

**PRACTITIONER CONCEPTIONS OF MATHEMATICAL KNOWLEDGE IN
EARLY CHILDHOOD DEVELOPMENT**

by

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A Thesis Submitted in fulfilment of the Requirement for the Degree

DOCTOR OF PHILOSOPHY

in

EARLY CHILDHOOD CARE AND EDUCATION

in the Department of Education

of the

University of the Free State

Bloemfontein, South Africa

2021

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ABSTRACT

The study explored practitioner conceptions of mathematical knowledge in Early Childhood Development (ECD) in the Oliver Reginald Tambo Inland District of the Eastern Cape Province. The study adopted a qualitative research design. Specifically, the study explored how practitioners of rural ECD centres use their conceptions of mathematical knowledge to enhance the learning of early mathematics in ECD settings. The study's theoretical underpinning was Pedagogical Content Knowledge (PCK), which was used to explore how early mathematical content and pedagogy were being utilised. The qualitative research design used was situated within an interpretivist paradigm. A purposive sample of five early childhood practitioners from five ECD centres in the OR Tambo Inland District, Eastern Cape Province, participated in the study. Semi-structured interviews and observations were used as data generation tools for the study. Data were analysed using thematic analysis in which themes were formed. There were also sub-themes that emerged from the themes. The findings of the study revealed that practitioners in the five ECD centres lacked a conception of mathematical knowledge in that they use traditional methods of enhancing early mathematics learning. This study amplifies the call for empowering practitioners with the knowledge of early mathematics curriculum, content and pedagogical knowledge, and cultural knowledge.

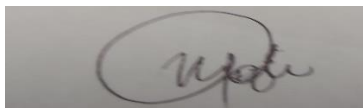
Keywords

Practitioners; early mathematics; mathematical knowledge; early childhood centres; pedagogical content knowledge

DECLARATION

I, Neliswa Gqoli, hereby declare that the thesis entitled: *Practitioner conceptions of mathematical knowledge in Early Childhood Development* is my original work, both in conception and execution. In addition, sources cited are acknowledged in the text, as well as in the list of references.

SIGNED:



DATE: 23/09/2021

ACKNOWLEDGEMENTS

The research towards the production of this thesis could not have been executed without the invaluable advice and words of wisdom from my informants, colleagues, my supervisor and co-supervisor. In particular, I am grateful to the following:

- ❖ Professor C.I. Okeke, my supervisor and Dr. C.S Ugwuanyi (postdoctoral fellow), my co-supervisor, for your advice, encouragement, patience and motivation when I most needed. It was not easy for any of us, but your positive and constructive comments served as motivation to push me towards the end of this project.
- ❖ I would like to record my appreciation to the Department of A, FP and EFE, Walter Sisulu, under the HOD Dr. Krexe, for the support, encouraging words, and your belief in my ability to complete this study.
- ❖ I would like to thank the Eastern Cape Department of Social Development for giving me the permission to conduct research in five ECD centres in the OR Tambo Inland District.
- ❖ I also express my gratitude to the centre managers and practitioners of the ECD centres that participated in the study for making it possible for me to conduct the research in their areas.
- ❖ My children, Sonwabile (Soso) and Qaqamba (Qaqa), for showing a passion for the completion of this research. I owe them my deepest gratitude.
- ❖ I would like to express my sincere gratitude to my church family under the leadership of Pastor P.P. Mdlokolo for their intense prayers and for being there for me when I was floundering during this journey.
- ❖ Finally, my indebtedness goes to God, my Creator, for being the source of my strength; without His helping hand, this study would not have been possible.

DEDICATION

This thesis is dedicated to my late mother, Angelina Novusile Gqoli and my children, Sonwabile and Qaqamba

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ABBREVIATIONS/ACRONYMS

CK	Content Knowledge
DBE	Department of Basic Education
DSD	Department of Social Development
ECCE	Early Childhood Care and Education
ECD	Early Childhood Development
ECPs	Early Childhood Practitioners
FoK	Funds of Knowledge
NAEYC	National Association for the Education of Young Children
NCTM	National Council of Teachers of Mathematics
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SMK	Subject Matter Knowledge

CHAPTER 1: OVERVIEW OF THE STUDY

1.1 INTRODUCTION

When South Africa entered a new era after the democratic elections in 1994, the education system was transformed and access to quality education was prioritised. Early Childhood Development (ECD) was recognised, and it laid a solid foundation for the improvement of quality basic education. The Department of Basic Education (2015) developed a National Curriculum Framework with the understanding that delays in cognitive and overall development before schooling can often have long-lasting and costly consequences for children, families, and society. Therefore, the most effective time for intervention is to lay a solid foundation in the early years (DBE, 2015). However, despite several interventions made by the DBE (2015), South African children continue to perform poorly in mathematics. Research and evaluation of mathematics education highlight the lack of foundational knowledge as one of the key factors for this poor performance (Feza, 2014). In addition, Sinyosi (2015), conducted a study on factors affecting grade 12 students' mathematical performance in Limpopo. The study's findings indicated a number of factors that contribute to low performance, one of which is a lack of a suitable mathematical foundation and background. This study explored practitioner conceptions of mathematical knowledge in the early childhood settings of the Oliver Reginald (OR) Tambo Inland District in the Eastern Cape Province.

The researcher visited some of the ECD centres in the OR Tambo Inland District, which is a rural and poverty-stricken region in the Eastern Cape Province. It became evident that most of the ECD centres in the district do not offer ECD programmes. The ECD programme includes the following fundamentals, literacy, mathematics, and life-skills, among others. Since this study focused on practitioner conceptions of mathematics, the researcher directed her attention towards the teaching of mathematics in these centres. Most practitioners in these centres were serving as volunteers, merely working as semi-skilled practitioners. The content knowledge gap in mathematics and lack of imparting skills became prevalent during these visits. These ECD centres were merely babysitting areas or serving as day-care centres,

rather than being educational environments. This ignited the interest of the researcher, because early childhood mathematics learning lays the foundation for future learning of all other subjects. Mathematical knowledge and understanding is a life-skill. The current situation certainly required further investigation into how the practitioners in this area apply the conceptions of mathematical knowledge to enhance learning and understanding of the subject.

1.2 BACKGROUND TO THE STUDY

The conceptions of mathematical knowledge have been under scrutiny in many parts of the world, such as the United Kingdom, the United States of America, New Zealand and Australia. Carrillo-Yañez, Climent, Montes, Contreras, Flores-Medrano, Escudero-Ávila, Vasco, Rojas, Flores, Aguilar-González, & Ribeiro (2018) define conceptions of mathematical knowledge as knowledge of content, knowledge of the topics, the interlinking systems which bind the subject, and how one proceeds in mathematics. They further state that knowledge of topics describes the *what* and *in what way* mathematics teachers know the topics they teach; it implies a thorough knowledge of mathematical content (e.g. concepts, procedures, facts, rules and theorems) and their meanings (Carrillo-Yañez et al., 2018). In addition, the understanding of mathematical properties and their underlying principles, particularly in relation to any work on a mathematical item, is the most significant component. However, little or nothing is mentioned about some other conceptions of mathematical knowledge in which children's cultural knowledge forms part.

