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Science Student Teachers' Pedagogical Content Knowledge and its Influence on their Science Teaching at Bagabaga College of Education, Tamale

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Abstract:- This study was conducted at Bagabaga College of Education, Tamale. Its purpose was to find out the Pedagogical Content Knowledge exhibited by science teacher trainees in their teaching practices and how it influenced their teaching of science. Qualitative (descriptive) research design was used for this study. The research targeted the third year science teacher trainees on their internship programme. Stratified sampling was used to get the science teacher trainees across the three districts of the partner schools and simple random sampling was used to select 21 participants (Science Teacher Trainees) for this study.The instrument used to collect data in this research was observation schedule. Observation checklist was used to track the pedagogical content knowledge of the science teacher trainees and its influence on their science teaching. The study found that Science Teacher Trainees had developed pedagogical content knowledge; knowledge of learners, knowledge of curriculum, knowledge of content and knowledge of pedagogy. The observation conducted on the science teacher trainees' works revealed that the pedagogical content knowledge had a significant influence on their teaching.

Keywords*: PCK; Content Knowledge; Pedagogical Knowledge; Knowledge of learners; science student teachers;*

I. INTRODUCTION

A major concern in science teacher education in recent times is the development of teachers' knowledge base for improving classroom practice and students learning (Kind, 2009). This concern has come about, fundamentally as a result of studies that show a strong relationship between what teachers know in terms of content, and how they teach in terms of pedagogy. Teachers' knowledge base must of necessity include knowledge of students' preconceptions or alternative frameworks which could be used as the basis of a good teaching point on students' behalf. The three types of teacher knowledge, according to Loughran, Berry and Mulhall (2012) namely, subject matter knowledge, pedagogical knowledge, and knowledge of students' preconceptions and learning difficulties, have collectively been referred to as pedagogical content knowledge (PCK). Pedagogical content knowledge is seen basically and described as that teacher knowledge which allows teachers to guide and direct students learning through specific content knowledge in a meaningful way (Miller, 2007).

The development of pedagogical content knowledge is to prepare the science teacher holistically with the requisite knowledge base to be able to teach effectively. This equips the science teacher trainees with the knowledge of content, the knowledge of pedagogy, knowledge of curriculum and knowledge of learner. A blend of these types of knowledge better prepares the teacher for the task of teaching science.

Teacher trainees' internship programme in the Colleges of Education is an essential component of teacher development in the college of education in Ghana. This is the period in which the teacher trainees are attached to some selected basic schools to understudy qualified and experienced teachers on the field. Prior to this period, teacher trainees are taken through the rudiments of teaching before they go on the internship programme. During this period, teacher trainees are prepared both in content and pedagogy. Peer tutoring (on-campus teaching practice) normally preceeds the off- campus teaching practice programme.

The development of the pedagogical content knowledge comes with its own challenges. The most significant of those challenges being that there is no single activity or programme that can easily be adopted as a means of developing pedagogical content knowledge in science teacher trainees. The Researcher being a tutor in one of the Colleges of Education in Ghana has been engaged in training of science teachers and supervision of both on-campus and off-campus teaching practice. The experience of the Researcher indicates that the trainees find it difficult to develop unique and independent styles of teaching, which the literature describes as pedagogical conntent knowledge.

However, the content courses as well as the methodology courses organised during the early years of the science teacher trainees' stay at the College gives the trainee an opportunity be learn many things concerning teaching. It is thhrough these programmes that the science teacher trainees get to learn the content, the pedagogy, the curriculum and characteristics of learners for teaching. This study thus examines a group of science teacher trainees for their pedagogical content knowledge during their internship in the basic schools and how it influences the way the teach science.

A. Statement of the Problem

A science teacher trainee is supposed to bring a whole lot of knowledge base to bear in his/her quest to become a good science teacher. This knowledge base is termed as pedagogical content knowledge. Available literature indicates that pedagogical content knowledge can be developed through well-structured programmes as well as unstructured programmes. Science teacher trainees at the Colleges of education in Ghana go through content and methodology courses in their early years in the College to help them develop the pedagogical content knowledge.

However, it is one thing mastering a skill and its application is another. One wonders how the trainees would be able to adapt their teaching strategies to the level of pupils so as to help them improve their comprehension of science concepts. Science teacher trainees do not normally teach for understanding specifically, but focuses on activity completion and good behaviour (Kind & Wallace, 2008). This study thus examines a group of science teacher trainees to determine the types of pedagogical content knowledge they exhibite during their off- campus teaching practice and how it affects their teaching.

B. Purpose of the Study

The purpose of the study was to investigate the types of pedagogical content knowledge exhibited by science teacher trainees during their off-campus teaching practice. The study also sought to find out how the pedagogical content knowledge exhibtted by the science teacher trainees influenced the way they taught science.

