

## Examining Pre-service Mathematics Teachers' Pedagogical Content Knowledge (PCK) during a Professional Development Course: A Case Study

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*Abstract: Peer teaching is a valuable practice that helps pre-service teachers to acquire the knowledge and the expertise required for teaching as well as improving their pedagogical content knowledge. For that reason, this study focused on the pre-service mathematics teachers' peer teaching, with the intention of exploring their pedagogical content knowledge as mirrored in peer teaching. The participants were four pre-service secondary mathematics teachers. Each participant designed a lesson plan and conducted peer teaching on a mathematics concept of her choice. The lesson plans and videotapes of the participants' peer teaching were the data collection instruments. The components of pedagogical content knowledge were used to analyze the data. The findings revealed that the pre-service mathematics teachers were knowledgeable about the subject content matter, but their knowledge of learners, understanding of instructional strategies and familiarity of context was inadequate about the topic of their peer teaching. The study recommends an amalgamated teaching of mathematics content courses and pedagogy courses.*

**Keywords:** pedagogical content knowledge, pre-service mathematics teacher, peer teaching

### INTRODUCTION

One of the crucial goals of mathematics teacher preparation curricula is to assist trainee teachers in improving their mathematics content knowledge and expertise for good teaching using their assignments, tests and practice. Mathematical content and general pedagogy courses are taught in mathematics teacher training institutions to enhance the development of trainee teachers' mathematical knowledge and pedagogical knowledge. Nevertheless, teachers not only require to be knowledgeable about mathematics content and pedagogy but in addition, knowledge of learners, instructional resources, curriculum and assessment as well as the ability to interlink

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them efficiently (Shulman, 1986). Peer teaching is considered to be one of the teacher training components that help trainee teachers in developing their skills of interlinking various forms of knowledge for realistic teaching. During peer teaching trainee teachers focus on how difficult or easy is a specific topic to the learners, learning objectives specified for a particular concept in the mathematics syllabus, teaching approaches and resources that enable learners' learning as well as assessing learners' intellectual capacity (Adu-Yeboah & Yaw Kwaah, 2018; Kilic, 2010).

For the purposes of providing trainee teachers with practical skills of teaching before they are deployed for practicum, trainees take part in micro-teaching and peer teaching activities. Peer teaching is carried out in artificial environments to prepare the trainees for the real classroom setup. Peer teaching provides the trainees an opportunity to use the mathematical subject knowledge in addition to instructional knowledge they have learned during training (Kartal, Ozturk, & Ekici, 2012). Hence, trainee teachers ought to nurture and develop pedagogical content knowledge (PCK) (Shulman, 1986). PCK skills and ability can be developed through reflection and practice (Mason, 1999; Ayhan, 2012). According to Kind (2010) the possession of good content matter, classroom familiarity as well as having emotional qualities such as individual self-confidence as well as providing a supportive working environment where collaboration is encouraged for the development of PCK in trainee teachers.

The PCK domains are integrated and connected hence cannot be regarded as distinct knowledge bases (Cochran, De Ruiter, & King, 1993). Although the domains of PCK are interrelated, scholars have concentrated more on how several opportunities provided in pre-service teacher training courses support the growth of PCK components separately (Kilic, 2010; Rianasari, 2017). Lee, Brown, Luft and Roehrig (2007) observed that pre-service teachers have fragmented pedagogical content knowledge, hence, it is vital to support the integration of PCK domains (Aydin & Boz, 2013). For that reason, further research is necessary concerning the nature and growth of the interface amongst pre-service teachers' pedagogical content knowledge domains, also with regard to how several situations inspire the interface of PCK domains (Aydin, Demirdogen, Nur Akin, Uzuntiryaki-Kondakci, & Tarkin, 2015). In view of that, the current study intended to explore pre-service teachers' growth of the integrated PCK domains during peer teaching in a mathematics pedagogy course.