Hoover, Mosvold, Ball & Lai (2016) mention that in the United Kingdom, the conception of mathematical knowledge is understood in terms of Shulman (1986), who stresses the combined knowledge of content and pedagogy. They argue that the most important contributions to teaching as a profession require professional knowledge of mathematics. They further reveal that the connection between the formal education of mathematics teachers and the content understanding is not straightforward. The teachers' formal mathematics education is not strongly linked to their learners' achievements, which indicates that this lack of linking of the two may lead to the underperformance of learners in mathematics.

Mazana, Montero, & Casmir (2019) state that a significant number of Tanzanian learners struggle with mathematics, despite the emphasis placed on the subject. This is evident in their poor performance during the national exams (Mazana et al., 2019). The high failure rate has severe consequences for the youth and the nation at large, as mathematics is not only important for acquiring academic qualifications but also prepares learners for the future (Mazana et al., 2019). Research conducted in Tanzania revealed that learners who fail mathematics face learning difficulties in the subject and other related courses at higher levels, particularly science, engineering, and business-related courses. Furthermore, Sa'ad, Adamu & Sadiq (2014), highlight that without mathematics, there is no science, without science, there is no modern technology, and without modern technology, there is no modern society. As a result of the poor mathematics performance, Sa'ad et al. (2014) are of the opinion that the Tanzanian education sector should emphasise building capacity of mathematics skills to foster development in science and technology for competitiveness and economic development of the country. While the mathematics issue in Tanzania appears to be glaring at higher levels, there is little or no mention of what is happening in ECD, which is the basis for future learning. This study's emphasis is on ECD, with the view that early mathematics learning and understanding predict future mathematics learning at higher levels.

In South Africa, the conceptions of mathematical knowledge are viewed as perceptions of roles, content knowledge, pedagogical knowledge, as well as children's capital and cultural knowledge. According to UNICEF & DBE (2010), self-perceptions of practitioner roles include observing children in their care, as well as planning and offering activities that will support children's developmental learning needs and interests. According to Chalmers & Crisfield (2019), every child and family who joins a setting will have their own knowledge and experiences that will link to their culture and wider family. Therefore, children's capital and cultural knowledge include knowledge gathered from the children's home surroundings. Regardless of the situation, practitioners should have substantial knowledge of quality teacher-child relationship ECD programmes, which will enable them to tap into the knowledge that children bring from their homes to scaffold their mathematics learning (O'Connor, 2010). Mofokeng (2018) asserts that practitioners should know how to infuse play into

learning to effectively develop mathematical skills. Such instructional practices require purposefully integrated experiences that provide practitioners with the opportunity to extend their mathematical and pedagogical understandings, as well as to create connections that facilitate the generation of new knowledge. This will also help improve the poor mathematics performance in the ensuing grades.

Moala & Hunter (2019) assert that research in Australia has shown that the development of "non-cognitive" factors, such as children's value of a subject, their confidence in their ability to learn, and their persistence through difficulty is a successful way of improving core mathematical skills. They further state that it is important for teachers to recognise that developing these non-cognitive factors is not a distraction from content, but rather a critical component of understanding mathematical content. Moala and Hunter (2019) also report that, despite recognising the importance of resilience, teachers often do not have access to a repertoire of practices to develop resilient learners, particularly in mathematics.

According to Wilson, McChesney & Brown, (2017) in New Zealand, teacher educators should also be knowledgeable beyond their subject areas. They should have knowledge and understanding of cultural aspects and cultural practices that are appropriate for the environment. Nelson & Guerra (2014) aver that a lack of cultural knowledge leads to a lack of understanding of intercultural interactions in the classroom; hence, teachers' cultural mathematical knowledge is important in assisting them in managing culturally diverse classrooms. Interestingly, the research by Wilson, et al. (2017) mentions little about the impact of cultural knowledge on children's mathematics teaching and learning in the ECD centres of New Zealand.

In the United States of America, Dooley (2019) found that teachers' mathematical knowledge is important in planning and implementing learning and teaching activities. Here, the emphasis is placed on primary school children's ability to cope with big and important mathematical concepts. Moreover, teachers' understanding of big ideas in children's mathematical learning is seen, especially in the US, as critical to the

development of young children's mathematical understanding (Dooley, 2019). Still, less is said on how teachers in the United States use their mathematical knowledge to help young children in the ECD centres cope with large and important mathematical concepts. Conceptions of mathematical knowledge are important, particularly for ECD practitioners, because mathematics is important not just in learning but in all practices. This can be accomplished when ECD practitioners recognise that children can have access to high-quality mathematics instruction and experiences in their early years. Parks & Wager (2015) state the importance of conceptions of mathematical knowledge in the United States of America as guides for early childhood practitioners to identify the particular knowledge, skills, and dispositions that teachers of young children need. In order to achieve this goal, practitioners need to be prepared to provide children with rich mathematical experiences that are aligned with knowledge of children's development across domains (Parks & Wager, 2015). Additionally, according to NAEYC (2010), conceptions of mathematical knowledge prepare early childhood practitioners in ways that disrupt the issue of poor mathematics achievement by teaching sufficient mathematical content for young children in ways that are intellectually relevant and mindful of their needs. Though early childhood educators are equipped with necessary skills to develop mathematics, little or nothing is mentioned about the effectiveness of these skills in the implementation of early mathematics with regards to young children in rural ECD centres.

Research carried out by Cohrssen & Tayler (2016) asserts that in Australia, conceptions of mathematical knowledge provide teachers in early childhood programmes with mathematical content knowledge and teacher self-efficacy. Additionally, the conceptions of mathematical knowledge empower teachers with skills to deliver high-quality, play-based education and care programmes that meet the current interests and learning needs of individual children, which prepare them for the transition to formal school education (Cohrssen & Tayler, 2016). Nevertheless, the researchers have not stated how mathematical content knowledge and teacher self-efficacy have been used in the development of mathematics in ECD centres in order to lay a solid foundation for mathematics learning in ensuing grades. Moreover, MacDonald & Carmichael (2018) mention that children begin to develop mathematical skills from a very young age, as babies and toddlers demonstrate competence

regarding a range of mathematical concepts and processes.

