Experienced Mathematics Teachers PCK in the Use of Learner-Centred Approaches in Tanzania's Secondary Schools

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Abstract

The study assessed experienced Mathematics teachers' pedagogical content knowledge (PCK) in the use of learner-centred approaches (LCA) and did not focus on a specific topic when teaching the subject. The study was guided by the multiple case study design underpinned by an interpretive research paradigm to assess four experienced Mathematics teachers' PCK in the use of LCA. Purposive sampling was applied to identify experienced teachers based on the premise PCK expands with the teachers' training and experience. The four experienced Mathematics teachers had at least five years of teaching experiences and their school and government authorities treated them as experts in teaching Mathematics. Consequently, two experienced teachers were selected from the categories of high performing schools and two others from the low performing schools in two political administrative districts. Data were collected through classroom observations, interviews, teachers' self-reflection, and documentary review. Data were analysed thematically using three out of five components of the teachers' PCK as identified by Magnusson, Krajacik, and Borko (1999) which served as the conceptual framework of the study. The results indicate that experienced Mathematics teachers demonstrated little knowledge of the LCA when teaching Mathematics concepts. Little knowledge of LCA led to their difficulties in put learners at the centre of their lessons. In fact, the experienced Mathematics teachers' classroom practices were mostly orientated towards teacher-centred approaches and were largely ineffective in transforming the components of PCK in the use of LCA and had little knowledge of learner-centred instructional strategies. The study concluded that although the teachers were trained and experienced, they had underdeveloped component of PCK in the use of LCA. Therefore, the study recommends that LCA be integral part of in-service teachers' training programmes in secondary schools to support those mathematics teachers who have not received training in LCA.

Keywords: Experienced teachers, PCK, Learner-centred approaches, Instructional strategies.

1.0 Introduction

Mathematics subject usually registers poor performance among students at the Certificate of Secondary Education Examination (CSEE) level in Tanzania when compared to language, social science and science subjects at the same education level. In fact, for six consecutive years from 2008 to 2013, the highest percentage pass in Mathematics has not been above 25 percent. This highest percentage pass in Mathematics is close to the lowest percentage pass of 24.4 percent in the History subject in the same period. Education statistics from the Ministry responsible for education in Tanzania shows that, about 80 percent of the students who sit for CSEE in Tanzania, each year, do not obtain a minimum pass in basic Mathematics (PMO-RALG, 2014). Low performance in Mathematics at the CSEE in Tanzania is attributable to inadequate number of Mathematics teachers and low quality of teachers (Tilya & Mafumiko, 2010).

In addition, low performance in Mathematics has been attributable to teachers' lack of knowledge of the subject matter and lack of PCK skills (Kitta, 2004). On the other hand, students' low performance in other subjects has been linked to classrooms being overcrowded with students (Msonde, 2011). In fact, there have been reports on the overloaded curriculum contents (Mosha, 2012). In the meantime, learner-centred teaching approaches have not been utilised in classrooms (Mtitu, 2013). To address the issue of low students' performance in Mathematics, teachers' PCK has been identified to be one of the factors that impacted on the students' learning and achievement in Mathematics (Anney, 2013; Hume, 2012; Rollnick, Bennett, Rhemtula, & Ndlovu, 2008). This implies that, raising the level of students' performance in Mathematics requires effective mathematics teacher with high levels of PCK (Kitta, 2004; Ojose, 2012).

Moreover, there is emphasis on the use of LCA in Tanzania's secondary school classrooms. However, teacher-centred teaching approaches remain dominant (see Kitta, 2004, Msonde, 2011) despite the ne tilt towards learner-centred approaches. In other words, there was a need to assess experienced teachers' PCK in the use of LCA. Consequently, this study was motivated by the related literature in Tanzania which identified pre-service teachers as having underdeveloped PCK (Anney, 2013). The study on trained and experienced Mathematics teachers found that, not all the teachers in Tanzania were trained in the learner-centred pedagogy. On the other hand, teachers, who were recruited by the government from 2008 to-date have knowledge and skills in learner-centred pedagogy. The fact\ that teacher-centred teaching approaches remained dominant in classrooms despite the government's deliberate policy to shift towards learner-centred approaches necessitated conducting this study on the experienced teachers' application of PCK in the use of LCA.

2.0 Literature review

2.1 Role of teachers' PCK on students' performance

Teachers with strong PCK can improve students' learning outcomes through their ability to amplify and filter students' beliefs, prior knowledge, and behaviours (Gencturk, 2012). In science teaching, Shulman (1987) has shown that teachers' PCK allows them to consider the structure, importance of a topic, recognise the features that will make the topic accessible to students, and justify the selection of teaching practices based on the students' learning needs. Shulman contends that, with developed teachers' PCK, an effective teacher can extend beyond content knowledge and generic teaching skills. Indeed, an effective teacher comprehends what facilitates or hinders the students' learning of specific contents and concepts. In addition, an effective teacher has preconceptions about variables that influence how students from different backgrounds learn concepts during the teaching and learning process. Ever since Shulman (1986) established the existence of teachers' knowledge base, researchers in PCK agree that PCK is an important in promoting knowledge and that high level of PCK predicts high levels of student achievement (Abell, 2007; Lange, Kleickmann, & Moller, 2012). Due to its importance in the improvement of learning outcomes, researchers have reported that it can be enhanced through teachers' participation in professional development programmes (Van Drel, Verloop, & Des Vos, 1998). Gencturk (2012) examined the relationship between teachers' mathematical knowledge, teaching practices, and students' achievement after a professional development intervention. The findings indicated that professional development programmes improved the teachers' classroom practices, improved teacher's PCK as related to their classroom practices significantly improves students' achievement (Meyer & Wilkerson, 2011).