## PEDAGOGICAL CONTENT KNOWLEDGE

Pedagogical content knowledge forms the basis for several teachers' actions during the teaching and learning process. According to Shulman (1986), pedagogical content knowledge is the technique of demonstrating and communicating the content so that it is understandable to the learners. For Shulman (1987) PCK is the amalgamation of subject matter and instruction in comprehending specific concepts and difficulties. His PCK takes account of knowledge possessed by learners, knowledge of instructional resources as well as educational context knowledge. Cochran, De Ruiter, and King (1993) retitled Shulman's PCK as pedagogical content knowing (PCKg) which is more aligned to the constructivist view of teaching and learning. As stated by them, PCK is dynamic. To put more emphasis on the dynamic nature of PCK, the term "pedagogical content knowing (PCKg)" was used, which according to them is the teacher's

combined comprehension of the characteristics of the learners, pedagogy, the learning environment and the subject matter content. According to them, pedagogical and content knowledge ought to be developed in the environment in which the teachers understand the learners as well as the environmental context of learning. PCKg is an amalgamation of the teachers' knowledge of pedagogy, subject matter, environmental contexts and learners.

## **SUBJECT MATTER KNOWLEDGE**

Subject matter knowledge is the content of the mathematics concepts that are taught to the learners (Koehler, 2011; Shulman, 1986). The subject matter knowledge consists of specifics of the guidelines of proof and evidence, facts, major ideas, concepts, propositions, interactions, theories, suitable illustrations that make the content understandable, principles that are taught and learned, processes of a specific concept and information of descriptive contexts that consolidate and link notions. Subject matter knowledge is important in teaching any topic and it influences how teachers think and implement the curriculum (Shulman, 1986; Cochran, et al., 1993). Teachers must not merely possess the content of teaching the concept but should be able to adjust this knowledge to make it easy to learn by learners (Marcon, Graça, Nascimento, Milistetd, & Ramos, 2015). Teachers' subject knowledge enables them to comprehend school and classroom organization in addition to administration, the societies in which the learners come from as well as the institutional, constitutional, and political extents that affect the educational organization (Marcon, et al, 2015).

## **KNOWLEDGE OF PEDAGOGY**

According to Shulman (1986), knowledge of pedagogy comprised teaching approaches, learning processes and classroom assessment. A deep understanding of pedagogical knowledge includes an understanding of learners' construction of knowledge; comprehend cognitive, societal, and understand the development of theories of learning as well as how those theories relate to the learners in the classroom; and being cognizant of what would be happening in all sections of the classroom and being able to handle a number of classroom events. In a nutshell, pedagogical knowledge consists of all issues linked to how learners learn, how they are assessed, how the classes are managed, knowledge of learners' characteristics, and the development and implementation of the lesson plan (Shulman, 1986). Pedagogical understanding consists of curriculum knowledge and knowledge of educational objectives and purposes as well as an understanding of what constitutes good teaching, taking into account the best teaching methods in a given situation, which are guided by suitable learning theories (Cochran, et al., 1993). Knowledge of pedagogy helps in developing teaching concepts and instructive principles, identifying pedagogical approaches, and planning, organizing as well as creating teaching and learning activities (Grossman, 2008; Marcon, et al, 2015).

## KNOWLEDGE OF CONTEXTS

Knowledge of context includes teachers' understanding of the environmental contexts of learning, which comprise resources, learners' socio-economic background, curriculum, cultural, political, social, classroom conditions, availability of time for teaching and learning and physical environmental situations that affect teaching and learning.

## KNOWLEDGE OF STUDENTS

This involves teachers' understanding of learners, such as skills, learning approaches, ages, developmental stages, attitudes, inspirations, and previous conceptions of a subject (Cochran, et al., 1993). Teachers need to be aware of the learners' misconceptions in a particular topic for them to understand learners' actions and ideas. The teachers need to know learners' previous knowledge before introducing new concepts. The student knowledge domain is important because teachers have to understand and consider their learners' needs including differences in learners' thinking, views, experiences, and knowledge of the environmental context (Marcon, et al., 2015).