Moving in the same vein, MacDonald (2019) also reveals that many early childhood teachers in Australia are reluctant to engage in intentional teaching of mathematics due to limited awareness of mathematics with which children engage. This affects other parts of the curriculum and results in teachers' anxieties about their own mathematical knowledge taking prevalence. However, the key challenge is to promote teacher knowledge about early childhood mathematics in order to provide children with access to high-quality mathematics education (MacDonald, 2019).

Inadequately qualified teachers of mathematics and poor teaching methods are amongst the findings of the study conducted by Sa'ad, Adamu, & Sadiq (2014) on the causes of poor performance in mathematics in Nigerian Senior Secondary Schools. The importance of conceptions of mathematical knowledge is highlighted in the recommendations, which include the availability of qualified and properly trained mathematics teachers, as well as the use of child-centred approaches to teaching mathematics. The poor performance in higher grades is identified, and interventions are recommended to be made in those grades as well, but little or no mention is made about interventions in the field of early childhood development, which is likely to be the root of the problem.

One of the major problems in education in South Africa seems to be a lack of foundational knowledge in mathematics performance. According to Tlou & Feza (2018), conceptions of mathematical knowledge are crucial in a child's development, particularly throughout the years from birth to four years of age, which is when cognitive development connected to intellect, personality, and emotions occurs. The practices of using age-inappropriate games, educator centred teaching, and giving learners no options to select activities they prefer, are among the practices that do not enhance mathematics learning properly in young children (Tlou & Feza, 2018). The issue of the poor performance of learners in mathematics is also confirmed by Sinyosi (2015), who reveals several factors related to the poor performance of learners in mathematics. Among these factors is that learners are poorly prepared in the lower

grades for senior grades. Sinyosi's notion is supported by Kühne, Lombard & Moodley (2013), who argue that the performance gap of learners goes back to their early years of schooling before the reception class.

This study is aligned with the studies of the researchers above, but the focus will be switching to exploring how practitioner conceptions of mathematical knowledge are used to enhance mathematics learning in children in ECD. It is important that practitioners have a sound and solid consumption that will have an influence on children's understanding of mathematics. The researcher is not oblivious to factors that might allude to the poor performance of learners in mathematics, but there may be other factors that contribute to varying degrees. For the purpose of this research however, the focus is on the exploration of practitioner conceptions of mathematical knowledge in rural ECD centres of the OR Tambo Inland District in the Eastern Cape Province.

Numerous studies by Ebrahim, Seleti & Dawes (2013), Feza (2015), Martin (2015), & Daries (2017), reveal much about practitioner knowledge in general, but little is known regarding practitioner conceptions of mathematical knowledge in early childhood mathematics in rural ECD settings. Additionally, these studies do not discuss how practitioners use their conceptions of mathematical knowledge (moving from the known to the unknown) to enhance early mathematics in the OR Tambo Inland District, Eastern Cape Province. It is therefore necessary to explore this neglected area and, by so doing, address this gap in the existing literature. The OR Tambo Inland District consists of schools clustered according to their geographic location. ECD centres in the District are infused in the schools as Grade R. There are also other ECD centres that are independent and are non-governmental.

Since the advent of democracy, a great deal of attention has been drawn to the importance of ECD. Early Childhood Care and Education (ECCE) has remained a priority for South Africa (DBE, 2005). Radical transformative policies that focused on addressing past inequalities were developed. The DoE (2001) developed, amongst those policies, the Education White Paper 5, which states that approximately 40% of

young children in South Africa grow up in conditions of abject poverty and neglect. The democratic Government of South Africa wishes to eradicate inequalities among children by helping to break the cycle of poverty through increasing access to Early Childhood Development (ECD) programmes, and by putting an action plan in place to address the early learning opportunities of all children (DoE, 2001).

Awareness of the critical importance of early interventions has been increasing worldwide to ensure a good start in life and prevent loss of human potential. International agencies, such as the United Nations International Children's Emergency Fund (UNICEF) and the World Health Organization (WHO), highlight the importance of a healthy start in life. This includes the development and stimulation of an early environment in which the foundation for later psychological, social, and physical development can be laid (UNICEF, 2007). UNICEF's education approach was aimed at improving children's right to education in order to achieve the 'Millennium Development Goals' by 2015 (UNICEF, 2007). Despite several interventions made, ECD practitioners in rural OR Tambo Inland District seemed to not understand what is expected from them as far as mathematics teaching in the early years is concerned. Therefore, it is the interest of the researcher to explore the kind of knowledge these practitioners use to develop mathematical knowledge and interest in the ECD centres.

According to UNICEF (2005), the National Integrated Plan 2005-2010 (NIP) was released to address the past inequalities for the age group birth to four years old. The above policy supports a social justice agenda by focusing on universal, equitable access to a significant package of quality for ECD services (UNICEF, 2005). The Republic of South Africa (2015) also developed a National Integrated Early Childhood Development Policy. The policy states that the Government of the Republic of South Africa has prioritised ECD within its National Development Plan 2030: *Our Future - make it work*. According to RSA (2015), the National Integrated Early Childhood Development Policy is aimed at transforming Early Childhood Development service delivery in South Africa. In particular, to address critical gaps and ensure the provision of comprehensive, universally available, and equitable ECD services. The researcher observed that, although there are several policies that have been formulated to address the past inequalities, ECD practitioners of the rural OR Tambo Inland District

do not have a deeper understanding of child development and early education issues. Moreover, they do not have the capacity to provide quality educational experiences for all children, including those who are vulnerable and disadvantaged. Therefore, it is necessary to explore how they manage to enhance mathematics in their centres in such situations.

Apart from the policies, it is vital for practitioners to understand the importance of creating a centre that is conducive to learning. UNESCO (2009) is of the opinion that learning begins before children go to school. Therefore, ECD is particularly important as an instrument to build inclusive societies, including the development of rights-based, child-friendly centres that help children realise their rights. The above statement calls for a complete ECD centre that offers possibilities and chances for a variety of working instructional practises to ensure that no child is left out in the operations of the centre. Therefore, the support from the practitioners is essential, but support from the communities that are nearer to the centre is even more vital. It is for this reason that the researcher wishes to investigate how practitioners of rural ECD centres in the OR Tambo Inland District form partnerships with the parents and community of the children, with the aim of developing mathematics in their centres.

1.3 PROBLEM STATEMENT

Bruce (2010) states that children are born into a mathematical world and that their earliest interactions are mathematical as they explore shapes, spaces, and patterns of their world. Despite children being born with innate mathematical understanding, many children fail mathematics in higher grades. The underperformance of learners in mathematics is worrisome and therefore requires investigation of the root cause of the problem. ECD appears to be the first level to explore, as this is the fundamental level that may be able to provide answers to this problem. There are possibilities for solutions to emanate from the findings to address the problem of mathematics performance. Although underperformance of children is evident in higher grades, it is instructive to trace it back to the early years of children's learning by exploring the ways in which practitioners use their conceptions of mathematical knowledge in ECD settings, particularly how they tap into children's pre-knowledge. The primary reason

for this study is to establish whether the practitioners' conceptions of mathematical knowledge can develop children's mathematics learning for future success. Furthermore, this study investigated whether these conceptions are aligned with the Department of Basic Education's requirements as outlined in the National Early Learning and Development Standards for Children (NELDS) policy framework.