In Mathematics subjects, a teacher with a strong PCK reportedly has an ability to improve the students' learning outcomes (Hill, Ball, & Schilling, 2008). In fact, a teacher with a strong PCK has knowledge of curriculum goals, teaching objectives, and what students are expected to learn (Karisan, Senay, & Ubuz, 2013). Learning outcomes also improve due to the teacher being knowledgeable of the content, students, teaching, and mathematics curriculum (Hill, Ball, & Schilling, 2008). This knowledge base for teaching Mathematics constitutes Mathematics Knowledge for Teaching (MKT) (Hill, Ball, & Schilling, 2008). Speer, King, and Howell (2015) have used this MKT model to analyse Common Content Knowledge (CCK) or knowledge of the subject matter, knowledge of the content or Specialised Content Knowledge (SCK) and PCK in Mathematics teaching. The findings from this study indicated that the teachers' PCK remains important in improving learning outcomes. However, research reports also indicate that, levels of teachers' PCK differ depending on the level of learners because the development of a teacher's PCK is embedded in his/her classroom practice (Van Drel, Verloop, & Des Vos, 1998).

According to Hill, Ball and Schilling (2008), MKT is divided into Subject Matter Knowledge (SMK) and PCK categories. SMK consists of three sub-elements. Common Content Knowledge (CCK) is the first sub-element used in several situations in life. The second sub-element is teacher's knowledge of the content or Specialised Content Knowledge (SCK). It is recognised through teacher's knowledge of the subject matter. The third sub-element is the teacher's Horizontal Content Knowledge (HCK), which helps a teacher to establish relationship within the field of Mathematics. The teacher's PCK category includes the Mathematics teacher's Knowledge of Contents and Students (KCS), Knowledge of Content and Teaching (KCT) and Knowledge of the Content and Curriculum (KCC) (Hill, Ball, & Schilling, 2008). Therefore, a Mathematics teacher with a strong PCK can effectively combine the content knowledge with knowledge of students, knowledge of teaching, and knowledge of curriculum (Hill, Ball, & Schilling, 2008).

2.2 Concept of Teaching Approaches, Methods, and Strategies

A teaching approach is a style or procedure of teaching applicable in the process of teaching (Thungu, Wandera, Gachie, & Alumande, 2010). In fact, a teaching approach encompasses the whole teaching orientation from planning, implementing the plan, and assessment of expected results. A teacher's education philosophy or teaching orientation is revealed by how he/she plans, implements the plans and assesses the students' achievement of learning outcomes (Jacobsen, Eggen, & Kauchak, 2006; Thungu *et al*., 2010). These three phases in teaching occur in a sequential order and are interrelated. During the planning, implementation, and assessment stages, a teacher asks a series of questions that leads to a teacher's decision making. A teacher's choice of an approach to teaching is usually influenced by the context and intended learning outcome, which include pupils' age, group, and learners' perspectives (Carr, 2008).

Teaching approaches are in a continuum with approaches which are more teacher-centred approaches (TCA), on the one end and leaner-centred approaches (LCA), on other end of a continuum. Both approaches do not refer to a single approach but rather to an array of complementary approaches that all proponents of TCA or LCA agree upon (Attard *et al*., 2010). All the LCA are based on the philosophy that, a learner is at the heart and curriculum organisation is based on high level of students' participation in the teaching and learning process (Attard *et al*., 2010). In LCA, the teacher shapes the framework within which learners work and then encourages them to make their decisions under guidance. Consequently, learners collect information, construct categories and test hypotheses that help them to acquire the meaning of what they are taught (Carr, 2008). In this regard, both teachers and learners play an equal active role in the teaching and learning process. Learner-centred approaches include peer teaching, individualised teaching approach, interactive approach, group teaching, inductive approach, constructivist approach, integrated approach, collaborative approach, and direct approach (Carr, 2008; Thungu *et al*., 2010).

Key components of learner-centred approaches are learning is personalised, learning is competency based, learners construct their own understanding rather than having it delivered or transmitted to them, new learning is a result of learners' prior understanding, learning takes place anytime and it is enhanced by social interaction, and authentic learning tasks are valued to promote learning (Jacobsen, Eggen, & Kauchak, 2006). Team learning or cooperative learning is encouraged in LCA to raise group co-operation and interactions among students. Strategies used to nurture group learning include peer tutoring, student-teams achievement divisions, group investigations and the jigsaw (Jacobsen, Eggen, & Kauchak, 2006). In LCA, a learner is an important resource of information because he/

she knows something and can share it during the teaching and learning process. In this set-up, the teacher assumes the role of a mentor or coach who facilitates the students' learning. Learners' learning and achievement in LCA is measured through formal and informal kinds of assessment. Tools for assessing the students' learning include alternative assessment techniques such as projects, portfolios, and class participation.

2.3 Magnusson et al.'s (1999) framework for assessing teachers' PCK

The study adopted the Magnusson et al.'s (1999) conceptual framework, which is an extension of the transformative PCK model (Grossman, 1990) and integrative PCK model (Gess-Newsome, 2002) to assess the teachers' PCK. In the integrative model, the components of PCK are a mixture or an "amalgamation" of the general teachers' knowledge, subject matter knowledge, and general context knowledge. In this case, the teachers' knowledge of content, general pedagogical practices and ability to recognise students' misconceptions can be contrasted. Teachers' PCK is measured through their planning, reflection, and practice, and knowledge of the other knowledge bases (Gess-Newsome, 2002). In the transformative model, the components of PCK (knowledge of curricular, students, teaching strategies, and assessment) are taken as a compound or synthesised:

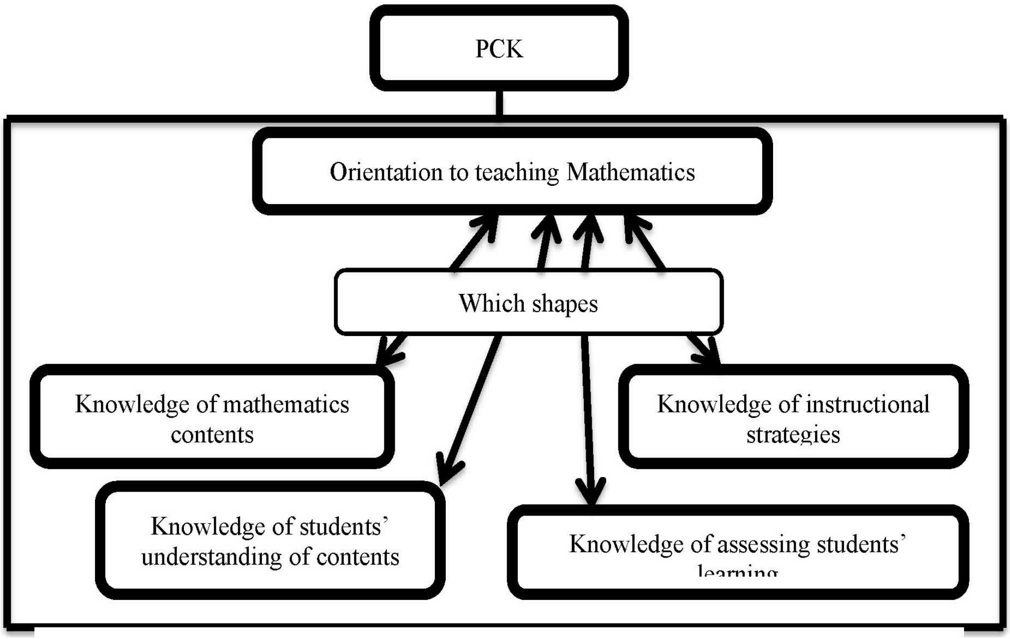

Figure. 2: A conceptual framework for assessing Mathematics teachers' PCK in LCA use as adapted from Magnusson et al. (1999)

2.4 Theoretical foundations of Learner-Centred Approaches (LCA)

The origin of learner-centred pedagogy is a constructivist theory (Tabulawa, 2003; TIE, 2010; Tabulawa, 2013). This non-positivist theory is attributable to prominent educational scholars and constructivist philosophers such as Jean Piaget, Lev Vygotsky, Jacques Rousseau, and John Dewey (Tabulawa, 2003). The main purpose of the learner-centred pedagogy is to develop a society with individuals who can analyse and solve daily problems they face in life (Tabulawa, 2013). Constructivists deny the existence of objective reality (Guba & Lincoln, 1989) by placing emphasis on the learner's use of experience to construct actively knowledge of what they learn (Eggen & Kauchak, 1997). Teachers, who effectively use LCA, are characterized by their stressing on giving a room for learners to construct meaning of what they learn (Cobb, 1994; Maypole & Davies, 2001; Weimer, 2002).

2.5 Teachers' PCK in the use of LCA

Shulman (1986) introduced PCK as a "missing paradigm" in the teaching of science to become an important component of an effective teacher. According to Shulman (1986), PCK is an important teachers' knowledge base because through it teachers formulate explanations, make decisions during the teaching process, decide on how to ask questions, and deal with students' learning. Shulman (1987) contends that, the teachers' PCK which distinguishes the teaching profession with other professions. Various studies have described PCK as a personal construct (Garritz, 2015; Kind, 2009), or as topic specifics, discipline specifics, and subject specifics (Andrews, 2001; Kitta, 2004; Magnusson et al., 1999). The level of PCK teachers possesses affects their general teaching performance, the expected students' achievement, and acquisition of knowledge and skills. High level of PCK helps a teacher to deliver contents to learners in the most effective, appropriate, and in an organised way that influence positively the learners' achievement of the subject matter (Shulman, 1987). Hauk, Jackson, Toney, Nair, and Tsay (2014) on their part have demonstrated that, the teachers' knowledge of the subject matter (SMK) and teachers' pedagogical knowledge are components in the teachers' PCK, which helps them understand the big ideas from concepts that they teach. Apart from discovering the big ideas, the teachers' PCK helps their thinking and knowledge building.

This study adapted five components of the teachers' PCK from Magnusson *et al.* (1999) framework to assess the teachers' PCK in the use of LCA. The five components of PCK used in LCA adopted in this study are the teachers' orientation to teaching mathematics; teachers' knowledge of students' understanding of mathematics concepts; mathematics teacher's knowledge of instructional strategies; Mathematics teachers' knowledge of the subject contents; and Mathematics teachers' knowledge of assessing students' learning. These five PCK components were adapted as they tend to influence the teachers' decision regarding when and why to use of LCA in teaching Mathematics. The focus was to describe how the study could these PCK components to generate data on mathematics teachers' use of LCA in teaching. The major areas of focus were assessing ways in which a Mathematics teacher uses learner-centred approaches to decide, group, and organise contents for teaching while putting students at the centre of teaching. Specifically, PCK components were used in the study to assess how experienced Mathematics teachers apply LCA to make decisions and organise contents for teaching the subject. Overall, the components of PCK guided the assessment of experienced Mathematics teachers' orientation in the teaching of subjects, teachers' knowledge of LCA, and teachers' knowledge of instructional strategies.