## THE INTERPLAY OF PCK COMPONENTS

Cochran, et al. (1993) stated that the amalgamation of the four domains consists of PCKg. The authors reported that teacher education must promote the acquisition of PCKg through offering concurrent experience of the four domains. According to Cochran, et al. (1993) PCK grows with the concurrent comprehension of the four domains of content matter, pedagogy, environmental context and students. The four domains must not be attained separately but must be attained simultaneously during training (Cochran, et al., 1993). According to Cochran, et al. (1993) the four domains might develop in an amalgamated way if the trainees experience the four domains simultaneously. PCKg growth is frequently complemented by educational change and notion amalgamation that comes from several hours of training, observing as well as imitating by trainees individually in addition to peers' teaching (Cochran, et al., 1993). According to Smith and Neale (1989) and Chien, Rohaida Mohd and Siow (2015), the amalgamation of PCK domains is crucial to the active teaching of mathematics and the more the domains are amalgamated the stronger they become and they result in a more developed PCK. Teaching is therefore an act of integrating all the PCK domains (Ayhan, 2012). Pre-service teachers usually acquire their pedagogical and subject matter knowledge from different academic departments (Ayhan, 2012). Cochran, et al (1993) buttressed a more all-inclusive approach to teacher education by disapproving the isolated acquisition of pedagogical and subject matter knowledge. Marcon, et al. (2015) also reported on the lack of evidence that shows the progress of PCK's acquirement throughout the teacher training program. Pre-service teachers' PCK is elementary and inadequate (Cochran, et al., 1993). Therefore, the focus of the current study is on the pre-service teachers' development of PCK during peer teaching.

## PEER TEACHING

PCK is making use of the comprehending of content knowledge, learning procedures, and approaches for teaching a particular mathematics concept in a manner that allows effective knowledge construction in a particular context by learners (Cochran, King, & De Ruiter, 1991). Peer teaching is an essential technique in teacher training institutions that significantly contribute to pre-service teachers' PCK development (Baştürk, 2016). Through peer teaching, trainee teachers have a chance of putting into practice their content knowledge and pedagogical content knowledge (PCK) (Baştürk, 2016). Pre-service teachers have a chance of identifying as well as improving their weaknesses of teaching skills, for instance, lesson planning and development, classroom management, organization of group work and many others. Peer teaching is an essential component for trainee teacher preparation programs that are more realistic as compared to traditional teaching (Baştürk, 2016). Peer teaching experiences help trainee teachers to be familiar with the actualities of teaching, to have a chance to have an understanding of their duties as teachers, to recognize the significance of making preparations for teaching, making decisions, and putting into practice instructional techniques, to cultivate and develop their teaching expertise, as well as building their sureness for teaching (Subramaniam, 2006; Baştürk, 2016).

Pre-service teachers are also required to master a number of basic skills of opening and closing lessons, asking questions as well as providing reinforcement, clarifying and giving varying incitement (Rianasari, 2017). According to Magnusson, Krajcik, & Borko (1999), teaching experience is an essential aspect for the growth of PCK. Consequently, pedagogical content knowledge comprises of experimental knowledge and skills acquired from teaching practice and are also an amalgamated organization of knowledge, ideas, theories, philosophies and principles developed by teachers during teaching practices (Magnusson, Krajcik, & Borko, 1999; Kartal, Ozturk, & Ekici, 2012).

Pedagogical content knowledge develops in conjunction with teaching experience (Rianasari, 2017). According to Lee, Brown, Luft and Roehrig (2007), courses that are taken by pre-service teachers during their training help in the growth of PCK. One of such courses is the mathematics methodology course in which peer teaching practices are carried out. Peer teaching is a hands-on method that provides teaching expertise as an output where there is an opportunity for analysis (Kartal, Ozturk, & Ekici, 2012). Thus, peer teaching contributes greatly to pre-service teachers' development of PCK (Kartal, Ozturk, & Ekici, 2012). Peer teaching involves a number of practices and ideas regarding how a topic might be taught better using diverse approaches, techniques and methods, how the topic might be made more comprehensible for learners (Kartal, Ozturk, & Ekici, 2012). Pedagogical content knowledge classifies the distinct forms of knowledge that are ideal for teaching (Shulman, 1987). Trainee teachers' growth of Pedagogical Content Knowledge skills can be measured from two facets, specifically, being able to develop a lesson plan and to implement the lesson plan in the class (Karim & Danaryanti, 2020). Hence, peer teaching contributes to the trainee teachers' development of their knowledge of teaching a specific subject-matter, pedagogy, and learners. Given the explanations provided above, this study focuses on the pre-service mathematics teachers' growth of pedagogical content

knowledge during peer teaching. The following research question guides the current study: How does a mathematics methodology course influence pre-service teachers' development of pedagogical content knowledge?

