as they taught mole concept to the SS 2 students. Thereafter the TSPCK mole concept questionnaire was given to the fifty-two (52) final year chemistry education student of the University which served as the total population for the study. The research embraced case study as a research strategy in order to determine the extent of transformation of the TSPCK components. Four (4) pre-service teachers were selected to be used as case study and a TSPCK conceptual understanding test in mole concept was given as well as an interview sections to elicit the extent to which they can transform the component of TSPCK in teaching the concept well. The convergent parallel mixed method was used as a research design. The TSPCK conceptual understanding Test was analyzed both quantitatively using the scoring rubric and qualitatively by explaining the content of the test written by each pre-service teachers and capturing his/her responses. Interview responses were coded to align with the TSPCK coding pattern adapted by Mavhunga (2012) and it was analyzed using the content analysis technique. The reliability was accessed through member checking. The likert survey questionnaire was analyzed quantitatively using the mean and standard deviation. To determine the extent of TSPCK transformation, the pre-service teachers were individually observed as they teach in the classroom. The actual findings shows that the TSPCK of the pre-service teachers in Mole concept were still developing. Two pre-service

teachers have a Developing TSPCK and were able to transform the components to a large extent. The other two pre-service teachers had a developing TSPCK and were able to transform the components to a Moderate extent. There was evidence of pre-service teachers lacking in these areas of TSPCK; the ability to identify student difficulties and some possible misconceptions they students have about the concept, suggesting the need for an improvement in pre-service teachers training would help address the needs of current and future chemistry teacher. To facilitate TSPCK development, new methods need to be explored to connect chemistry education research to practice

Keywords:- Knowledge of Learners, Misconception, Curricular Saliency, TSPCK, PCK, Pre-Service Teachers, Transformation, Interview, Coding.

I. INTRODUCTION

The concept of pedagogical content knowledge (PCK) conceived by Shulman (1986) embraces the idea that successful teachers have a special understanding of content knowledge and pedagogy which they draw on in teaching. Pedagogical content knowledge (PCK) is an academic construct that represents an intriguing idea. It is an idea rooted in the belief that teaching requires considerably more than delivering subject content knowledge to students, and that student learning is considerably more than absorbing information for later accurate regurgitation. PCK is the knowledge that teachers develop over time, and through experience, about how to teach particular content in particular ways in order to enhance student understanding. However, PCK is not a single entity that is, it is not the same for all teachers of a given subject area; it is a particular expertise with individual specialty and important differences that are influenced by (at least) the teaching context, content, and experience. It may be the same (or similar) for some teachers and different for others, but it is, nevertheless, a corner stone of teachers' professional knowledge and expertise.

From the inception of the mole in science and in science education, a number of studies have been conducted, certain studies were carried out to identify difficulties experienced by students when they solve problems involving the mole concept (Morikana and Newbold, 2013; Krishnan, 2014, Steiner, 2016;). Other studies focused on teachers' understanding of the mole (e.g. beall & Stromdahl, 2014; Padilla, 2014). It has been revealed that there has been an agreement from different studies that the pre-service teachers do not have the adequate scientific understanding of the concept called Mole and consequently, they face a lot of difficulties in teaching the topic (Mavhunga & Rollnick, 2018). Suffice it to say that students' learning difficulties and consequently their poor performance in mole concept can be to larger extent attributed to the teachers' difficulties in presenting the concept to them.

Peloagae (2017) carried out investigations to identify difficulties experienced by students using the mole in stoichiometric calculations. The findings revealed that students generally did not find it difficult to solve the problems because they seemed to understand and use the mole as a unit of quantity. However, students failed to form a strategy for solving other problems related to the mole concept.

A. Aim and objectives of the Study

The aim of this study was to determine pre-service chemistry teachers' topic specific Pedagogical Content Knowledge (TSPCK) in mole concept.