C. Objectives of the Study

The objectives of the study were to:

- Identify the types of pedagogical content knowledge displayed by teacher trainees during their off-campus teaching practice.
- Find out the effects of the science teacher trainees' pedagogical content knowledge on their teaching practices.
- Determine the characteristics of science teacher trainees who have developed pedagogical content knowledge.

D. Research Questions

The following research questions guided the study.

- What types of pedagogical content knowledge do science teacher trainees exhibit during their off-campus teaching practice?
- What is the effect of the science teacher trainees' pedagogical content knowledge on their instructional approaches during science lessons?
- What are the characteristics of science teacher trainees who develop pedagogical content knowledge?

E. Significance of the Research

The outcome of the research would be useful to science educators, science subject advisors and science curriculum developers. This work would enable them make policies that would improve the teaching and learning of science and serves as a source document for practitioners and upcoming science teachers.

F. Limitations of the study

This research used 21 participants from Bagabaga College of Education who were doing their teaching practice in different schools. This sample was a bit small and was not representative distribution of the population. Hence, it made the generalisation of the study not too satisfactory.

During the data collection, the researcher did the observation personally. Even though a checklist was used in collecting the data, there were instances of biasness in the observation. Fatigue also impeded the validity of the data since the researcher had to observe every single lesson of all the participants.

The use of a single instrument in collecting the data also limited the validity of the results. Two or more instruments could have been used and the data triangulated to see a true manifestation of the PCK the participants possessed.

II. LITERATURE REVIEW

A. Components of Pedagogical Content Knowledge

PCK is a construct that is theoretically integrated and coherent whole, for which the ingredients cannot be separated, and is therefore practically significant to clarify its components (Jing- Jing, 2014). If the components of PCK are distinctly clarified, researchers will have clear ideas of what they need to explore with teachers (Jing- Jing, 2014).Researchers have sought to classify the components of PCK differently to suit their works, depending on what they emphasis on in their work. Halim and Meerah (2002) explored two main components of PCK; (1) the knowledge of students understanding, conception and misconception of a specific topic which help teachers to interpret students' actions and ideas as well as plan effective instruction and (2) the knowledge of representation of specific topics, which refers to knowledge of specific strategies that are useful in helping students to understand specific science concepts. According to Halim and Meerah (2002), these are the core of teachers' knowledge for effective lesson delivery.

Content knowledge and knowledge of pedagogy are the main components of PCK that are very vital in science teacher trainees' effectiveness since it equips the science teacher trainees with the necessary competencies for teaching of science (Ayoubi, El Takach & Rawas, 2017). If science teacher trainees' PCK expand, within the confines of content and pedagogy, they will make tremendous impact on their students leading to serious increase in learning (Ayoubi et al., 2017).

Also believing in the content knowledge and pedagogy knowledge as the main components, Ding, He and Leung (2014) said that both Pedagogical knowledge and subject matter Knowledge are important categories of science teacher trainees' professional knowledge. According to Ding et al. (2014), these two categories of knowledge have been found to interact with effective teaching. Whereas subject matter Knowledge is grounded in core teaching activities and influences science teacher trainees' in making decisions about content-specific instruction, such as designing a task

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or posing a meaningful question for student exploration, Pedagogical knowledge is regarded as a tool or vehicle for science teacher trainees to deliver the content knowledge in their mind to pupils in a comprehensive manner (Ding et al., 2014)

Subsequent researchers expanded PCK components. Jing-Jing (2014) belief the components could be summarised into three: knowledge of topics regularly taught in ones' subject area, knowledge of forms of representation of those ideas and knowledge of students' understanding of the topics.

Mizzi (2013) further expanded Pedagogical Content Knowledge to include five component areas; (1) Orientation towards science teaching, (2) Knowledge and believes about the science curriculum, (3) Knowledge about assessment in science, (4) Knowledge about students understanding and misconceptions of specific science topics and (5) Knowledge about instructional strategies for teaching science or topic specific pedagogy.