## **METHODOLOGY**

The current study used descriptive case study to describe in detail the pre-service teachers' growth of PCK in a mathematics methodology course. Saunders, Lewis and Thornhill (2009) pointed out that descriptive research depicts a precise of events, situations or individuals. This design helped the researchers to describe in detail the relevant aspects of the pre-service teachers' PCK development.

## **PARTICIPANTS**

The population of this study comprised four second-year undergraduate female pre-service mathematics teachers taking a mathematics methodology course at a university in Zimbabwe. After completing the second year the pre-service teachers are deployed into schools for a year for their practicum. The teachers were diverse in terms of ethnicity. The four female pre-service teachers enrolled in the methodology course were invited to take part in the study at the beginning of the semester and volunteered to participate in the study by signing their consent forms.

## **CONTEXT OF STUDY**

Pre-service teachers' PCK needs to be developed for effective mathematics teaching. For that reason, courses focusing on teaching about the connection of subject matter content knowledge and pedagogy integration have been of great importance particularly for the teacher training department at the university under study. One such course is the mathematics methodology course offered to pre-service teachers before they are deployed for practicum. The course aimed to equip the trainee teachers with the expertise required for the actual teaching during practicum and after graduating. In addition, to the provision of practical experience on how to integrate theory and practice through the amalgamation of content and pedagogy, the course could be ascribed as focusing on the integration of subject matter content and pedagogy to become Pedagogical Content Knowledge (PCK). The implementation of the methodology course was designed based on the notion that the course would support trainee mathematics teachers' growth of Pedagogical Content Knowledge (PCK). The implementation of the course took 12 weeks, which is 48 hours per semester excluding examinations. The course comprised of topics such as aims of teaching mathematics and the mathematics curriculum, interpretation and development of a school syllabus, scheming and lesson preparation, teaching approaches, assessment and evaluation, question techniques, teaching/learning challenges in mathematics, peer teaching as well as a focus on content courses such as set theory, vectors, matrices, functions and their graphs, linear programming, simultaneous equations. Trainee teachers were required to develop a lesson plan based on the knowledge they gained during theoretical and practical lectures, in

which they had to provide a description of what they were going to teach and how they were to teach it. In an attempt to meet the demands of such a lesson plan, pre-service teachers had to make use of their mathematics content knowledge, curriculum knowledge, pedagogy knowledge, knowledge of contexts and knowledge of learners and knowledge of pedagogy thus pedagogical content knowledge. They were also required to present peer teaching sessions based on the lesson plan they would have developed. Pre-service teachers assess and learn from their teaching practices and experiences during and after the implementation of the lesson. Teachers tend to rely on their experiences when teaching (Kilic, 2010), hence, peer teaching experiences might help in developing their knowledge domains. The peer teaching sessions were implemented during the eleventh and twelfth weeks.

### **PEER TEACHING PROCEDURES**

In this study, peer teaching is whereby the pre-service teacher teaches her peers. Each pre-service teacher was asked to plan and present her lesson during the eleventh and twelfth weeks of the methodology course. Each peer teaching lesson was to be presented within 45 minutes followed by a brief discussion of the lesson. Additionally, the researchers and the peer teachers provided written feedback to the peer teacher. In the current study, peer teaching was used to assess trainee teachers' pedagogical content knowledge. The context of peer teaching was considered to be safe from the known constrictions that possibly obstruct the teaching of mathematics, for instance, classroom management, institutional constraints and the pressure to cover mathematics content.

Peer teaching provided the pre-service teachers with an opportunity of planning mathematics lessons and implementing their lesson plans, as well as observing their peers' teaching in the context of numerous mathematics content and teaching methods. Essentially, it must be noted that peer teaching cannot reflect the actual classroom context. There are chances that teachers might not implement the same teaching presented in peer teaching in their actual classroom situation. This is one of the limitations of the current study that must be well-thought-out in interpreting the findings.

### **DATA COLLECTION INSTRUMENTS**

Two types of data collection instruments were used, written documents and classroom observations. The written documents comprised pre-service teachers' lesson plans. The lesson plans were prepared in such a manner to meet the requirements of the secondary school mathematics curriculum. The participating pre-service teachers were observed during peer teaching using an observation instrument. The lesson presentation was video recorded. A total of four pre-service lesson plans and videotaped lessons were gathered.