Specifically, the study sought to achieve the following objectives:

- To determine the extent to which pre-service chemistry teachers transform knowledge of learners' component of TSPCK in mole concept.
- To find out the extent to which pre-service chemistry teachers transform curricular saliency component of TSPCK in mole concept.

II. LITERATURE REVIEW

According to Shulman (1986) what makes a topic understandable for learners is PCK by means of representations, analogies, examples and demonstrations. Therefore, Shulman's view (1986, 1987) explain PCK as including knowledge of learners which has to do with the pre-service teachers' knowledge of what the learners know as well as some possible misconceptions the learners may have as regards the subject matter as well as the knowledge of learners' subject matter and learner difficulties. The curricular saliency refers to the pre-service teachers' ability to sequentially arrange the subject matter or content in order from simple to complex and to effectively break the content into bits for easy comprehension by the learners.

However, Shulman's view in a more recent study (Mavhunga, 2016) has been noted that 'teachers generally transform their content knowledge through drawing interactively on other teacher knowledge bases to formulate effective teaching strategies. The other knowledge bases referred to in Mavhunga (2016)'s study are the two TSPCK transformation components which are the knowledge of learners component and the curricular saliency component as explained above. The study further examines how the improved TSPCK can be translated into the teaching practices of the participating pre-service teachers.

The topic mole concept plays a very significant role in helping students answer examination questions (such as WAEC, NECO JAMB) involving the quantitative analysis of chemical phenomena. The topic mole concept has been chosen because it forms the baseline understanding of a number of other topics in chemistry such as chemical equilibrium, acids and bases, stoichiometry electrochemistry, concentration, pH, equilibrium constant as well as solubility etc. It is essential that learners who intend to master the basic concepts of chemistry must have a good understanding and use of the mole.

The mole, symbol mol, is the SI unit of amount of substance of a specified elementary entity, which may be an atom, molecule, ion, electron, any other particle or a specified group of such particles; its magnitude is set by fixing the numerical value of the Avogadro constant to be exactly 6.022×10^{23} when it is expressed in the SI unit mol⁻¹. An understanding of the mole concept is key and very important in laying a strong foundation in chemistry. But it has been discovered that some teachers find it very difficult to comprehend the concept accurately and this has to a large extent affected the way these pre-service teachers teach this concept to the students. This implies that teachers don't have adequate knowledge to transform the mole concept content knowledge in the form that could be easily understood by learners. Shulman (1986, 1987) identified this transformation of knowledge as PCK. He described PCK as "the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the learners" (1987)

There has been a diversion in research from focusing just on the teaching and learning difficulties encountered by both the pre-service teachers and the students to the understanding of the knowledge possessed by teachers in the transformation of the mole concept. In a study conducted by Rollnick, (2018) she sought to determine the quality of teachers' mole concept PCK, it was discovered that although some teachers showed that they have some classroom experience and a good understanding of their learners' context as well as the ability to develop teaching procedures, their mole concept PCK was weak and still developing. The pre-service teachers' knowledge of learners the and curricular Saliency was

inadequate. This, This is the gap this research intends to fill by mapping out ways of transforming the specific topic which is mole concept for easy comprehension of the learners.

A. Nature of PCK

A key characteristic of PCK is its elusiveness. Shulman, in his 1986 essay, was commenting on the need to restore balance between content knowledge and pedagogical knowledge and was concerned to emphasize the inter-relation between the two concepts. He suggested that content teachers' knowledge comprised of 3 categories:

- Content knowledge – this refers to the amount and organization of the teachers knowledge

- Pedagogical Content Knowledge - which goes beyond knowing the subject matter and includes knowledge of teaching methods or strategies
- Curricular Knowledge - which is an understanding of the curriculum and knowledge the materials available to support the curricular goal (Shulman, 1986).

B. Conceptual Frameworks

The conceptual frameworks covered embraced some vital ideas that are related to the study. The framework unified the Model of TSPCK and the Mole concept CK model. The TSPCK model was developed by Mavhunga and Rollnick (2013) while The mole concept CK model was developed by Fang, Hart and Clark, (2014) which revealed some ideas in the concept map.