Although there is an emphasis on the use of LCA in Tanzania's secondary school classrooms, teacher-centred teaching approaches remain dominant, which suggests a need to assess the teachers' PCK in the use of LCA. The related literature in Tanzania had established that pre-service teachers have underdeveloped PCK (Anney, 2013). The concentration was on experienced teachers, as not all the teachers in Tanzania were trained in the learner-centred pedagogy. As such, assessing the PCK for teachers who were trained in the use of LCA was necessary to understand the experienced Mathematics teachers' knowledge, skills, and classroom practice in the use LCA. In addition, it helps science educators to understand what shapes teachers' skills and knowledge of Mathematics teaching. Such understanding is also useful in identifying strengths and weaknesses in the teachers' pedagogy, content, and in the application of LCA. The assumption was that teachers who were recruited from 2008 to-date possessed knowledge and skills in learner-centred pedagogy. However, there is little research that had already been conducted to assess experienced teachers' learner-centred pedagogical knowledge and skills. In this case, it was plausible to conduct a study involving experienced Mathematics teachers' PCK in learner-centred approaches. This study, therefore, assessed how experienced Mathematics teachers use three out of five PCK components to influence their application of LCA in teaching and learning of Mathematics in the classroom. The study was guided by three research questions:

i. How does ‘Mathematics teachers’ orientation to teaching the subject’ guide their classroom instructional decision on the use of LCA?

ii. How does Mathematics PCK component of ‘teachers’ knowledge of students’ understanding of Mathematics content’ support the teachers’ decisions to use LCA?

iii. How does the Mathematics PCK component of ‘teachers’ knowledge of instructional strategies’ help them apply LCA?

3.0 Research methodology

This study was guided by interpretivism due to the nature of PCK as both an implicit knowledge and a personal construct. Interpretivism offered the study an opportunity to select purposively the study participants. The study employed a multiple case study design. The researchers interviewed four different experienced Mathematics teachers from four different secondary schools (see Table 1). The four (4) experienced mathematics teachers are represented by a combination of the English alphabet capital letters and numbers. The first letters A, B, C and D represent an identity of a teacher, S1 to S4 are schools, R and U represent rural and Urban district, respectively, whereas L represent a school from low performing and for H a school from the high performing schools’ category. Therefore, the participant teachers were AS1RL, BS2RH, CS3UL, and DS4UH. Table 1 presents their demographic data, specifically, their academic qualifications, teaching experience, and the teaching workload per week for each individual participant:

Table 1: Teachers’ qualifications, experience and workload per week

Teacher’s name	Year employed	Year completed		Work load per week			
		Diploma in education with Mathematics	Bachelor of science with Education and Mathematics	Maths streams	Non-Maths streams	Class size	No. of 80 minutes lesson/week
AS1RL	2010	2009	-	3	0	50-80	6 to 10
BS2RH	2011	2010	-	More than 10	More than 6	50-80	More than 10
CS3UL	2008	2007	2011	4	0	50-80	More than 10
DS4UH	2001	2000	2009	3	2	50-80	More than 10

Each participating teacher in this study served as an individual case study. In analysing and interpreting multiple case study, "each case should be viewed as if it were a separate experiment rather than a single sampling unit, thereby following a replicating logic" (Campbell & Ahrens, 1998, p. 542). The use of the multiple case study design helped to establish the uniqueness of each individual case study and how the findings from one case study conformed or deviated from the findings of another case study. In addition, a multiple case study "enhances confidence in the [transferability] of the findings" (Campbell & Ahrens, 1998, p. 543) compared to a single case study design. The experienced teachers in this study were graduate teachers from teacher education training colleges and universities who had experience in the use of LCA and had worked for at least five years. Thus, the use of the multiple case study design allowed the research to capture data on the participating teachers' classroom practice of LCA and their explanations on the nature of LCA.

Data was collected through interviews, observation and documentary review. Since the teachers' PCK is measured through the capture of what a teacher verbalises, structured interviews were used because it gave the researcher room to plan the issues for investigation. Teachers were given the interview guide in advance before the interview sessions for them to be aware of the topic and plan accordingly for the answers. It was in that format because the required data were based on their personal construct. The required time for each interview session was 60 minutes. However, the actual interview sessions lasted between 30 minutes and 40 minutes. All the interview sessions were recorded using voice recorder.

Classroom observations were based on topics and sub-topics that each teacher had planned based on each teacher's scheme of work. During classroom observation, the researcher identified the main features in the teachers' lessons in relation to the research questions. In addition, the kinds of instructional strategies that the teachers used, the teachers' knowledge on the use of LCA, and how students responded to their questions were assessed as well. Each of the classrooms that were observed was video-recorded by the researcher to capture teachers' classroom practice and content representation. After the recording process the recorded video clips for every teacher were stored on a compact disk (CD). Immediately after each classroom observation session, there was a mini-interview with the teachers whereby each teacher using the teacher's self-reflection guide. During the mini-interview sessions, each teacher described a lesson he or she had taught and the different stages in their lessons. Assessing the personal construct through observation was challenging since respondents could not automatically reveal all their natural classroom practices. As the observation was coupled with video recording, the participants chose the day, classroom, and time. Finally, the recorded video was first shared with the respective participant. This helped participants and the researcher to reflect on the purpose of the study. The reflection on the purpose of the study and longer stay with the participants helped to improve data collection process in the natural setting in the aftermath of observation days. The findings from this study are limited to four (4) experienced Mathematics teachers from the two districts, and thus the findings cannot be generalised. Also, since PCK is a personal construct knowledge (see Hume & Berry, 2011), and implicit in nature (Kind, 2009), the findings may be not transferable to other areas of similar context.

The PCK components derived from Magnusson *et al*.'s (1999) framework were assessed using the PCK rubrics developed from the work of Hume and Berry (2010), Gardner and Gess-Newsome (2011), and Anney and Hume (2014). In such qualitative studies, the PCK rubrics are documented to best represent the assessment of the teachers' PCK (Loughran, Mulhall & Berry, 2004; Loughran, Berry, & Mulhall, 2006). In the study by Anney and Hume (2014), teachers' PCK rubrics helped to represent the teachers' PCK on a continuum with weak components of their PCK at one end and strong components of their PCK at the other end. The study applied content representation (CoRes) rubrics to document the big themes in a matrix format to represent teachers' PCK. The formulation of CoRes was guided by Loughran *et al*. (2006) and Hume and Berry (2010) CoRes whereby the themes were identified as big ideas. A professional development Repertoires (Pap-eRs) for capturing the teachers' PCK as each teacher's self-reflection was adapted from Gardner and Gess-Newsome (2011) to document the teachers' self-reflection on classroom practices after an individual teacher's lesson.