### **DATA ANALYSIS**

The researchers read lesson plans and watched each of the videotaped lessons. Each peer teaching (videotapes and lesson plans) was coded and then categorized into themes as described

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by Patton (2002). The data were categorized into four themes: subject matter knowledge, Knowledge of teaching approaches, knowledge of learners, and knowledge of context. Specifically, each peer teaching was analyzed as per the four themes, using the following procedures: (0) if the pre-service teacher did not state the teaching approach in the lesson plan, (1) if the pre-service teacher stated the teaching approach. The four pre-service teachers were coded L, M, N and S for confidentiality purposes.

## FINDINGS

The findings of this study were presented in two categories as an assessment of the four teachers' PCK through lesson planning and assessment of the pre-service teachers' PCK through observation.

### ASSESSMENT OF THE FOUR TEACHERS' PCK THROUGH LESSON PLANNING

The knowledge that is essential for planning a good mathematics lesson is an aspect of the domains of pedagogical content knowledge (Prescott, Bausch, & Bruder, 2013). This section discusses the pre-service teachers' PCK through lesson preparation. Table 1 shows each pre-service teacher's evaluation regarding their knowledge of the subject matter.

Subject matter knowledge	Pre-service teachers			
	L	M	N	S
Major concepts to be taught were indicated in the lesson plan	1	1	1	1
Possible mathematics processes to be taught to the learners were indicated in the lesson plan	1	0	1	1
The lesson plan mirrors correct concepts related to the topic to be taught	1	1	1	1
Methods of summarizing the lesson through learners' involvement were indicated in the lesson	1	0	1	1

Table 1: Pre-service teachers' subject matter knowledge

An examination of the four pre-service teachers' lesson plans revealed that the lesson plans contained correct information regarding the concepts to be taught implying that they have the required knowledge about the content of the concepts to be taught. Teacher M did not indicate possible mathematics procedures associated with the concepts that she intended to teach. All four lesson plans comprised correct information about the topics they were going to teach. Teacher M also did not indicate ways of reflecting or making a summary by involving the learners.

Table 2 shows pre-service teachers' knowledge of teaching approaches.



Knowledge of teaching approaches	Pre-service teachers			
	L	M	N	S
Suitable teaching approaches were stated in the lesson plan	1	1	1	1
Inclusion of different instructional approaches in the lesson plan	1	0	0	0
Examples including real-life examples and analogues to be used during teaching indicated in the lesson plan	1	0	1	1

Table 2: Pre-service teachers' knowledge of teaching approaches

The four pre-service teachers (L, M, N, and S) stated the teaching strategy to be used during. Only the pre-service teacher (L) stated alternative teaching strategies such as group work activities to be used during the lesson. The examination of the lesson plans of the three pre-service teachers (M, N and S) showed that they have insufficient knowledge of teaching approaches to teach mathematics concepts as they heavily relied on the demonstration method which makes them the main imparters of mathematics knowledge.

Table 3 shows the pre-service teachers' knowledge of learners.

Knowledge of learners	Pre-service teachers			
	L	M	N	S
Inclusion of learners' prior knowledge in the lesson plan	1	1	1	1
Inclusion of learners' possible difficulties in the lesson plan	1	1	1	1

Table 3: Pre-service teachers' knowledge of learners

From the lesson plan analysis, it was noted that all four pre-service teachers indicated learners' prior knowledge and their possible difficulties in their lesson plans.

Pre-service teachers' knowledge of contexts is indicated in Table 4 below.

Knowledge of contexts	Pre-service teachers			
	L	M	N	S
Stating resources/media to be used during the lesson	1	1	1	1
Involvement of learners in the utilization of stated resources/media	1	0	1	1
Relevance or appropriateness of stated resources/media to be used to the concepts to be taught	1	0	1	1

Table 4: Pre-service teachers' knowledge of contexts

All the pre-service teachers stated the media/ resources in their lesson plan. Pre-service teachers L, M and S showed how the resources were to be used by students and the resources were relevant to the topics to be taught. Although, stated the resources to be used during the lesson plan did not show how the students were to utilise those resources. And an analysis of the stated resources revealed that those resources were not relevant to the topic that was to be taught.