B. Developing Science Teacher Trainees Pedagogical Content Knowledge

It is the aim of any teacher education programme to produce science teacher trainees who can start their career with significant knowledge and initial teacher education has a critical role to play in developing PCK and making a teacher (Mutisya, 2015). Lipowsky and Rzejak (2015) conducted a research into teacher development and found that the quality and quantity of learning opportunities during initial science teacher training programme, the characteristics and competencies of the facilitator, the perception, interpretation, and use of received training programmes by participants, the general conditions at the schools where the participants teach, as well as interactions among these variables were key in developing science teacher trainees PCK. Even though it could be developed through training, significant improvements in PCK are made in early months of teaching career (Evens et al., 2015). Evens et al. (2015) suggested in their work some key elements which are necessary for PCK development: Reflection for PCK development, making PCK explicit to participants in the intervention, course facilitation by experts in the field and clear conceptualisation of PCK. Zhou, Wang and Zhang (2016), in analysing previous works of other researchers found that the effective use of several tools depends on science teacher trainees' knowledge of student difficulties, such as reflection on teaching practice, group discussion or analysis of student conceptual understanding and students' work. These according to Zhou et al. (2016) may benefit in-service science teachers in the long run as they might make conscious efforts to expand their understanding and development of PCK. Some researches on science teacher trainees' PCK have suggested that pre-service science teachers show little consideration for students and have poor knowledge of students' learning difficulties. Science teacher trainees should then consider their learners in their efforts to develop PCK.

PCK development according to Kind (2009) is complex, occurs in phases and relates to science teacher trainees' abilities to integrate knowledge from a variety of sources. To develop PCK, science teacher trainees should have a good mastery of certain competencies and knowledge to build on. Possession of content knowledge is identified as essential to Pedagogical Content Knowledge development (Kind, 2009).

To some researchers, experience is the best teacher. Classroom experience has the strongest impact on PCK development (Ayoubi et al., 2017). According to Ayoubi et al. (2017), these experiences include activities and events in classroom teaching which also positively affect the knowledge of representation and teaching strategies among the science teacher trainees. PCK represents an understanding of the complex relationship between teaching and content taught through the use of specific teaching approach and it is developed through the process based practices in the classroom (Purwianingsih, Muthmainnah & Hadiyat, 2017). There is no limit to the development of PCK. The process of development of PCK is on- going and requires the innovativeness of the science teacher to develop it. The development of the knowledge is a process where teachers try new ideas, refine old ones, and engage in classroom problem solving (Wallace, 2003).

C. Science Teacher Trainees' PCK and Their Teaching Practices of Science

Mansour (2009) observed in his work that although there is a lot of research which indicates that the teachers' practices in the classrooms are affected by their beliefs, there is still a need to examine teachers' beliefs to clarify how they affect their practices. Teachers' beliefs play a major role in defining teaching tasks and organising the knowledge and information relevant to those tasks. However, some researchers have noted that reflecting on practice can change beliefs (Mansour, 2009). The important role played by competent science teachers to any nation's school system can in no way be over emphasised (Mutisya, 2015). A competent teacher has full knowledge of PCK, is temperamentally warm and cordial, has clear vision of set objectives, executes meticulously his/her plans and manages affairs effectively both in and outside the classroom (Bhargava & Pathy, 2011). According to Bhargava and Pathy (2011), a teacher who has firm grasp of PCK shows skill of presentation of subject matter which is able to seek the attention of students and capable of motivating learners to learn.

Zhou et al. (2016) in conducting their research found out in their work that science teacher trainees who could give explicit explanations of student learning difficulties were more likely to generate effective teaching strategies. A teacher who is better able to answer questions on a science test in a bit to developing PCK is more likely to perceive their science knowledge with more confidence and demonstrate more accurate science knowledge during instruction (Diamond, Maerten-Rivera, Rohrer, & Lee, 2013). There are some researchers who believe that the science teacher trainees' knowledge base has a major influence on how they teach science. Kind (2009) argues

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that gaining better overall understanding of science teachers' PCK, its development and the relationship between PCK and subject matter knowledge will help establish science teaching practice of consistently higher quality.

Halim and Meerah (2002) in investigatng the PCK of 12 Malaysian science teacher trainees with varied degree backgrounds used for teaching physics concepts explored the teachers' awareness of possible misconceptions and explanations of science ideas. A good number of the science teacher trainees did not understand the ideas correctly themselves which was seen as negatively affecting trainees' ability to select appropriate instructional strategies, suggesting that secure content knowledge may be a pre-requisite for sound PCK and effective science teaching for that matter.

How best one can teach has a direct link with what one knows. Science teacher trainees' understanding of the content to deliver and method they should use to send home their message are highly correlated. This can be manifested when some researchers have seen how the teacher's PCK is significantly associated with student gain and achievement, although not at a high intensity (Olfos et al., 2014). In addition, it is clear that the teaching components is significantly associated with achievement and, even more significantly, with students' gain (Olfos et al., 2014). To Olfos et al, if the science teacher trainees' knowledge about the content and pedagogy is good, it influences their way of teaching science and that turns to impact positively on their pupils learning.