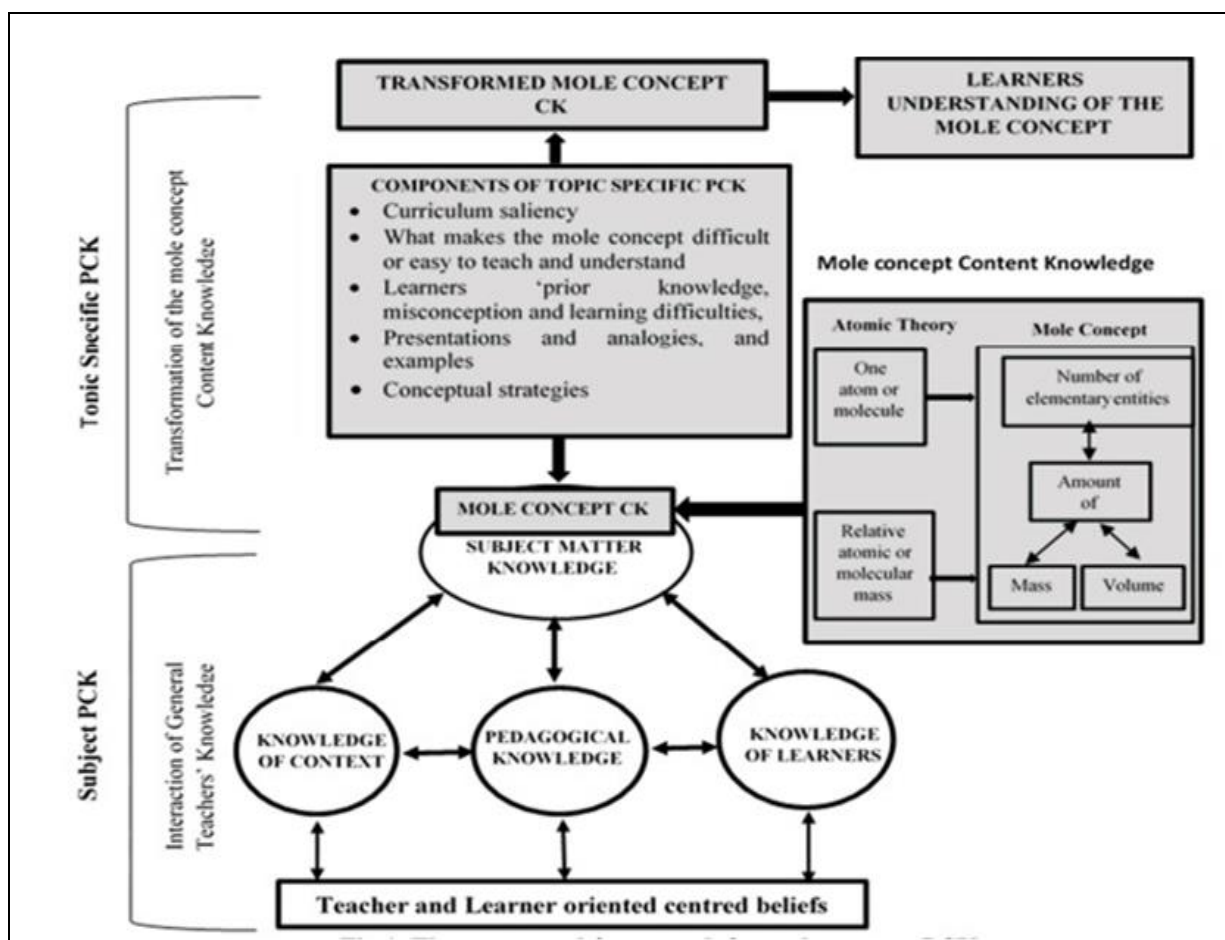


Fig. 1: The Conceptual Framework for Mole Concept PCK by Gess-Newsome, 2015; Kind, 2009, Mavhunga & Rollnick, 2013