Kühne et al. (2013) aptly state that babies start to make sense of the world in mathematical ways from birth. They are able to recognise the difference between small numbers of objects and identify familiar shapes and patterns in their environment. Kühne et al. (2013) further mention that toddlers and young children continue to develop mathematical concepts through exploring objects with their mouths, tracking objects and people visually, and finding their fingers in order to suck them. These basic actions are important emerging mathematical insights for the growing child. Therefore, it is of utmost importance that ECD practitioners should have the knowledge and understanding of children's development and skills to support their learning of mathematics. When practitioners are equipped with mathematical knowledge, they are able to empower children to gain a better chance of fulfilling their academic potential in their future learning of mathematics. Based on the above opinion, the researcher was motivated to explore whether practitioners in ECD centres in the OR Tambo Inland District use their conceptions of mathematical knowledge and skills in a proper way to develop mathematical concepts in children.

1.4 RATIONALE FOR THE STUDY

Selmi (2015), reveals that mathematical skills do not only concern learning numbers and methods of linking them. A significant part of early mathematics focuses on gaining a broad understanding of ideas that help young children link concepts, learn critical reasoning, and analyse experiences in their environment. This suggests that mathematics in children might not be a problem, as they apply the mathematical knowledge they gain from the early childhood level to other similar situations in higher grades. Nevertheless, most learners in higher grades fail mathematics, especially in the Eastern Cape Province, prompting the need for a strong foundation in learning mathematics in earlier grades.

This underperformance in higher grades suggests that there is more that needs to be done in using practitioner conceptions of mathematical knowledge and children's mathematical knowledge to prepare children for ensuing grades. It is the researcher's interest to investigate where things went wrong, starting in early childhood, which is the foundation. The researcher aims to accomplish this by exploring the ways in which practitioner conceptions of mathematical knowledge are used in the teaching of mathematics in rural ECD centres of the OR Tambo Inland District in the Eastern Cape Province.

1.5 AIM OF THE STUDY

The aim of this study is to explore how early childhood practitioner conceptions of mathematical knowledge enhance children's learning in mathematics in selected ECD centres in the OR Tambo Inland District of the Eastern Cape Province.

1.5.1 Specific objectives

In order to achieve this aim, the researcher envisaged to:

- Understand the meaning ECD practitioners ascribe to mathematical knowledge;
- Understand why knowledge of children's mathematical knowledge development matters within the ECD learning of mathematics;
- Understand the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics;
- Explain the kind of mathematical knowledge ECPs draw on to develop early mathematics;
- Explore ECPs' use of the mathematical knowledge in the development of early mathematics;
- Establish the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning;

- Highlight some of the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children; and
- Enable a new understanding of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge.

1.6 RESEARCH QUESTIONS

The main research question of this study is:

- How do early childhood practitioners' conceptions of mathematical knowledge enhance children's learning in mathematics?

1.6.1 Sub-research questions

The following critical sub-research questions inform the exploration of the main research question and the analysis of data:

- What meaning does ECD practitioners ascribe to mathematical knowledge?
- Why does the knowledge of children's mathematical knowledge development matter within the ECD learning of mathematics?
- What is the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics?
- What kind of mathematical knowledge do Early Childhood Practitioners (ECPs) draw on to teach early mathematics?
- How do ECPs use mathematical knowledge in the development of early mathematics?
- What are the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning?
- What are the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children?
- What are the new understandings of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge?

1.7 SIGNIFICANCE OF THE STUDY

The findings of the study may aid practitioners in using their conceptions of mathematical knowledge, together with children's knowledge, to create a scaffold for developing and connecting mathematical content knowledge. Practitioners might understand various ways of applying their mathematical knowledge to develop mathematics in the ECD setting, and also see the need to upgrade their qualifications to broaden their content knowledge.

The Department of Education can be made aware of the current situation in rural ECD centres regarding the learning of mathematics. This will necessitate the provision of support and intervention to improve the underperformance in mathematics. Practitioners will understand the importance of the availability of conceptions of mathematical knowledge when implementing mathematics in ECD learning environments. The study aims to generate a model that could assist in counteracting the underperformance in mathematics by finding various ways in which practitioners can use their developed conceptions of mathematical knowledge to successfully develop mathematics in ECD centres. This study adopted the Pedagogical Content Knowledge (PCK) theory; therefore, the expected findings can assist in the alignment of mathematical content knowledge with the instructional practises (pedagogy) suitable for young children.

1.8 DELIMITATION OF THE STUDY

The study explored how early childhood practitioners use their conceptions of mathematical knowledge to enhance early mathematics in the OR Tambo Inland District, Eastern Cape Province. The study was limited to early childhood practitioners. Practitioners are involved because they are well-positioned to give feedback on how they use knowledge, experiences, and understanding of children in enhancing early mathematics. The study focused on rural ECD centres in the OR Tambo Inland District.

1.9 DEFINITIONS OF OPERATIONAL CONCEPTS

Early Childhood Development Practitioners

According to DBE (2009) ECD practitioners are persons who provide early childhood development (ECD) services through formal ECD programmes, family services and playgroups, and training, as well as those providing management support services to these workers

Conceptions

Conceptions are defined by Sumper (2015) as meanings, understandings, conscious or subconscious beliefs, perspectives and mental images of mathematics, in which teachers understand and emphasise the application of knowledge gained or transferability.

Mathematical knowledge

Zazkis & Leikin's (2010) define mathematical knowledge as the mathematical content knowledge learned as the result of undergraduate coursework from colleges or universities as part of a mathematics teacher preparation program.

Early Childhood Development

According to the Department of Education (2001), the term Early Childhood Development (ECD) is an umbrella term for the education of children from birth to nine years of age in order to allow them to grow and to thrive physically, mentally, emotionally, spiritually, morally, and socially. ECD is a highly diverse field that serves children from birth through age nine, and during these years, children participate in many different kinds of care and education settings.