D. Challenges in Developing Science Teacher Trainees' Pedagogical Content Knowledge

Initial teacher education programmes aims at imbibing in trainees the required content and pedagogical knowledge to be able to teach well in their classrooms. Pre service Science teacher trainees show little consideration for students and have poor knowledge of students learning difficulties (Zhou et al., 2016). Although there is wide agreement that PCK is a useful construct, finding out exactly what it comprises and using this knowledge to devise good practice in teacher education is not easy (Kind, 2009). Science teacher trainees themselves enter the classroom with a lot of misconceptions about the content to be taught and luck strategies to drive home their messages (Halim & Meerah, 2002).

The challenge for teacher preparation programmes is to prepare their candidates to teach from an integrated knowledge structure of teaching their specific subject matter the intersection of knowledge of the subject matter with knowledge of teaching and learning (Niess, 2005). Evens et al. (2015) found novice science teachers to take time to develop PCK hence educators would be faced with a challenge in helping them develop PCK progressively rapid. Purwianingsih et al. (2017) believe that science teacher trainees reliance heavily on assumptions rather than making conscious efforts to understand the concepts and the way and manner concepts are taught are the major challenges faced in developing PCK.

III. RESEARCH

A. Research Design

This study used descriptive research design. Descriptive research design was used in this research because it had the potential of providing a lot of information from a very large sample. Descriptive research design is normally used when the study is intended to assess the situation directly as it pertains to science teacher trainees. Many researchers use this type of design since it makes large data simple to handle and manipulate. Being able to accurately summarise a large data, according to Donnelly (2007), to get a look at the 'big picture', either graphically or numerically, is the job of descriptive statistics. The data was collected in the form of numbers and as such qualitative in nature. In this qualitative study, the Researcher aimed to get deeper information for tacit and complex structure of PCK. It also enabled data generalisations to facilitate easy assessment of science teacher trainees' PCK and the role it plays in their teaching of science.

B. Research Instruments

The Researcher used basically observation as the main instrument to achieve the desired results. Data is a piece of information that is derived by researcher from various types of documents such as interviews, and field notes in qualitative research (Merriam, 2009). The instrument that was used to collect data for the research made use of ethnographic research procedures.The instrument was carefully selected bearing in mind the research questions and what the Researcher sought to achieve. To obtain data that could be relied on, the reliability, validity and ethical issues were also taken into consideration.

C. Population

Population in statistics is used to represent all possible measurements or outcomes that are of interest to the Researcher in a particular study (Donnelly, 2007). The target population in this study involved all the science teacher trainees of Bagabaga College of Education in their internship programme.The subjects in this study were 21 science teacher trainees. Out of the number, the Researcher chose seven science teacher trainees each from Sagnarigu district, Savelugu district and Tamale metropolitan. The science teacher trainees were selected across the three districts to get a fair representation of participants.

D. Sampling procedure

All the science teacher trainees from Bagabaga College of Education who were sent to the Sagnarigu district, Savelugu district, and Tamale metropolitan were purposively sampled for this study. Cluster random sampling was used to select the 21 participants for the study. The science teacher trainees were divided into three mutually exclusive districts and seven (7) randomly sampled from each district (Donnelly, 2007). According to Donnelly (2007), for cluster to be effective, it is assumed that each cluster selected for the sample is representative enough of the population at large.

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E. Pre- Observation Conference

Observation of science teacher trainees lessons were preceded by pre- observation conference. During the pre-observation conference, the Researcher interacted extensively with the participants on the topics to be taught. The participants' lesson notes were vetted to ensure that participants actually prepared on the said topics. The science teacher trainees were to respond to what they expected to achieve in the lesson and the challenges they could foresee. This was done before the actual teaching was done for observation. The objective of the pre- observation conference was to find out the readiness of the science teacher trainees to teach and to put the science teacher trainees in their right frame of mind to feel free to teach. Appendix B presents a sample of the pre- observation conference questions.

F. Observation

Since PCK is tacit construct hidden in teachers' minds (Abell, 2008), observation needed to be carried out in a real classroom context so as to get first- hand information as to whether the science teacher trainees possessed them or not. Furthermore, although science teacher trainees appeared to have appreciable level of PCK in the pre- observation conference, PCK is subject to change depending on contextual factors and students' needs. It therefore was reasonable to observe science teacher trainees' PCK to get a reliable data.

In observing the science teacher trainees' lessons, the researcher was involved in looking and noting certain features of interest down that could be used to influence a decision. One of the most important and distinctive features of observation as a research process is seen as a research method that offers an investigator the opportunity to gather live data from naturally occurring setting (Cohen et al., 2011). A major advantage of observation according to Bond- Robson (2005) is its directness. To Bond- Robson (2005), one needs not ask people about their views, feelings and attitudes but only watch what they do and listen to what they say.