3.1 Data analysis procedure

This study adapted Creswell' (2009) and Braun and Clarke's (2006) six steps thematic analysis strategies due to the nature of the investigation which was purely qualitative, and data were tacit in nature. Thematic analysis in this study was a data-driven type of data analysis which allowed for identifying, analysing and reporting patterns (themes) within data as they emerged from the participants' perspectives during investigation (Yin, 2009). Thematic analysis allowed for data analysis both at the manifest and theoretical level as were collected from different sources under the same theme. Also, thematic analysis allowed for cross-case analysis and comparison of data from different case studies. Themes emerged during classroom observation, documentary review, and from the participants' responses during the interview sessions. The themes or the big ideas that emerged were used to highlight evidence of LCA characteristics that were known by study participants. The evidence was used to illustrate the level of the teachers' PCK in LCA.

The first step in this study was describing each case with its data to become familiar with the data. At this stage, the researchers transcribed raw data, reading and re-reading the raw to obtain meaning or the initial ideas from participants. Collected data in the form of field notes from each case study were then coded and organised into themes according to the sources (observation, interviews and documentary review) and in the form of data. Video data from classroom observations and documents were coded to obtain the manifest themes according to the research questions and PCK rubrics. The experienced Mathematics teachers' classroom practices in the video were matched with the PCK components in the learner-centred teaching approach. This video analysis procedure, as described in the work of FitzGerald (2012), was adopted so that "the video data is scrutinised for specific types of events and is most relevant where the research is driven by existing questions … about those events" (p.2).

In the second step, the researchers conceptualised the required answers to the main questions of the study to remain focused on the main themes of the study. At this stage, Kombo and Tromp (2006) propose that a researcher re-reads the data to obtain the general meaning of the data collected and to reflect on the overall meaning.

Then in the third step, the researchers created codes by assigning those features that were used to identify and categorise the themes from the raw data. The researcher analysed and categorised data into chunks or segments of text before bringing meaning to information.

The fourth stage was theme searching. The researchers involved in unitising data, developing categories and themes for analysis. At this stage, supporting extracts per theme and relationship (establishing pattern) among themes were identified to reform the analysis at broader levels of themes.

The fifth stage focused on descriptions and theme representation whereby the themes were described in the form of narration. The events and discussion of the themes as they emerged from different sources were chronologically organised.

The sixth step was the interpretation of themes or meaning of data. At this stage, meaning from the findings was derived and lessons learned were stated as they were interpreted by the researcher. Finally, cross case analysis was conducted based on the themes identified before report writing.

3.2 Cross-case analysis

Although generalizability is inappropriate for qualitative studies, cross-case analysis in a qualitative study aims for generalizability. Cross-case analysis aims to know the applicability or transferability of finding from one qualitative study to others of similar setting (Miles & Huberman, 1994). After individual case analysis, cross-case analysis was done to deepen understanding on how data from each individual case study related or differed from others. This stage involved the analysis of the similarities and differences in participants' interpretation, context, and knowledge in the different sources of data regarding the research objectives and questions of the study. The individual participants' profiles helped to categorise participants in the groups based on their teaching experiences and categories of their schools. Also, individual profiles helped to categorise different themes that emerged in the process of data collection. From cross-cases analysis, a summary that identified the components of PCK in LCA as the main themes in the study was formed. To identify the major emerging ideas, summarising the themes was according to the research objectives and attendant questions.

The components of PCK in LCA for this study guided the identification of the main themes that characterise the knowledge base for Mathematics teaching using LCA. The main themes in this study were teachers' orientation to teaching Mathematics, teachers' knowledge of instructional strategies, teachers' knowledge of content, teachers' knowledge of students' understanding of Mathematics, and teachers' knowledge of assessing students' learning. The themes identified from different cases were then subjected to content representation (CoRes) and PCK rubrics to capture the profile of the teachers' PCK in LCA. In cross-case analysis, triangulation of data from multiple sources was performed and a general profile of teachers' PCK in the use of LCA was inferred (Baxter & Lederman, 1999)

4.0 Findings

4.2 Experienced Mathematics Teacher's PCK and Teaching Orientations

Data from classroom observation sessions, which were video tapped when teachers were teaching four different subtopics revealed seven major themes. The themes are highlighted in Box 1, Box 2 Box 3, Box 5, Box 6 and Box 7 of an extract of the lesson. These were regarded as components of PCK in the use of LCA; teachers' knowledge of LCA, knowledge of instructional strategies, reasons for teachers' decision on the use, and students' background knowledge in Mathematics. Other themes are teachers' knowledge on the role of teachers and students when LCA are used, the nature of Mathematics contents, and the availability of teaching material. The themes identified revealed that experienced Mathematics teachers were oriented to teacher-centred teaching approaches. In the context of this study, classroom Orientation is PCK component that "guides teachers in their decisions about content, instructional strategies, and assessment ... teachers' orientations as one of the amplifiers and filters that mediate teachers' translations of topic-specific professional knowledge to their classroom practice" (Demirdöğen, 2016, pp. 495-96). For teachers with developed PCK, their classroom orientation or practices were geared towards learner-centred classroom approaches. Since the classroom practices was toward learner-centred suggests that suggest that their PCK under-developed in the use of LCA.