The PCK has been discussed using different models the main ones being; transformative, integrative and PCK models from the psychological perspective (Kind, 2009). The transformative model which is the model used in this study holds the view that CK is not part of PCK. It proposes that the teacher transforms CK using the knowledge components of TSPCK into the form that is comprehensible to learners. Therefore, Content Knowledge (CK) is seen as an integral part of PCK. The models reveal how teachers continue to create

different teaching strategies for teaching specific topics or content in such a way that it would be comprehensible for the students. All the models agree to the fact that PCK is topic specific and it develops through experience, constant practice and the CK is very important for the development of PCK. The conceptual framework captured what make up the mole concept CK and how it is transformed through the different components of TSPCK by the teacher in a classroom practice to make the mole concept comprehensible to learners.

III. METHODOLOGY

The design used for this study is the Convergent Parallel Mixed-Methods Design. It is an approach in which two data sets are combined to get a complete picture of the issue being explored and to validate one set of findings with the other. This study employed case study as a research strategy of mixed method. In this study, the mixed methods all have equal weight as each has captured the same or different aspect of the research question. The target population for this study were all the fifty-two (52) pre-service teachers that is the final year chemistry education students of 2020/2021 Academic Session. However, Four (4) of these pre-service chemistry teachers were selected and participated in the case study, they were selected because they have done their teaching practice during their fourth year of study at Abubakar Tafawa Balewa University, Bauchi.

The sample size for this study was four (4) pre-service chemistry teachers which were selected from the total population for the case study. All the fifty-two (52) final year chemistry education students that constituted the population were given a selection test on mole concept (containing 20 questions, which served as a standard for the selection of the required sample for the case study. Based on a pre-determined score of 10 as bench mark for selection, only four (4) out of the forty-one (41) met the criteria and therefore, qualified for sampling. Purposive sampling technique was used to choose the required number. The Idea is to pick out the sample in relation to some criterion, which are considered important for the particular study. In this study, the criteria used were; participants must offer chemistry education as a degree course, they must be in their final year, they must have completed their teaching practice and finally the students have acquired chemistry knowledge (as measured by the pre-election test on Mole concept) and pedagogical skills to be able to transform TSPCK in mole concept during their undergraduate teaching training programme in ATBU Bauchi. Two (2) males and two (2) females were selected for the case study from the pre-selection test conducted. This will also serve as a base of accessing their pedagogical and content knowledge.

A. Participants in the Case Study

- **Salamatu:** A female final year chemistry education student with a highest entry qualification of WAEC and NECO into ATBU Bauchi. Her mode of entry into the University is through the Unified Tertiary Matriculation Examination. She did here teaching practice in Government Day Secondary School Miri, Bauchi and has taught in different primary and secondary schools before gaining admission into the University. She taught at General Hassan Unity School in Bauchi during which she taught mole concept, stoichiometry, redox reaction etc
- **Tanko:** A male final year chemistry education student with a highest qualification of WAEC and NECO and he his mode of entry into the University is through the Unified

Tertiary Matriculation Examination. He did his teaching practice in LYS Academy Bauchi during which he taught central topics in chemistry such as mole concept, chemical equilibrium, redox reaction etc.