G. Post- Observation Conference

After each science teacher trainee presented his/her lesson for observation, the researcher held a post-observation conference with them. The post- observation conference was held purposely to appreciate the lessons of the science teacher trainees. The strengths and weaknesses of the lessons were discussed with the trainees. Suggestions were then made for further improvement. Appendix C presents a sample of the post- observation conference questions.

H. Data Collection Procedure

The Researcher personally collected the data for the study. Permission was sought form the internship programme coordinator to use the science teacher trainees at their post for the study. Permission was granted indicating the dates and days the researcher could meet each cluster to observe their lessons.

The researcher personally went to each cluster and to each school for the administration of the instrument. Each observation was preceded by a pre- observation conference. The Researcher had extensive discussion with the participants before the actual observation was done. The exercise was repeated for one more time and data collected for analysis.

IV. DATA PRESENTATION AND ANALYSIS

- ***Types of pedagogical content knowledge exhibited by Science Teacher Trainees during off – campus teaching practice.***

  In this section, analysis of data is presented on the effects of pedagogical content knowledge exhibited by Science Teacher Trainees on their off-campus teaching practices. It captures Science Teacher Trainees' knowledge on the curriculum, Teacher Trainees' knowledge on learners, Teacher Trainees' knowledge on content and Teacher Trainees' knowledge on pedagogy during the first and second observations as presented in Tables 1, 2, 3 and 4.

A. Teacher Trainees' Knowledge of the Curriculum

Table 1 summarises the science teacher trainees' knowledge of the science curriculum as observed on the field. The analysis is done using numbers and percentages.

Statement	Observation	Excellent N (%)	Above Average N (%)	Average N (%)	Weak N (%)
Cites at least the Syllabus, Pupils textbook and Teachers' Guide in the lesson plan	Ob 1	4 (19.0)	16 (76.2)	1 (4.8)	0 (0.0)
	Ob 2	15 (71.4)	6 (28.6)	0 (0)	0 (0.0)
Makes reference to the materials cited in the lesson notes	Ob 1	2 (9.5)	18 (85.7)	1 (4.8)	0 (0.0)
	Ob 2	12 (57.1)	7 (33.3)	2 (9.5)	0 (0.0)
Sets specific, measureable, achievable, relevant and time bound objectives	Ob 1	9 (42.9)	9 (42.9)	2 (9.5)	1 (4.8)
	Ob 2	12 (57.1)	8 (38.1)	1 (4.8)	0 (0.0)
Frames the objectives to reflect knowledge about nature and goals of science curriculum	Ob 1	0 (0.0)	14 (66.7)	6 (28.6)	0 (0.0)
	Ob 2	7 (33.3)	14 (66.7)	0 (0.0)	0 (0.0)
Chooses content that matches with the age of pupils	Ob 1	9 (42.9)	11 (52.4)	1 (4.8)	0 (0.0)
	Ob 2	11 (52.4)	10 (47.6)	0 (0.0)	0 (0.0)

Table 1: Knowledge of Curriculum

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As shown in Table 1, results of the first and second observations indicate that Science Teacher Trainees had knowledge of the curriculum of science during their off-campus teaching practice. In terms of citing at least the Syllabus, Pupils textbook and Teachers' Guide in the lesson plan, the first observation showed that greater number (16 Science Teacher Trainees) representing 76.2% were Above Average at this. This means that majority of the Science Teacher Trainees always consulted those curriculum materials before teaching. Also, 4 Science teacher trainees, representing 19% of them were Excellent and about 5% of them were Average. The second observation showed an improvement over the first observation as 15 (71.4%) of the trainees were Excellent in citing the Syllabus, Pupils textbook and Teachers' Guide in their lesson plans. In terms of making reference to the materials cited in the lesson notes, the first observation indicated that majority (85.7%) of the Trainees were Above Average at it. The second observation however showed an improvement of making references to materials cited in the lesson notes as more than half (57.1%) of trainees were Excellent as compared to the first observation which was 9.5%. This improvement could be attributed to the post observations discussions held with trainees after the first observation. Furthermore, the first and second observations showed that Teacher Trainees set specific, measureable, achievable, relevant and time bound (SMART) objectives. It was however observed during the first observation that about 5% of the trainees did show some weakness in setting specific, measureable, achievable, relevant and time bound objectives. But this did not come up during the second observation due to the post observations discussions held with trainees. In terms of framing lesson objectives, Teacher Trainees framed objectives that reflected knowledge about nature and goals of science curriculum. Teacher Trainees also chose content that matched the ages of pupils.

B. Science Teacher Trainees' Knowledge of Learners

In the table 2 below Science Teacher Trainees' knowledge of their learners is summarised. This sought to find out how much the science teacher trainees knew their learners and their learning.