1.10 PRELIMINARY LITERATURE REVIEW

1.10.1 Introduction

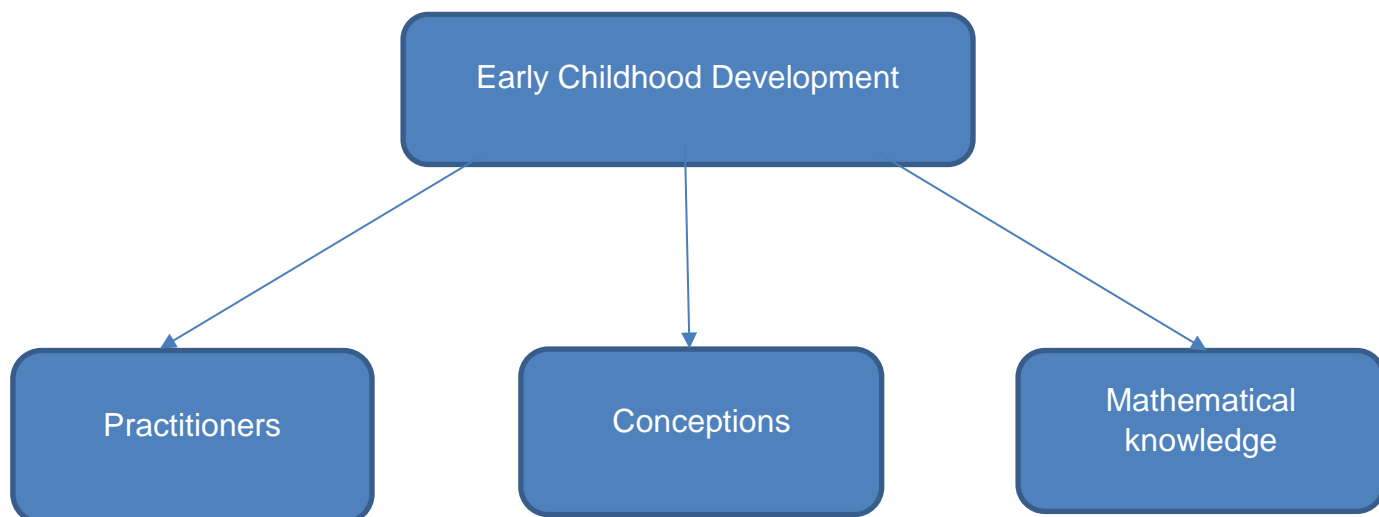
A range of relevant literature to the study was reviewed to place the study in perspective. The literature included information from pioneering researchers and scholars in the field relating to practitioners' conceptions of mathematical knowledge.

A conceptual framework and sub-headings from the research objectives were used to review relevant literature. These include:

- The meaning of mathematical knowledge;
- The knowledge of children’s mathematical knowledge development;
- The importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children’s learning of mathematics;
- Types of mathematical knowledge that enhance the development of early mathematics;
- Uses of mathematical knowledge in the development of early mathematics;
- Challenges confronting ECD practitioners that impact their abilities to adequately conceptualise mathematical knowledge; and
- Some intervention strategies to enhance the practitioners’ ability to conceptualise mathematical knowledge within the ECD context.

In addition, the theoretical framework that underpins this study is also discussed.

Figure 1.10.2: The concepts for the study created by the researcher



In ECD, practitioners are advocates for learning; hence, they should have a clear understanding of what mathematical knowledge is for the effective development of

children's mathematics. The DBE (2015) states that a reflective ECD practitioner facilitates learning and also observes all children in their care, offering activities that support their developmental learning needs and interests. Furthermore, practitioners should have conceptions of mathematical knowledge, which includes providing activities or creating learning environments (Lerman, 2014). These activities offer young children experiences aimed at stimulating the development of mathematical skills and concepts. Early childhood practitioners are professionals, which means that they make decisions based on a specialised body of knowledge, continue to learn throughout their careers, and are committed to providing the best care and education possible for every child (DBE, 2015).

Practitioner knowledge of ECD programmes enables them to design and develop activities that are conducive to both indoor and outdoor play in a healthy environment for children. ECD programmes are defined by the DBE (2015) as planned activities designed to promote the physical, mental, emotional, spiritual, moral and social development of children from birth to nine years. Moreover, these programmes are important in the development of a conducive and safe learning environment. Practitioners should therefore undergo proper training to provide quality mathematics development.

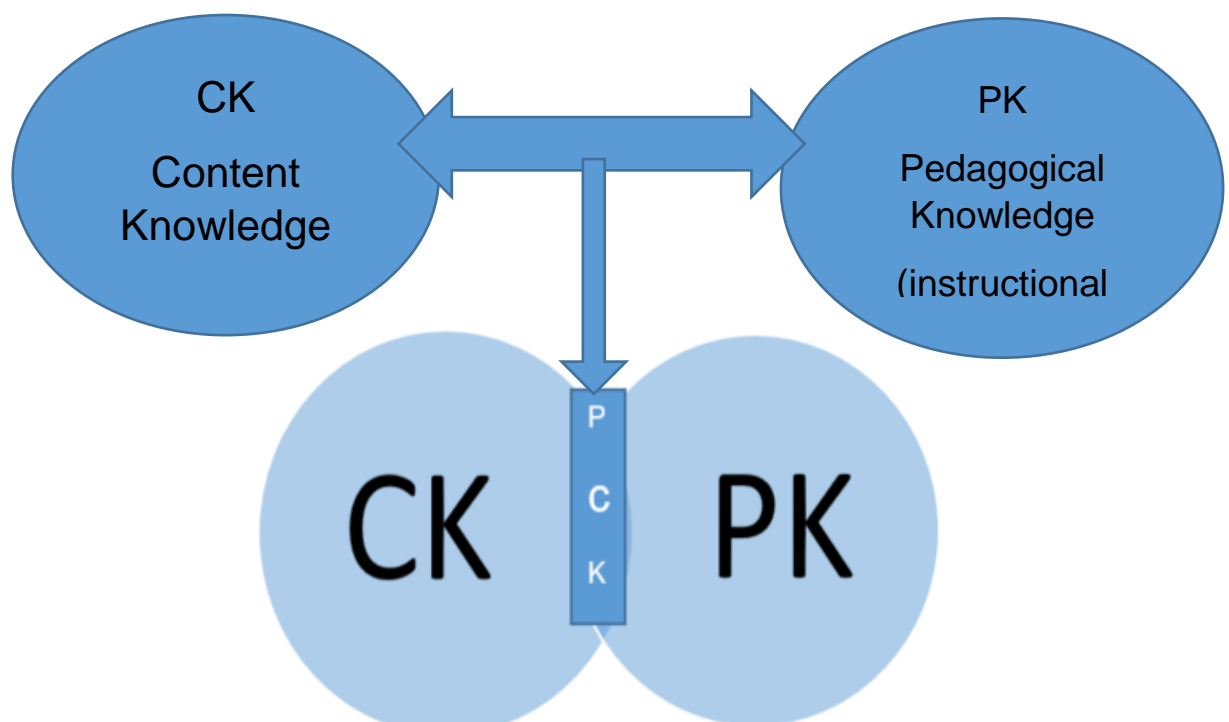
The learning environment, as explained by Bullard (2010), is an area that affects the moods, ability to form relationships, and effectiveness in work or play. In addition, the early childhood group environment plays a crucial role in children's learning and development. According to the DBE (2015), the learning environment consists of an indoor, outdoor, and conducive environment in which children develop and learn. The early childhood group environment plays such a strong role in children's development because of the amount of time children spend in these environments. Many children spend a large portion of their wakeful hours in early childhood group settings. Hence, the early childhood environment that the child enters should reflect the practitioner's idea (philosophy), values, and beliefs about children and learning through deliberate design by providing messages to all those entering, including children, parents, and staff.