## ASSESSMENT OF THE PRE-SERVICE TEACHERS' PCK THROUGH OBSERVATION

The lesson observation focused on examining the pre-service teachers' subject matter knowledge, knowledge of teaching approaches, knowledge of learners and knowledge of context. The topics in which lessons were observed were number patterns, simultaneous equations, matrices and sets. Table 5 presents the evaluation of the pre-service teachers' peer teaching in terms of the participants' knowledge of the subject matter.

Knowledge of the subject matter	Pre-service teachers			
	L	M	N	S
Demonstrating mastery of concepts being taught.	1	1	1	1
Identification of crucial mathematical domains in the concept of mathematics that are essential for comprehending as well as applying that concept.	1	1	1	1
Explaining learning objectives related to the concept being taught	1	1	1	1
Performing procedures for solving mathematical problems	1	1	1	1
Makes connections between concepts and topics, including interdependence of concepts	0	0	0	1

Table 5: Pre-service teachers' subject matter knowledge

Generally, the pre-service teachers revealed that they had the required knowledge of the subject matter as they were able to present correct mathematical ideas about the concepts that they choose to teach. This could be due to the fact that they choose the topics that they were good at. However, three teachers could not make connections between concepts and topics, including the interdependence of concepts, except for pre-service teacher S.

Pre-service teachers' knowledge of teaching approaches is shown in Table 6 below.

knowledge of teaching approaches	Pre-service teachers			
	L	M	N	S
Using proper strategies or approaches to teach concepts	1	1	1	1
Using real-life examples and analogies when teaching	0	0	0	1
Utilizing different instructional strategies when teaching	0	0	0	0
Using various illustrations when teaching such as formulae and graphics	0	0	0	1
Actively engage the learners	1	0	0	1
Checking for learner understanding during interactive teaching.	0	0	0	1

Table 6: Pre-service teachers' knowledge of teaching approaches

Generally, the pre-service teachers lacked the knowledge of teaching approaches for the mathematics concepts that they had chosen for their peer teaching. All the teachers demonstrated insufficient knowledge to teach the topics that they selected. Three teachers did not use real-life examples and analogies when teaching. All the teachers used the demonstration method; they did not vary their teaching approaches to meet the diversity of the learners. Although pre-service teachers N and S engaged the learners, they asked recall questions that were purely low order level. These types of questions did not engage learners in mathematical thinking. Only pre-service teacher S checked for learners' understanding during interactive teaching.

Table 7 shows an evaluation of the teachers' peer teaching concerning the learners' knowledge.

Knowledge of learners	Pre-service teachers			
	L	M	N	S
Identifying learners' particular ways of thinking about a concepts	0	0	0	0
Identifying certain learners who have misunderstandings about the concept, then giving an explanation	0	0	0	0
Identifying tasks that students feel are difficult to do	0	0	0	0
Linking concepts to the knowledge possessed by learners	0	0	0	1

Table 7: Pre-service teachers' knowledge of learners

The study showed that the pre-service teachers had insufficient knowledge of learners in the mathematics concepts that they had chosen to teach during peer teaching. However, pre-service teacher S made an effort to make links to students' prior knowledge to the topic she was teaching, whilst the three teachers could not make the connections. The pre-service teachers seemed not to have adequate knowledge to identify tasks that were challenging for the students in the topics that they selected to teach.

Pre-service teachers' knowledge of contexts is shown in Table 8.

Knowledge of context	Pre-service teachers			
	L	M	N	S
Linking concepts learned with everyday life	0	0	0	1
Using proper learning resources (locally, contextualized)	0	0	0	1
Linking concepts learned with other mathematics concepts related topic concepts	0	0	0	1
Involving learners in the utilization of resources/media	0	0	0	1

Table 8: Pre-service teachers' knowledge of contexts

Generally, the pre-service teachers demonstrated inadequate knowledge about knowledge of context. The three teachers were not able to link concepts learned with everyday life, use proper learning resources, linking concepts learned with other mathematics topics as well as involving

learners in the utilization of resources/media. It appeared that pre-service teacher S was the only one who demonstrated adequate knowledge about the knowledge of context.