Box 1, AS1RL's teaching actions and the noted big ideas

Topic/subtopic: "Inverse of a Mathematic relation"
Teaching actions: AS1RL introduced the lesson by asking students about the lesson they had been taught previously. Some students responded in a chorus "*drawing a graph of a relation*". This was followed by AS1RL task of writing notes on the chalkboard for students to write down. Examples of phrases that were written to reflect the meaning of inverse of a relation reads "*the inverse means that the values of x become the values of y and vice-versa*" After completing some initial and other steps, AS1RL asked a question, "Who is now able to find the inverse of a relation?" However, due to time management it was not possible to go over some other examples
Big ideas: *Orientation to teaching, knowledge of strategies and knowledge of content*

Box 2 AS1RL's Self-reflection

Researcher: What did you do when you were introducing the sub-topic to your students?
AS1RL: *I introduced by brainstorming the students on the previous part of a relation.*
Researcher: What did you do to enable students to acquire this new knowledge?

AS1RL: *I demonstrated on the new sub-topic which was the inverse of the relation*.
Researcher: Which teaching approaches were you using in the class I observed? Was it LCA or TCA? Why?
AS1RL: *I used both LCA and TCA because it is not true that students are empty minded when they come to class. I used TCA to introduce the idea of inverse itself which was new to them. When most of students were familiar, it was upon them to follow procedures that I gave them.*
Researcher: Which teaching techniques or strategies did you use in the lesson that I observed?
AS1RL*: I used demonstration to impart new knowledge and used questions and answers to know their understanding.*
Researcher: What did you do at the reflection stage of your lesson?
AS1RL: *I gave them more questions and marked to reflect on the things my students have faced. That is to identify the difficulties they faced.*

Box 3 BS2RH's teaching actions and the noted themes

Topic/subtopic: "Power"
Teaching actions: BS2RH began a lesson with greetings then wrote the definition of power on the chalkboard. "*Power is the short method of writing the product of the factors*" "For example when you are given $2 \times 2 \times 2 \times 2 \times 2 = 2^5$, this one "$2^5$" is a power". "*Are we together*?" BS2RH asked. Students responded "*Yes*" in a chorus. BS2RH then provided examples and appointed some students one after the other to write some Mathematical expressions in the form of power. "Now listen to me, who can come to the front and show us the power, base, and exponents?" BS2RH asked. "*Clap hands for her/him*" BS2RH ordered students to clap their hands each time there was a response from individual students. "*Is there any problem in these questions*?" BS2RH asked after a series of drill on some examples. "No" students replied in a chorus. After a moment of silence BS2RH winded up the lesson by providing homework.
Big ideas: *Orientation to teaching, knowledge of strategies and knowledge of content*

Box4 BS2RH's Self-reflection

Researcher: What did you do to introduce the lesson?
BS2RH: *I introduced the topic by guiding the students to know how to describe meaning or define the concept of power. Through my observation, I thought*

most of them had no ideas before.
Researcher: What did you do to enable students to acquire this new knowledge about exponents?
BS2RH: *By giving more examples.*
Researcher: Were you using TCA or LCA in the lesson I observed? Why do you think so?
BS2RH: *I used both LCA and TCA because it leads to all the students understanding well. Some of them will understand through teacher-centred approaches (TCA) whereas others through LCA. So, all together, when you combine the two methods all the students may be able to understand.*

Box 5 CS3UL's teaching actions and the noted big ideas

Topic/subtopic: "The distance between two points in a plane"
Teaching actions: CS3UL introduced the lesson by reminding students about the previous lesson. "*Let us remind ourselves about the previous lesson. Which formula is used to find the midpoint*?" GS4UL named two students to write the formula on the chalkboard "$M.P = \frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}$, $(x, y)\left(x = \frac{x_2 + x_1}{2} \; y = \frac{y_2 + y_1}{2} \right)$". These answers were written by the student. There was no comment from GS4UL about the answer after students had written. "OK, can someone find the midpoint of the point $A(2,4)$ and $B(6,8)$?" GS4UL asked thereafter. "*If I want to know the distance between point A and point B, I take the difference between x_2 and x_1, then the distance between y_2 and y_1 in the points A and B using the distance formula".* After demonstration using some examples and individual exercises BS2RH finished the lesson
Big ideas: *Orientation to teaching, knowledge of students' learning, knowledge of strategies and knowledge of content, knowledge of assessment*

Box 6 CS3UL's Self-reflection

Researcher: What did you do to introduce the topic to your students?
CS3UL: *I reminded them about the previous topic which was about midpoints. I also reminded students on how to locate two points in the X and Y axes.*
Researcher: What did you do to enable students to acquire this new knowledge?
CS3UL**:** *I guided them to derive the formula.*
Researcher: Which teaching approaches were you using in the class that I observed? Was it LCA or TCA? Why?
CS3UL**:** *I used both. When you use LCA only, at one point you realise the students lacking some knowledge. You use both approaches to help students to*

understand the lesson well.
Researcher: Which were the teaching techniques or strategies that you used in the lesson that was observed that were leaner-centred approaches?
CS3UL: *Actually, when I was teaching, I used both approaches but most of the time I used TCA. The two approaches helped me to share what I know and what my students have.*

Box 7 DS4UH's teaching actions and the noted big ideas

Topic/subtopic: "Fractions"
Teaching actions: DS4UH introduced the lesson by reminding students about the topic. "*Let us proceed with our topic. Our topic is fractions. Observe this figure."* DS4UH *reminded students about the topic and to hold an object and then asked the students to observe it. "What is the name of this shape*? DS4UH asked. "*Circle,*" students replied in a chorus "*How many parts do you see?"* DS4UH *continued with questions without commenting anything on the previous answers. "Four parts," student replied in chorus. "How many parts are shaded*?" DS4UH asked again. "*One part is shaded"* student replied in chorus. *"Is the shaded part out of how many parts*?" DS4UH asked "*Out of four parts*" students responded in a chorus. "*We can write this as* $\frac{1}{4}$ *or one quarter and* $\frac{2}{8}$ *as two over eight*". DS4UH wrote on the chalk board while explaining. After that, DS4UH demonstrated using other examples of fractions and types of fractions and, finally, provided an exercise for students to work individually.
Big ideas: *Orientation to teaching, knowledge of students' learning, knowledge of strategies and knowledge of content, knowledge of assessment*