1.10.2. Theoretical framework

The theoretical framework that underpins this study is Pedagogical Content Knowledge (PCK), which is a theory developed by Shulman (1987). PCK is defined as the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of children, and presented for instruction (Shulman, 1987). Shulman's proposed definition of PCK implies that it is a combination of early mathematics content and pedagogy (instructional practices). Shulman (1987) further refers to PCK as a combination that is unique to the field of practitioners, their own special form of professional understanding.

The study's theoretical understanding of PCK is based on the assumption that practitioners' self-perceptions of their subject-matter knowledge (early mathematics) plays a key role in how well or poorly they can apply early mathematics curriculum in ECD centres (Sintema & Marbán, 2020). The study applies PCK because it encompasses the foundations of knowledge that practitioners should possess in order to successfully teach mathematics to young children. Shulman (1987) also suggests combining the two categories of knowledge (pedagogical and content knowledge), which in this study are mathematical content knowledge and the instructional practises for young children. Many researchers have used Shulman's theory of pedagogical content knowledge in various ways, including: Evens, Elen & Depaepe (2015), Melo, González-Gómez & Jeong (2020), and Jacob, John & Gwany (2020).

Figure 1.10.3: Pedagogical content knowledge (Mishra & Koehler, 2006)



Mishra & Koehler (2006) mention that PCK exists at the intersection of content and pedagogy, as it goes beyond a simple consideration of content and pedagogy in isolation from one another. At the heart of PCK is the manner in which subject matter is transformed for teaching, which occurs when the practitioner interprets the subject matter and finds different ways to represent it and make it accessible to children. At the same time, pedagogical content knowledge is of importance because it classifies the unique bodies of knowledge for instructional practises (mathematics content and instructional practices). PCK signifies the combination of content and pedagogy into an understanding of how particular early mathematics topics, problems, or issues are organised, represented, and adapted to various interests and abilities of children and presented for instruction. Magnusson, Krajcik & Borko (1999) define pedagogical content knowledge as a practitioner's understanding of how to help children understand a specific subject matter. Therefore, practitioners need to have certain skills and personalities in their interactions with children or families.

1.10.3 Review of related empirical studies

This part of the study deals with reviewing studies that are based on observations or experiences of the researchers. The review of related empirical studies was directed by the specific objectives that informed the formulation of the following subheadings:

- The meaning of mathematical knowledge;
- The knowledge of children's mathematical knowledge development;
- The importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics;
- Types of mathematical knowledge that enhance the development of early mathematics;
- Uses of the mathematical knowledge in the development of early mathematics;
- Challenges confronting ECD practitioners that impact their abilities to adequately conceptualise mathematical knowledge;
- Some intervention strategies to enhance the practitioners' ability to conceptualise mathematical knowledge within the ECD context; and
- Enable a new understanding of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge.

1.10.4 Summary of preliminary literature review

Literature related to practitioner conceptions of mathematical knowledge in developing mathematics has been reviewed, starting with a conceptual framework that includes the relationship among the important concepts of the study. Reflections on the theoretical framework that informs the study have been made to indicate the relationship between content knowledge (mathematical knowledge) and knowledge of pedagogy (instructional practices). The literature on related empirical studies has been reviewed in which similarities and distinctions between the studies, including this one, are identified. What practitioners should include in their conceptions of mathematical knowledge is specified. These conceptions of mathematical knowledge will assist practitioners in enhancing mathematics in ECD effectively.

1.11 RESEARCH METHODOLOGY

1.11.1 Introduction

This chapter highlights the methodology used in the study. It includes the research paradigm; the research approach; research design; study site; participant selection; data collection instruments; ethical considerations; the procedure for data collection and data analysis; discussions; and finally, recommendations and conclusion.

1.11.2 Research paradigm

The study is underpinned by the interpretivist paradigm. According to Saunders, Lewis & Thornhill (2012), interpretivism is a paradigm which assumes that reality is subjective and can differ considering different individuals. In this study, the advantage of using the interpretivist paradigm is that the researcher is able to collect rich data with descriptions in which the participants developed subjective meanings of their experiences (Creswell, 2018).

1.11.3 Research approach

This study used a qualitative research approach. McMillan & Schumacher (2014) describe the qualitative research approach as an analysis of people's individual and collective social actions, beliefs, thoughts, and perceptions. This approach is used in

the study to get descriptive information of how practitioners used their conceptions of mathematical knowledge through interpreting the participants' feelings, experiences, and actions in human terms, rather than statistical presentations (Terre-Blanche, Kelly & Durheim, 2010). This approach may help the researcher to establish the meaning of a phenomenon (mathematical knowledge) from the views of participants (Creswell, 2018).

1.11.4 Design of the study

The study used a multiple case design to explore how early childhood practitioner conceptions of mathematical knowledge are used to enhance children's learning in ECD centres of the OR Tambo Inland District, Eastern Cape Province. According to Creswell (2018), a multiple-case study design explores a real-life multiple bounded system through detailed data collection involving multiple sources of information. In this study, the researcher collected multiple views of the participants concerning practitioner conceptions of mathematical knowledge.

1.11.5 Study site

The study sites for the research include five (5) rural ECD centres, which were conveniently selected. Creswell (2018) advises that it is important to select sites that are information-rich. The five (5) ECD centres selected were believed to be information-rich sites.

1.11.6 Participants' selection

The population of the study is a group of practitioners from the five (5) selected ECD centres. The study used purposive sampling, which is defined by Pietersen & Maree (2016) as sampling that allows the researcher to make a "judgement" and select criteria to identify the most appropriate participants. The participants for the study include one practitioner from each of the five (5) centres selected as information-rich participants related to the phenomenon of interest (practitioner conceptions of mathematical knowledge), making a total of five (5) practitioners (purposive sampling).

1.11.7 Instruments for data collection

- **Interviews**

Semi-structured interviews with five early childhood practitioners were used to understand how practitioners use conceptions of mathematical knowledge to develop mathematics in young children within its real-life contexts (Nieuwenhuis, 2016b). According to Creswell (2018), a semi-structured interview is a data collection tool in which the researcher poses questions to and records answers from only one participant in the study at a time. Probes were used as encouragement to fill in details and gain clarification to address the specific objectives (Nieuwenhuis, 2016b).