Statement	Observation	Excellent N (%)	Above Average N (%)	Average N (%)	Weak N (%)
Identifies pupils by the names	Ob 1	1 (4.8)	16 (76.2)	4 (19.0)	0 (0.0)
	Ob 2	2 (9.5)	18 (85.7)	1 (4.8)	0 (0.0)
Takes prompt action to address poor behaviour	Ob 1	2 (9.5)	12 (57.1)	7 (33.3)	0 (0.0)
	Ob 2	4 (19.0)	14 (66.7)	3 (14.3)	0 (0.0)
Treats all pupils fairly and praises pupils for their efforts and achievement	Ob 1	3 (14.3)	7 (33.3)	11 (52.4)	0 (0.0)
	Ob 2	2 (9.5)	15 (71.4)	4 (19.0)	0 (0.0)
Identifies pupils with learning difficulties and gives them special assistance during lesson delivery	Ob 1	1 (4.8)	8 (38.1)	9 (42.9)	3(14.3)
	Ob 2	1 (4.8)	10 (47.6)	10 (47.6)	0 (0.0)
Identifies exceptional pupils in the class and gives them additional task	Ob 1	0 (0.0)	9 (42.9)	12 (57.1)	0 (0.0)
	Ob 2	0 (0.0)	4 (19.0)	17 (81.0)	0 (0.0)

Table 2: Knowledge of Learners

With reference to Table 2, it is obvious that Teacher Trainees had knowledge of learners. The first observation revealed that greater proportion (76.2%) of the Science teacher Trainees identified pupils by their names. There was slight improvement of this in the second observation as 85.7% of trainees were able to identify their class pupils by names during lessons. Also, some trainees were Excellent in identifying pupils by names during lessons.

In terms of Teacher Trainees taking prompt action to address poor behaviour of pupils during lessons, majority of them were Above Average at this. Some were also only Average in taking prompt action in addressing poor behaviour of pupils during lessons. This therefore implies that the pedagogical knowledge acquired by trainee teachers during on-campus teaching practice was applied during the off-campus teaching practice.

The first and second observations showed that Science Teacher Trainee treated all pupils fairly and praised them for their efforts and achievement. During the first observation 33% of the trainees were Above Average whilst in the second observation it was 71.4%. The improvement was mainly due to the post observation conference with trainees as majority corrected their initial mistakes during the second observation. It is worth noting that during the first observation more than half of the Science Teacher Trainees were Average in relation to how they fairly treated and praised pupils for their efforts and achievements in class.

Despite that some Teacher Trainees (14.3%) showed weaknesses in identifying pupils with learning difficulties and giving them special assistance during lesson delivery, greater percentage of the Science Teacher Trainees did this averagely. Others were also Above Average at carrying out this activity. In addition, majority of the trainees were

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Average in identifying exceptional pupils in the class and giving these pupils additional assistance. This suggests that pedagogical content knowledge acquired by trainee teachers during their on-campus teaching practice was exhibited during the off-campus teaching practice.

C. Science Teacher Trainees' Content knowledge

The table below presents information of observed content knowledge exhibited by the science teacher trainees. The analysis is done using numbers and percentages.

Statement	Observation	Excellent N (%)	Above Average N (%)	Average N (%)	Weak N (%)
Gives accurate information to pupils	Ob 1	0 (0.0)	19 (90.5)	2 (9.5)	0 (0.0)
	Ob 2	1 (4.8)	18 (85.7)	2 (9.5)	0 (0.0)
Gives adequate examples when presenting the lesson	Ob 1	1 (4.8)	12 (57.1)	8 (38.1)	0 (0.0)
	Ob 2	0 (0.0)	17 (81.0)	4 (19.0)	0 (0.0)
Uses analogies/ alternate concepts/ illustrations to help pupils understand the concept	Ob 1	3 (14.3)	11 (52.4)	7 (33.3)	0 (0.0)
	Ob 2	6 (28.6)	12 (57.1)	3 (14.3)	0 (0.0)
Shows in-depth knowledge of subject matter in teaching	Ob 1	2 (9.5)	6 (28.6)	10 (47.6)	3 (14.3)
	Ob 2	6 (28.6)	10 (47.6)	5 (23.8)	0 (0.0)
Presents content systematically starting from the less difficult concepts to the more difficult concepts	Ob 1	0 (0.0)	9 (42.9)	11 (52.4)	1 (4.8)
	Ob 2	0 (0.0)	11 (52.4)	10 (47.6)	0 (0.0)