- **Ajoke:** A female final year chemistry education student with a highest qualification of WAEC and NECO. Her mode of entry into the University is through his Unified Tertiary Matriculation Examination. She did her teaching practice in Intergrity International Secondary School, Gombe, Gombe State for a period of 3 months which was her first teaching experience and she also taught in International Secondary School, ATBU Bauchi during which she taught some related topics in chemistry such as mole concept, electrochemistry, La Chatelier's principle, redox reaction etc.
- **Dauda:** A male final year chemistry education student with a highest qualification of WAEC, NECO and NCE. His mode of entry into the University is through a Direct entry of National Certificate of Examination (NCE). He did his teaching practice at International Secondary School, ATBU Bauchi Town, in Bauchi State and majored on some central topics in chemistry such as Mole concept, chemical equilibrium, redox reaction etc
- Three instruments for data collection in this study include, TSPCK in Mole Concept questionnaire, conceptual understanding test in mole concept and the TSPCK scoring rubric Each of these instrument played a complementary role in data collection because they were meant to answer all research questions on the two (2) components of topic specific Pedagogical Content Knowledge (TSPCK).

Analysis of data was made using the following methods:

- The TSPCK in Mole Concept questionnaire was analysed quantitatively using the mean and standard deviation and thereafter conclusions were drawn using the upper limit of the liberty scale.
- The conceptual understanding understanding test in mole concept was analysed quantitatively using the TSPCK in Mole Concept Scoring Rubric and qualitatively by explaining in details the result obtained from the case study for all the two research questions and finally the TSPCK in Mole Concept Scoring Rubric was used to determine the pre-service teachers extent or level of PCK possessed .

IV. RESULTS

A. Research Question

To what extent do pre-service chemistry teachers transform the knowledge of Learner's component of TSPCK in mole concept? The results presented in Table 1 indicates the mean and standard deviation of the sample response to items on knowledge of learners (1-4 items).

➤ *Knowledge of Students*

Table 1: Pre-service Teachers' Mean and Standard Deviation of Responses to knowledge of Learners items

TSPCK Component & Statement	LE	ME	SE	NA	Total	Mean	SD	D
During my lesson on Mole high interest in learning.	27	18	5	2	52	3.50	3.00	concept, the students expressed
When I asked questions on Mole concept, most of the students responded correctly to the questions asked.	11	25	13	3	52	2.90	2.40	SE
As I taught the concept of Mole, realized that some students found the topic difficult and challenging	4	11	17	20	52	1.80	1.40	NA
I also discovered that some that some students had wrong definition about mole concept	5	15	14	17	52	2.00	1.70	SE

The results in Table 1 showed that item i-iv have mean scores of 3.53, 2.90, 1.80, 2.07 and standard deviation of 3.0, 2.4, 1.4, and 1.7 respectively. From the first item on the questionnaire, the mean score obtained was 3.53 and based on the units of the likert scale, it falls under the "Moderate extent". This indicated that in the teaching process carried out by the pre-service teachers, the extent to which the students expressed interest in learning was to a moderate extent and this revealed a good ability of transformation being done by the pre-service teachers in the teaching process.

For the second item, the mean score obtained was 2.90 which indicated "Small Extent" from the units of the likert scale. Based on the statement made, this indicated that the extent of the students response to questions correctly when the pre-service teacher was teaching was to a Small Extent hence the need for an improvement in this aspect.

From the third item on the questionnaire, the mean score obtained was 1.80, which indicated "Not at All" from the units of the likert scale. This showed that as the pre-service taught teachers that they realised that some students found the topic very easy while a few found it very difficult and challenging, hence the need to identify each learner's learning difficulty and address it.

➤ *Curricular Saliency*

Table 2: Pre-service Teachers Mean and Standard Deviation of Responses to Curricular Saliency items

TSPCK component & Statement	LE	ME	SE	NA	Total	Mean	SD	D
As a teacher, I develop strategies of teaching the Mole concept from simple to complex for better understanding.	35	10	5	2	52	3.70	3.20	ME
I broke down the Mole concept topic into sub-topics and units for easy comprehension by the students	29	21	9	4	52	3.40	3.00	ME
I arranged the sub-topics in the concept sequentially for easy teaching	26	18	6	2	52	3.40	2.90	ME
The Mole concept taught is equivalent to their level of learning.	21	20	6	5	52	3.20	3.80	ME