Box 8 DS4UH's Self-reflection

Researcher: How did you introduce the lesson?
S4UH: *I introduced the lesson by demonstrating using the teaching aids that was having some figures on fractions that I wrote on the manila card. I asked them about what they had observed from the pictures. They discovered it was a circle and the parts contained within.* Researcher: Which teaching approaches were you using in the lesson that I observed? DS4UH: *It was a discussion and, sometimes, a lecture citation method. Due to the nature of the class, students were somehow fast learners. Very few were slow learners. In a class where I have majority students who are slow learners, I mainly use lectures and demonstrations.*

4.3 Experienced Mathematics teachers' knowledge of students' understanding of LCA

The themes as identified from interview revealed that the responding experienced Mathematics teachers believed that when they used LCA students were the only sources of classroom material. In this regard, AS1RL confirmed during an interview: "*In LCA, the student is taken as the main source of the knowledge. A student is the main provider of knowledge. I mean someone who knows something and who can give that knowledge to others in large percentage*". On the same aspect, DS4UH said during an interview that the teacher's role was to direct and explain when the students were wrong: "Under TCA, the teacher is the *main source of all ideas* when teaching. *Under LCA, on the other hand, students act as sources of materials during the teaching and learning process. I direct and explain when students are wrong; students provide what they know, discuss, criticise themselves and ask questions" (*Interview with DS4UH). Regarding students' and teachers' participation, BS2RH and CS3UL both affirmed during interviews that students participated more than their teachers: "*LCA is the one in which students participate fully in the lesson* with the teacher remaining a *facilitator* (BS2RH) and "*It is the one in which students participate fully in the lesson while a teacher remains the facilitator or guide"* (CS3UL).

4.4 Experienced Mathematics Teachers' Knowledge of Instructional Strategies

AS1RL used group discussions, questions and answers, and presentations, while working on the assumption that the role of a teacher when using LCA is to facilitate learning by controlling the class. This is confirmed by the following assertion: *"The role of a teacher is to control the class, to pass through groups as they discuss, listen to their presentation, guide their discussions, ask and answering some questions"* (Interview with AS1RL).

Data from classroom observations were subjected to a PCK rubric. The data revealed that teachers encouraged chorus answers. For example, AS1RL encouraged chorus answers by asking low quality question that demanded low level of thinking in the classroom. AS1RL's self-reflection confirmed that she/he used teacher-centred oriented techniques in the lesson. This was confirmed by AS1RL's knowledge that, the students were conversant with the use of teacher-centred teaching approaches.

BS2RH recognised individual effort in group tasks by asking questions such as *"Who can come to do question one or two for us?"* BS2RH's questions during the lesson were often low-level questions which demanded "yes or no" responses such as "*Are we together*?" or *"Is it clear?"* Asking these kinds of questions during teaching did not augur well with the BS2RH's plan aimed to help students to construct their own understanding on the concept that they had learned. Essentially, BS2RH's classroom activities such as demonstrations, questions and answers, and lecture encouraged low level of thinking.

The results show that CS3UL was conversant with very few learner-centred instructional strategies and most often used groups that he/she identified as belonging to both groups of LCA and TCA. In fact, CS3UL's questions were not used to trigger students' higher order thinking, involvement, and learning but rather made them recite only on what they had learnt. Though CS3UL used grouping and questioning techniques, the main challenge was the number of students in the classroom which CS3UL perceived as too big:

> *I group the students, ask them questions for discussions; I give them tests, quizzes and oral questions. I guide, help students to construct their own knowledge, contribute, take notes, answer questions, and participate effectively. Also, it depends on the availability of time, the number of the students; it is difficult, for example, to divide 100 students in groups* (Interview with CS3UL).

CS3UL had knowledge of students' learning aspects. However, during the teaching process, CS3UL did not pay attention to the students' errors and neither commented on them to alert the students to the mistakes they were making so that they could learn from them.

Though DS4UH had knowledge of learner-centred instructional strategies that were suggested by the mathematics syllabus, she/he used instructional strategies which were more conventional than students-centred. In fact, DA4UH preferred the use of demonstration, questions and answers, group work and discussions. Moreover, DS4UH's lessons were dominated by traditional strategies which valued individual student's accountability in learning rather than co-operative learning. During lessons, DS4UH mainly asked questions such as *"Is there anyone …?"* and *"Who can give an example of…?"* which did not encourage equal students' participation. Furthermore, DS4UH did not solve the apparent students' learning difficulties constructively and some of the students' concerns remained unattended to. This practice affected negatively students' involvement in the lessons.

4.5 Experienced Mathematics Teachers' Decision and Use of LCA

AS1RL's choice of LCA depended on the students' background knowledge of the subject matter and respective topic. This teacher reported that the slower the students in learning the more difficult it was to manage the LCA. AS1RL said that there were topics which could not be taught using LCA:

> *It depends on the nature of the topic. Other topics are difficult to students to understand. At the same time there are easier topics where the students can find materials and read. Students' level of understanding and time … If I have enough time; if the class size is large it may be difficult to manage (Interview with AS1RL).*

Similarly, BS2RH's decisions depended on the level and nature of the learners. BS2RH did not even use LCA because it required more time and was not applicable to a large number of students in the class. For BS2RH, the use of LCA applied only to lessons and topics that were easy for students grasp through in-class interactive activities. Indeed, BS2RH insisted that the only successful method was TCA, arguing that LCA should be used for non-complicated problems: "I use TCA because students perceive the Mathematics subject to be very difficult. If you ask a complicated question they say, 'I don't know'. As such, you are supposed to teach them, and after that give them a question to discuss to evaluate them (Interview with BS2RH). BS2RH further elaborated: "Students have no knowledge of any concept or content in mathematics. Therefore, in order for students to understand the subject, the teacher must teach them. Some concepts may be understood with the use of LCA. However, other subject contents cannot be understood". Elucidating further on the issue, BS2RH said that students such as Form ones could not learn via the LCA methods and as such they needed "only the teacher to deliver the materials because they are not mature enough" and because LCA required ample time and cover all the content was to be covered within a year, which was a tall order (Interview with BS2RH).