Table 3: Content Knowledge of Trainees

Table 3 presents and discusses content knowledge of Science Teacher Trainees. In this regard, the first and second observations indicated Teacher Trainees had the content knowledge. Following from this observation, a greater percentage of the science teacher trainees performed Above Average in giving accurate information to pupils. Some science teacher trainees also barely were Average in giving expected information to pupils. In terms of science teacher trainees giving adequate examples when presenting lessons, majority of them were Above Average at this. More so, greater percentage of trainees used analogies/ alternate concepts/ illustrations to help pupils understanding basic concepts. It is also worth noting that some Science Teacher Trainees were Excellent in using analogies/ alternate concepts/ illustrations to help pupils understand basic concepts in Science. Furthermore, despite the fact that some trainees (14.3%) showed weaknesses in demonstrating in-depth knowledge in the subject matter, majority of were Average. This implies that the PCK knowledge acquired by Science Teacher Trainees during their on-campus teaching practice was exhibited during their off-campus teaching practice. The observations further revealed that Science Teacher Trainees presented content systematically starting from the less difficult concepts to the more difficult concepts.

D. Science Teacher Trainees' Pedagogy Knowledge

The table 4 below presents observed pedagogical knowledge exhibited by the science teacher trainees. The analysis is done using numbers and percentages.

Statement	Observation	Excellent N (%)	Above Average N (%)	Average N (%)	Weak N (%)
Uses varied methods in teaching the topic	Ob 1	0 (0.0)	14 (66.7)	7 (33.3)	0 (0.0)
	Ob 2	0 (0.0)	18 (85.7)	3 (14.3)	0 (0.0)
Uses clear and audible voice to communicate to pupils	Ob 1	1 (4.8)	11 (52.4)	9 (42.9)	0 (0.0)
	Ob 2	1 (4.8)	19 (90.5)	1 (4.8)	0 (0.0)
Teaches the topic systematically with appropriate pacing (not too fast and not too slow)	Ob 1	1 (4.8)	9 (42.9)	11 (52.4)	0 (0.0)
	Ob 2	0 (0.0)	16 (76.2)	5 (23.8)	0 (0.0)
Uses appropriate questioning strategy in seeking responses from pupils (i.e.; ask question- pause- call pupil to answer	Ob 1	4 (19.0)	13 (61.9)	4 (19.0)	0 (0.0)
	Ob 2	5 (23.8)	13 (61.9)	3 (14.3)	0 (0.0)
Combines appropriate methods with appropriate teaching and learning materials in teaching	Ob 1	1 (4.8)	14 (66.7)	6 (28.5)	0 (0.0)
	Ob 2	1 (4.8)	15 (71.4)	5 (23.8)	0 (0.0)

Table 4: Pedagogy Knowledge

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As seen in Table 4, the statistics showed that Science Teacher Trainees had the pedagogical knowledge in teaching Science. The first and second observations indicated that greater percentage of the Trainees used varied methods in teaching which included demonstration, questioning and answering, and discussion among others. Science Teacher Trainees used clear and audible voice to communicate to pupils. Specifically, during the first observation, more than half (52.4%) were Above Average at this whilst 42.9% were Average. The second observation saw a much more significant improvement of Trainees using clear and audible voice to communicate to pupils as significant majority (90.5%) of the Trainees demonstrated this. In some instances, a few of the Science Teacher Trainees were Excellent.

Science Teacher Trainees also taught the topic systematically with appropriate pacing (not too fast and not too slow) as more than half (52.4%) of them in the first observation were Average. There was however improvement in the second observation as 76.2% of the trainees were Above Average at presenting lessons systematically with appropriate pacing compared to the first observation where less than half (42.9%) of the Science Teacher Trainees were able to do this. Additionally, Science Teacher Trainee used appropriate questioning strategy in eliciting responses from pupils (i.e. ask question- pause- call pupil to answer). It is also worth noting that Science Teacher Trainee combined appropriate methods with appropriate teaching and learning materials in teaching. In this case, during the first observation, majority (66.7%) of the trainees were Above Average at this. However, as a result of the post observation conference, there was an increase of the number of Trainees who were able to combine appropriate teaching and learning materials in teaching.

E. Characteristics of Pedagogical Content Knowledge developed by Teacher Trainees

This section of the study presents analysis of field observation data on the characteristics of Science Teacher Trainees who have developed PCK. The personal qualities as well as professional qualities are looked at (Bhargava & Pathy, 2011). The key characteristics considered in this case are enthusiasm and confidence of Teacher Trainees; arousing and sustaining the interest of pupils by Trainees; questionning ability of Trainee Teachers and motivation of pupils by Trainees as presented in Table 5.