The mean score obtained from the fourth item is 2.07 which falls under the category of the unit of the likert scale "Small Extent". This revealed that the extent to which the pre-service teachers' discovery of wrong definition of the concept is to a small extent and hence a need for an improvement in that aspect. Finally, based on the cumulative mean scores obtained which was 2.55, This showed that the pre-service chemistry teachers ability to transform the knowledge of Learner's component of TSPCK in mole concept was to a small extent (SE). Hence the pre-service teachers need to develop a good knowledge of the learners as well as the knowledge of the existing misconceptions in mole concept in order to effectively transform the knowledge of Learners component during the teaching process in the class.

B. Research Question

To what extent do pre-service chemistry teachers transform curricular saliency component of TSPCK in mole concept?

The results presented in Table 2 indicates the mean and standard deviation of the sample response to items on Curricular Saliency (5-8 items).

The result presented in table 2 showed that item v-viii have mean score of 3.73, 3.48, 3.46, 3.21, and standard deviation of 3.23, 3.01, 2.99, and 2.81 respectively. From the fifth item, the mean score obtained was 3.73 and based on the units of the likert scale, it falls under the category "Moderate extent". This indicated that the extent to which the pre-service teacher was able to develop strategies to teaching the Mole concept from simple to complex for better understanding was to a moderate extent and this indicated that the pre-service teachers had good ability of transforming the first item statement under the Curricular Saliency.

For the sixth item, the mean score obtained was 3.48 which indicated "Moderate Extent" from the units of the likert scale. Based on the statement made, this indicated that the extent to which the pre-service teacher was able to split the Mole concept into sub-topics and units for easy comprehension was also a moderate extent and this indicated a good transformation ability by the pre-service teachers.

From the seventh item on the questionnaire, the mean score obtained was 3.46, which indicated "Moderate extent" from the units of the likert scale. This showed that the extent to which the pre-service teachers were able to sequentially arrange the sub-topics in the concept for easy teaching was to a moderate extent which really helped them in the teaching process and this revealed a good ability of the pre-service teacher to effectively transform this item statement of the Curricular Saliency.

The mean score obtained from the eighth item is 3.21 which falls under the category of the unit of the likert scale "Moderate Extent". This revealed that the aspect of the Mole concept being taught by the pre-service teachers is equivalent to the level of learning of the students and this indicated that the pre-service has a good knowledge of and ability of their students.

Finally, based on the cumulative mean scores obtained which was 3.40, This showed that the pre-service chemistry

teachers ability to transform the Curricular Saliency component of TSPCK in mole concept was to a Moderate extent (ME). Hence This further revealed that the pre-service chemistry teachers ability to transform curricular saliency component of TSPCK in mole concept is to a Moderate extent (ME). This implies that the pre-service teachers were able to use the curriculum and break down the topic - Mole concept into bits from simple to complex for the students to understand better.

C. Qualitative results /Discussions

➤ Pre-service teachers understanding of knowledge of learners component/ learners misconceptions

The TSPCK test assessed each pre-service teacher's ability to access the knowledge of the learners or the learners prior knowledge of the subject matter as well as how to easily identify student misconceptions and preconceptions that might alter students' ability to learn the topic. The four pre-service teachers used for the case study were given some conceptual understanding test question to ascertain their ability to effectively transform these components of TSPCK and their various responses indicated that their PCK was still developing. Two of the pre-service teachers were able to transform the two components to a moderate extent and the other two were able to transform the components to a large extent. As the pre-service teachers taught the students the concept in class, they asked some questions at key points of the lesson to find out the student's view or definition of the mole concept. All the students gave their different definition of what they understood mole to be and finally, the pre-service teachers qualitatively listed out the wrong definition of the concept defined by some of the students in order to correct them. Some of the misconceptions or wrong definitions students have about the Mole concept are clearly captured below.

The most commonly identified misconceptions is that the Mole is equivalent to Avogadro's number.