CS3UL's decision to use LCA depended on the topic at hand and certainty that students will have something to contribute during the interactive learning session:

> *I use all the approaches but most of the time I normally use TCA. It also depends on the topic; there are topics for which you can use LCA and yet find students not contributing anything. I plan for LCA when many learners have ideas from lower levels that they can contribute. I don't know about other subjects but in Mathematics,*

it is better to know first what the students can contribute before using LCA. Therefore, it depends on the topic or sub-topic I teach. But to save time, I use TCA (Interview with CS3UL).

Similarly, DS4UH's decision on and actual application of LCA depended on the students' background ability and knowledge of the concept. DS4UH reported that LCAs were applicable only with faster learners. As for JS5UH, she/he usually introduced lessons by demonstrating when the concept appeared new to the students. Therefore, DS4UH implored Mathematics teachers to plan for both approaches during teaching and learning process. Impliedly, DS4UH recognised a thin boundary between the two approaches. Indeed, the teacher contended: "*The use of LCA depends on the students' knowledge of the concept, their participation, fast or slow learners, and students' attitudes towards the subject. Go to the class with the two approaches ... When students are not comfortable [with LCA] use TCA*" (Interview with DS4UH)."

5.0 Discussion of the Findings

The study findings from classroom observations, documentary review and face-to-face interviews indicate that experienced Mathematics teachers did not generally use LCA. Specifically, they reported that they did not employ LCA in teaching Mathematics because teaching materials were not always accessible to the students in their respective schools. In addition, they had to contend with larger classrooms and found the application of LCA time consuming. Furthermore, they lamented that it was difficult for the teacher to cover the syllabus in the allotted period and to teach Mathematics to low achievers. The experienced Mathematics teachers also voiced their concern on the inherent challenge of covering the contents of the syllabus when they applied LCA, which indicates that LCA was associated with classroom events only and hints at the apparent weakness of experienced teachers in PCK. Since PCK reportedly evolves with experience inadequate use of LCA among experienced Mathematics teachers suggests that their PCK remained underdeveloped despite being experienced teachers.

This study's finding contradicts with those of previous researches, for example, by Mavhunga and Rollnick (2015), which reported that Science teachers with developed PCK tend to shift their beliefs and classroom practices to more learner-centred teaching approaches. Despite being experienced, the veteran Mathematics teachers exhibited teaching practices that did not reflect the practices of teachers with developed PCK. Previous studies (Hume & Berry, 2010; Kind, 2009) reported that teachers' PCK develops with experience, and thus the more experienced the teacher is, the stronger the PCK and effectiveness in using learner-centred teaching approaches. In this study, the experienced Mathematics teachers reported that the use of LCA changed theirs and students' roles. Students were regarded by the teachers as knowledge givers whereas teachers being knowledge receivers from the students. In this case, the teachers' decision to use LCA is based on the premise of their being released from a burden of being searchers of knowledge to being receivers of knowledge from the students. The experienced Mathematics teachers understood that when LCAs were used, students became the only source of teaching and learning material.

On the other hand, the teachers' lack of motivation to apply learner-centred teaching approaches in the classroom was being contributed by their attitude towards teacher-centred teaching approaches. Indeed, teachers' beliefs and attitudes influence their instructional decisions including their choice of instructional strategies (Flowerday & Schraw, 2000). Given that experienced Mathematics teachers in Tanzania have been trained in the use of teachers-centred approaches, changing their attitude towards learner-centred teaching approaches takes time. In this regard, Mavhunga and Rollnick (2015) observed that teachers might have some development in PCK but "without a shift from teacher-centred beliefs about science teaching" (p. 831). As such, the adoption of LCA was likely to be limited in teaching and learning despite the heavy emphasis placed on it in the school curriculum.

The experienced Mathematics teachers also reported that large class sizes also contributed to teachers' decisions to employ teacher-centred approaches. In fact, larger classroom size has been reported in the literature as one of the barriers to effective Mathematics teaching and student learning (see, for example, Kirstein & Kunz, 2011; Prendergast, 1994). Prendergast (1994) reported that there is myth among educators that student-centred teaching is only practised in smaller classrooms. He argues that careful planning, good teacher organisation, visiting groups randomly during classroom discussion and knowing the names of the students also result in effective learning of students in the large classrooms (ibid.).

6.0 Conclusion and recommendations

6.1 Conclusion

Teachers' choice of specific classroom for observation sessions revealed the implicit nature of PCK in the use of LCA. The findings reveal that, the teachers' PCK in learner-centred approaches in the context of this study is shaped by their acquired knowledge of LCA, their knowledge of learner-centred instructional strategies, and orientation to LCA. The experienced Mathematics teachers in this study, who were not trained in the application of learner-centred pedagogy, revealed through their interpretation of LCA in the classroom situation and interviews that their PCK in the use of LCA was underdeveloped. Implicitly, the experienced Mathematics teachers more unlikely than otherwise to address effectively the problem of low performance in Mathematics in Tanzania's secondary schools.

6.2 Recommendations

To improve the experienced teachers' PCK in the use of LCA, there is a need to provide practical and theoretical professional training to enhance their knowledge and skills to transform the PCK components in the use of LCA. Moreover, the in-service teacher's training should attract equal attention in both the practical and theoretical aspects of LCA to help teachers apply LCA effectively in the teaching process. Since teachers in the study had to contend with large classrooms, the training on LCA should capture this dimension to adequately prepare teachers for this inevitable eventuality in their situation. Also, a similar study should be conducted with a focus on other science subjects.

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