Statement	Observation	Excellent N (%)	Above Average N (%)	Average N (%)	Weak N (%)
Shows enthusiasm and confidence in teaching	Ob 1	4 (19.0)	16 (76.2)	1 (4.8)	0 (0.0)
	Ob 2	2 (9.5)	18 (85.7)	1 (4.8)	0 (0.0)
Arouses and sustains pupils interest making them participate actively in the lesson	Ob 1	2 (9.5)	12 (57.1)	7 (33.3)	0 (0.0)
	Ob 2	4 (19.0)	14 (66.7)	3 (14.3)	0 (0.0)
Asks thought provoking and probing questions	Ob 1	3 (14.3)	11 (52.4)	7 (33.3)	0 (0.0)
	Ob 2	2 (.5)	15 (71.4)	4 (19.0)	0 (0.0)
Motivates pupils to complete exercises correctly and in time	Ob 1	1 (4.8)	8 (38.1)	9 (42.9)	3(14.3)
	Ob 2	1 (4.8)	10 (47.6)	10 (47.6)	0 (0.0)
Gives ,marks pupils exercises and gives prompt feedback to pupils	Ob 1	0 (0.0)	12 (57.1)	9 (42.9)	0 (0.0)
	Ob 2	0 (0.0)	17 (81.0)	4 (19.0)	0 (0.0)

Table 5: Characteristics of Teacher Trainees

From Table 5, statistics of the field observations revealed that Teacher Trainees showed enthusiasm and confidence during teaching. The first observation showed that 76.2% of the Science Teacher Trainees were rated Above Average whilst the second observation indicated an improvement over the first observation. In this regard, over eighty percent (85.7%) of the Trainees were rated Above Average at demonstrating enthusiasm and confidence in teaching. Added to this, some Trainees were outstanding in terms of showing confidence and enthusiasm. In relation to how Science Teacher Trainees arouses and sustains pupils interest making them participate actively in the lesson; greater percentage of the Trainees were Above Average at doing this. During the first observation, 57.1% of the Trainees were Above Average at arousing and sustaining pupils' interest, and in the second observation 66.7% were Above Average at this. The observations further revealed that Science Teacher Trainees asked thought provoking and probing questions as well as motivates pupils to complete exercises correctly and in time. Teacher Trainees also gave exercises, marked pupils' exercises and gave prompt feedback to pupils during lessons. This is evident in the science teacher trainees performing above average in the first observation and even marked improvement in the second observation.

V. FINDINGS

The study revealed that Teacher Trainees had knowledge of the curriculum of science during their off-campus teaching practice. In this case, they cited at least the Syllabus, Pupils textbook and Teachers' Guide in the lesson plan. Trainees also made references to materials cited in their lesson notes. The Teacher Trainees had knowledge of learners. The observation revealed that greater proportion (81%) of trainees identified pupils by their names. Teacher Trainees also took prompt action to address poor behaviour of pupils during lessons. The observations indicated Teacher Trainees had the content knowledge. Following from this, greater percentages (88%) of science teacher trainees were above average at giving accurate information to pupils. The study found that Science Teacher Trainees had pedagogical knowledge in teaching Science. The observations revealed a greater percentage (76.2%) of the Trainees used varied

methods in teaching which included demonstration, questioning and answering, discussion among others. The key characteristics considered in this case are enthusiasm and confidence of Teacher Trainees; arousing and sustaining the interest of pupils by Trainees; questionning ability of Trainee Teachers and motivation of pupils by Trainees. Therefore, the observations revealed that a little over eighty percent (81%) of Teacher Trainees showed enthusiasm and confidence during teaching.

VI. CONCLUSION

Based on the findings, the study concludes that PCK acquired by Teacher Trainees during their on-campus teaching practice were exhibited during the off-campus teaching practice in terms of knowledge on the curriculum, Knowledge of learners by Trainees, content and pedagogy.Trainees cited the Syllabus, Pupils textbook and Teachers' Guide in the lesson plan and set specific, measureable, achievable, relevant and time bound objectives. Trainees identified pupils by their names and took prompt action to address poor behaviour of pupils during lessons. Teacher Trainees also gave accurate information to pupils; used analogies/ alternate concepts/ illustrations to help pupils understanding basic concepts and presented content systematically starting from the less difficult concepts to the more difficult concepts. In relation to the pedagogy, Trainees used varied methods in teaching; used clear and audible voice to communicate to pupils; taught topics systematically with appropriate pacing and used appropriate questioning strategy in eliciting responses from pupils. The study found that Trainees were enthusiastic and confident during teaching; aroused and sustained pupils' interest by making them participate actively in the lesson; asked thought provoking and probing questions as well as motivates pupils to complete exercises correctly and in time. Teacher Trainees also gave, marked pupils exercises and gave prompt feedback to pupils during lessons. Teacher Trainees however showed weaknesses in identifying pupils with learning difficulties and giving them special assistance during lesson delivery as well as setting specific, measureable, achievable, and relevant and time bound objectives.

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