Table 3: List of Misconception/ Wrong Definition of the Mole Concept Given by the Students During the Teaching Sessions

1	Mole is the amount of substance
2	Mole is the amount of substance which contains carbon
3	Mole is the mass given per relative atomic mass
4	Mole is the number of molecules in a substance
5	Mole is defined as a substance that contains the same particles as the one in carbon
6	Mole is the Avogadro's number
7	Mole contains the same number of atoms in carbon

➤ Pre-service teachers understanding of Curricular saliency

The curricular saliency of the pre-service teachers was also examined through the TSPCK conceptual understanding test in mole concept in order to identify how the pre-service chemistry teachers sequenced the unit and connected the concepts within the unit as well as to other chemistry topics. The pre-service teachers all had a firm grasp of what the

Nigerian curriculum required. They were able to state the major understandings associated with the Nigerian Core Curriculum, in particular what content was required for the teaching and understanding of Mole concept in chemistry. In fact, the pre-service teachers by name Salamatu, Tanko and Ajoke seemed extremely focused on teaching exactly what was in the curriculum and nothing beyond this. The pre-

service teachers were all asked why they thought it was important for students to learn about the Mole concept. Every pre-service teacher listed the importance of learning the mole concept with some real-life or practical application in their responses.

V. IMPLICATIONS

This section addressed implications that could be derived from the results of this study. The current educational system in Nigeria does not assess Pre-service teachers in their TSPCK, and their proficiency may not progress as long as overall student performance met current guidelines. Pre-service Teachers could lack TSPCK in a particular topic, but still possess sufficient general PCK to guide students towards success on the class assessment. The means by which pre-service teachers were assessed needed to be adapted to show teacher proficiency in all topics within the curriculum.

Another implication of this study is that a pre-service teacher's TSPCK becomes limited by the nature of the assessment. Finally, all four of the pre-service teachers in this study were chemistry education students who have little experience in teaching. Dauda had more exposure and experience in teaching because his mode of entry into the University was through direct entry and hence has been exposed to series of classroom teaching and contact with the students as well as one of the pre-service teachers by name Salamatu. Studying the additional chemistry content could provide a source of enrichment necessary for the teacher to develop more sophisticated TSPCK.

A. Recommendations

The results of this study suggested the need for curricular and testing overhaul. Pre-service Teacher evaluation systems needed to be revised to improve student learning. To help current pre-service teachers who may lack TSPCK, PCK development opportunities need to be made available to assist Pre-service teachers in TSPCK growth. In addition, the means by which teachers are trained should be altered to include explicit TSPCK training.

Pre-service Teacher preparation needed to be modified to meet the needs of current Pre-service teachers. A recommendation is the implementation of TSPCK coursework for pre-service teachers. Pre-service Teachers are traditionally taught chemistry content in their subject area coursework and then proper pedagogy in their education coursework.

B. Suggestions for Further Studies

PCK is difficult to assess due to its complexity and abstract nature. The classroom observation and interview section may be a more effective means of evaluating pre-service teacher competency in a particular discipline than a content knowledge exam.

A future study could explore whether TSPCK composites were correlated with students learning outcomes in line with the curriculum and if so which components of TSPCK were most significant. Follow-up research utilizing exploratory sequential design could use the results of this qualitative study to inform a randomized, controlled quantitative study of pre-service teacher TSPCK.

C. Conclusion

This study revealed the PCK of the pre-service teachers and their ability to understand the two (2) components of the TSPCK as well as how to transform these components effectively in the classroom during the teaching and learning process. However the pre-service teachers need to develop specific pedagogical content knowledge to effectively teach their subject matter. This knowledge includes an understanding of how students learn and how to Use this knowledge to plan and implement effective lessons. It also includes an understanding of the subject matter itself and how to adapt teaching strategies to meet the needs of different students. Pre-service teachers need to have a solid foundation in their subject matter, but they also need to develop the ability to apply this knowledge in the classroom.

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