## **DISCUSSION AND CONCLUSION**

PCK is essential in pre-service mathematics teacher preparation. Teaching experiences such as peer teaching influence pre-service teachers' PCK which concurs with Rianasari (2017) that PCK is generally influenced by pre-service teachers' teaching experiences. Mastering the content only is not sufficient for teachers to teach, they must have the knowledge of pedagogy that would enable them to transfer the content in a manner that the students would understand. Lim (2007) pointed out that successful teaching of a particular mathematics concept hinges on the deepness and comprehensiveness of the teachers' pedagogical content knowledge for the reason that, before teaching any lesson, it essential for the teacher to plan the lesson, select a teaching approach as well as choosing the content that is appropriate for the student's level of understanding. Teachers must have both the content and pedagogy knowledge which includes knowledge of learners, contexts and instructional strategies.

### **PRE-SERVICE TEACHERS' SUBJECT MATTER KNOWLEDGE**

An analysis of both the lesson plan and the classroom observation demonstrated that the pre-service teachers had the knowledge of the subject matter required to teach the topics that they choose. The pre-service teachers' adequate knowledge of the subject matter could be due to the content courses that they had taken during training (Lee, Brown, Luft, & Roehrig, 2007). In addition, their knowledge of the subject matter was influenced by the fact that they were allowed to choose the topics that they were more knowledgeable about. Their knowledge of the subject matter could also have been influenced by the content which they have learned from high school and university as reported by Chien, Rohaida and Siow (2015).

### **PRE-SERVICE TEACHERS' KNOWLEDGE OF TEACHING STRATEGIES**

The pre-service teachers' knowledge of teaching strategies in both the lesson and classroom observation was inadequate. All the teachers used only one method of teaching that is the demonstration method. The findings of this study concur with Kilic (2010) who also noted that pre-service teachers had inadequate knowledge of teaching approaches and representations as they view teaching as telling and demonstrating the procedures to the students so that they practice them. Although, pre-service teacher L indicated that she would use group work activities in her lesson plan, this was never used during her lesson delivery. Teachers' PCK encompasses their ability to use various teaching approaches that are appropriate for various learners with varied interests, abilities and learning styles.

### **PRE-SERVICE TEACHERS' KNOWLEDGE OF LEARNERS**

Although, all the pre-service teachers indicated in their lesson plans the possible students' difficulties and their prior knowledge, their classroom observation did not reflect so. The

classroom observation revealed that the pre-service teachers did not pay attention to the students' prior knowledge, misconceptions and difficulties; therefore, they lacked the knowledge of students. Since the pre-service teachers did not vary their teaching strategies, this also implies that they were not able to cater for the students' learning differences. They used the demonstration method only that disregarded students' differences and needs. The findings of this study are in line with (Kula Ünver, Özgür, & Bukova Güzel, 2020) who pointed out that pre-service teachers' knowledge of learners was very poor.

### PRE-SERVICE TEACHERS' KNOWLEDGE OF THE CONTEXT

Even though the pre-service teachers demonstrated their knowledge of the context in lesson plans, they, however, demonstrated inadequate knowledge of context during a classroom observation. This could have emanated from the idea that the pre-service teachers had acquired the knowledge of context from their courses in the teacher education program that they applied in lesson planning but had a limited teaching experience which hinders their ability to consider the knowledge of context during peer teaching.

Overall, the pre-service teachers had inadequate PCK. This finding is in line with Chien, Rohaida and Siow (2015) who reported insufficient pre-service teachers' PCK. Personal learning history, teacher education and teaching practice experience influence teachers' PCK (Cochran, et al., 1993; Chien, Rohaida & Siow, 2015). In this study, teacher education could be the major factor contributing to the pre-service teachers' inadequacy in PCK, because the mathematics content courses are taught in isolation from the methodology courses. The mathematics content courses are learned for three semesters (one and a half years) before introducing the methodology course in the fourth semester (after one and half years) and the courses are offered from the different departments. This was also reported by Ayhan (2012) who reported that pre-service teachers generally acquire their pedagogical and subject matter knowledge from different academic departments. Cochran, et al (1993) was against the isolated acquirement of pedagogical and subject matter knowledge. The study recommends amalgamated teaching of both mathematics pedagogy and content courses. Mathematics teachers must be educated in both mathematics courses and mathematics pedagogy courses as combined courses and not as separate courses.

In this research pre-service teachers' growth of the integrated PCK domains during peer teaching in a mathematics pedagogy course was investigated. In order to get detailed information, more studies could be done using other data collection methods such as interviews that solicit pre-service teachers' views on PCK.

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