- **Observations**

This study also used observations to collect information about events occurring at the centres, including how practitioners use their conceptions of mathematical knowledge to enhance early mathematics in the classroom. Moving with the same view, McMillan & Schumacher (2014) state that observations are a way for the researcher to see and hear what is occurring naturally in the research site. An observation schedule was developed prior to the observations

1.11.8 Instrument credibility, triangulation and trustworthiness

Credibility triangulation is used to enhance trustworthiness. Triangulation is defined by Wilson (2014) as the use of more than one particular approach when doing research in order to get richer, fuller data, and/or to help confirm the results of the research. McMillan & Schumacher (2014) also describe triangulation as the cross-validation among data sources, data collection strategies, time periods and theoretical schemes. Triangulation was enhanced through the use of semi-structured interviews and observations. The findings are therefore based on the participants' responses.

1.11.9 Data collection procedures

During data collection, the researcher respected the autonomy of the ECD centres involved, the authority of the departments, including the Department of Social

Development, as well as the authority of the centre managers of the respective ECD centres.

The study used face-to-face interviews and observations to collect data on how practitioner conceptions of mathematical knowledge are used to develop mathematics in ECD classrooms. An interview guide with questions related to the phenomenon of the study was used (Creswell, 2018). During the interviews, a tape recorder was used to collect data, and probes were made in order for participants to provide further information. After completion of the interviews, the participants were given the opportunity to ask questions and get some clarification regarding the study. The participants were thanked for their time, contributions, and for agreeing to take part in the research.

During observations, the focus was based on interactions that occurred during the enhancement of mathematics by practitioners. The researcher was a non-participant observer when exploring how practitioner conceptions of mathematical knowledge to enhance early mathematics were used in the five ECD centres. The researcher sat at the back of the classroom, taking field notes describing classroom activities. An observation schedule was used for this purpose.

1.11.10 Data analysis procedures

The study used thematic analysis to identify patterns or themes within qualitative data (Braun & Clarke, 2013). Thematic analysis, as stated by Creswell (2018), is the method in which data are transcribed into segments, followed by codes, categories, and themes. The data were analysed using thematic analysis as outlined by Creswell (2018) in the following three steps:

Step 1: Organising the data and defining the code.

Step 2: Developing the categories and codes.

Step 3: Developing themes and sub-themes.

1.12 ETHICAL CONSIDERATIONS

Creswell (2018) states that researchers need to protect their research participants, develop trust with them, promote the integrity of the research, and guard against misconduct and impropriety that might reflect on their organisations or institutions. Ramrathan (2017) maintains that access to research sites is a controlled activity. Therefore, without prior official approval, researchers are not permitted to access a test site and perform research. The researcher ensured that a series of ethical protocols were in place to guarantee that the research process was ethical. The protocols included participants' rights, informed consent, maintaining professionalism, confidentiality, protection from harm, achieving anonymity, and participants' vulnerability.

1.13 ORGANISATION OF CHAPTERS

Chapter 1: Chapter one provides an orientation of the study. This includes the background, problem statement, research questions, aims and objectives, preliminary literature review and theoretical framework, and the methodology.

Chapter 2: Chapter two reviews a range of literature relevant to the focus of the study, which helped in placing the study in its prospective context. The theoretical framework underpinning the study is also discussed in detail.

Chapter 3: Chapter three outlines the research design and research methodology used to examine the research problem.

Chapter 4: Chapter four focuses on the presentation and discussion of the qualitative results according to the key theme, as well as the sub-themes.

Chapter 5: In chapter five, the researcher discusses the findings in detail.

Chapter 6: In this chapter, the researcher provides the findings, recommendations, and general conclusions. This includes a summary of the main findings in respect to the research questions provided. The researcher reflects on the gaps identified, and finally, general conclusions informed by the findings are presented.

1.14 CHAPTER SUMMARY

In this chapter, the introduction provides the context of the study. In the background, the focus of the research study is stated in which the situation of ECD centres in the OR Tambo Inland District, Eastern Cape Province is revealed. The reader is also provided with a review of the literature that relates to practitioner conceptions of mathematical knowledge. The chapter includes the problem statement and reasons for conducting the research. The conceptual and theoretical frameworks on which the study is grounded are discussed. The research methodology, which explains how data was collected and analysed, including ethical considerations that were observed when collecting the data, is provided. The manner in which findings were generated from the data is also discussed, followed by recommendations and general conclusions informed by the findings. Finally, the chapter is concluded by providing an overview of the thesis to reveal the interconnection between the various chapters.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter consists of a review of some of the relevant literature with respect to practitioner conceptions of mathematical knowledge in early childhood development. It commences with a conceptual framework in which key concepts related to practitioner conceptions of mathematical knowledge are examined to clarify their use in the study. The literature review helps to identify the relationship between the concepts. Thereafter, reflections are made on the theoretical framework adopted by the study, which is Pedagogical Content Knowledge (PCK). How PCK guides the research study in exploring practitioner conceptions of mathematical knowledge in early childhood development is discussed. The theoretical framework is elaborated upon, explaining the connection between content knowledge and pedagogical knowledge as mathematical knowledge practitioners should possess for the development of mathematics in ECD. This is based on the assumption that content knowledge and pedagogical knowledge cannot be separated, and that the manner in which subject matter is transformed for teaching is at the heart of PCK (Mishra & Koehler, 2006). Furthermore, the evaluation of literature is examined using sub-headings drawn from the study's objectives. The chapter is concluded with a summary of a preliminary literature review.

2.2 THEORETICAL FRAMEWORK

According to Osanloo & Grant (2016), a theoretical framework is the foundation from which all knowledge is constructed (metaphorically and literally) for a research study. The theoretical framework provides a grounding base, or an anchor, for the literature review and, most importantly, the methods and analysis (Osanloo & Grant, 2016). The theoretical framework has an important role in directing the researcher in the theory to be used, providing insight into understanding the phenomena to investigate. In relation to this study, the phenomena of investigation included practitioner conceptions of mathematical knowledge in developing mathematics in early childhood centres.

As mentioned earlier, the theoretical framework that grounded this study is Pedagogical Content Knowledge (PCK) by Shulman (1986). Shulman (1987) stated that PCK is a special combination of early mathematics content and pedagogy, a combination that is unique to the field of practitioners in ECD and their own special form of professional understanding. Fariyani, Mubarak, Masfu'ah & Syukur (2020) define Pedagogical Content Knowledge (PCK) as the portrayal of a teacher to teach a subject in understanding the content material, skills, curriculum related to the material, and appropriate method to teach accurately. Furthermore, Alimuddin, Tjakraatmadja & Ghazali (2020) state that PCK was first introduced by Shulman in 1986 as the type of teachers' knowledge that combines the teachers' mastery of content and pedagogical knowledge.

Shulman (1987) further describes PCK as the practitioner's interpretations and transformations of subject-matter knowledge in the context of facilitating student learning. It is therefore evident that the inclusion of knowledge of children, knowledge of educational context, and knowledge of instructional practices is of importance. PCK in mathematics should be transformed in such a way that practitioners' subject-matter knowledge (SMK) is appropriate for instructional practices in the mathematics classroom (Shulman, 1987). In addition, practitioner conceptions of mathematical knowledge of how to represent the concepts, methods, and rules of the subject (mathematics) should be part of the transformation. Knowing mathematics for instructional practises involves more than knowing mathematics for oneself. Thus, practitioners should have a proper understanding of mathematical concepts and how to perform procedures correctly. This can be done through an understanding of the conceptual basics of mathematics and how to relate cultural concepts to mathematics and children's learning. Simply put, practitioners should not only possess academic knowledge of mathematics, but should also be able to impart it in an understandable manner. It is vital that the vehicle of the practitioner's beliefs and knowledge ought to be clear and vibrant to the child. Many researchers have used Shulman's concept of pedagogical content knowledge in various ways to fill the gaps identified in Shulman's study of knowledge required for teaching.

This study uses PCK as a theoretical framework because its focus is on knowledge of mathematics. Since practitioners play a major role in children's understanding and achievement, it increases the importance of their professional development activities that enrich the teachers' knowledge and skills. The framework of the study also elaborates on how practitioners use PCK components, which include mathematics content knowledge and pedagogical knowledge concurrently, in order to make the topic being taught more understandable to children. As a knowledge base for teaching, pedagogical content knowledge (PCK) by Shulman (1986) is used as a theoretical framework for investigating how practitioners understand and use their knowledge of mathematics in the rural ECD centres of the OR Tambo Inland District.

Pedagogical content knowledge theory is relevant to the study because it provides an analytical lens and serves as a guide to make sense of the data to be generated. Through the use of PCK, the study also answers research questions and elaborates on how practitioners use content knowledge (mathematics) together with pedagogical knowledge (instructional practices), providing activities that developed skills for children's future learning. Shulman (1986) further states that pedagogical knowledge means the "how" of teaching, generally acquired through education coursework and personal experiences; whereas content knowledge is the "what" of teaching. It differs from the knowledge of a disciplinary expert and from general pedagogical knowledge. In Shulman's view, pedagogical content knowledge is a form of practical knowledge that is used by practitioners to guide their actions in highly contextualised ECD settings. PCK illustrates how the subject matter of a particular discipline is transformed for communication with learners.

The subject matter in this study includes mathematics content, of which practitioners should have a deep understanding; whereas pedagogy encompasses instructional practises, which practitioners use to enhance mathematics in early childhood settings. Shulman (1986) identifies several key elements of pedagogical content knowledge, which comprise: knowledge of representations of subject matter (content knowledge); understanding of learners' conceptions of the subject; learning and teaching implications that are associated with the specific subject matter; and general

pedagogical knowledge (instructional practices). To complete what he called “the knowledge base for instructional practices”, other elements mentioned include curriculum knowledge, knowledge of educational contexts, and knowledge of the purposes of education. Shulman (1987) stresses that, in mathematics, PCK should be transformed in such a way that practitioners’ subject-matter knowledge (SMK) should be appropriate for instructional purposes in mathematics in early childhood settings.

PCK was introduced by Shulman (1986) as a possible answer to the so-called “missing paradigm” in research and practice in teaching. Teaching was either approached by only focusing on content or by exclusively focusing on pedagogy. Shulman (1986) first described PCK as a separate knowledge base where both content and pedagogy are combined to create professional knowledge, specifically for teaching. Furthermore, he elaborated on many practices a teacher with PCK could accomplish, which include clarifying materials, making representations, and navigating student difficulties. He introduced a special blend of content and pedagogy that is unique to the field of teachers, including their own special form of professional understanding. Theorists like Mishra and Koehler (2006) recognise that content knowledge and pedagogical knowledge cannot be separated. They further mention that, at the heart of PCK, is the manner in which subject matter is transformed for teaching, which occurs when the practitioner interprets the subject matter and finds different ways to present it and make it accessible to children.

Other theorists study PCK in different fields. Ward & Ayvazo (2016) use PCK in physical education and view PCK as being informed and influenced by teachers’ knowledge of children, knowledge of pedagogy, knowledge of curriculum, knowledge of context, and knowledge of content. This position is strongly influenced by Shulman’s (1987) conceptualisation of PCK. In physical education Ward & Ayvazo (2016) opine that knowledge of children includes how children learn, their developmental characteristics, characteristics of their culture, and what a practitioner has learned from previous children. Metzler (2011) explains that knowledge of pedagogy includes not just the basic pedagogies such as class control, class organisation, and instructional techniques, but also overlaps with knowledge of curricula like knowing

play pedagogies, cooperative learning models, or the sport. In addition, knowledge of context includes knowledge of the resources that are available and the socio-cultural context of the community in which the centre is located, district policies, and standards for learning that are established by the district and the state. Content knowledge, as a knowledge base that informs PCK, can be differentiated into two sub-domains (Ward, 2009). Content knowledge (CK) refers to knowledge of the technique as well as the tactics of a movement and the rules governing its performance (Ward, 2009).

Melo, González-Gómez & Jeong (2020) conducted a study on exploring pedagogical content knowledge (PCK) of physics teachers. The success of PCK is seen in the findings, whereby categories such as knowledge about the curriculum and teaching strategies, evolved after the intervention program. This is in contrast with knowledge about evaluation and pupils, which allows for progression towards a teaching and learning process and is more focused on innovative tendencies. Jacob, John & Gwany (2020) also explored teachers' pedagogical content knowledge and learners' academic achievement by measuring teachers' knowledge. The findings revealed that existing educational production function research could be limited in its conclusions, not only by the magnitude of effects that teachers' knowledge has on children's learning, but also about the kinds of teacher knowledge that matters most in producing learners' learning outcomes. Teachers were expected to process and evaluate new knowledge relevant for their core professional practice and to regularly update their profession's knowledge base.

Kunter, Klusmann, Baumert, Richter, Voss & Hachfeld (2013) confirmed that teachers' PCK had a positive effect on student motivation. Hence, to improve the quality of education, investing in prospective teachers' PCK seems to be a good strategy. Moreover, the pedagogical content knowledge (PCK) in ECD is different from that of subject specialists, because it includes play in its curriculum. The researcher is of the opinion that the speciality of practitioners in ECD is in the development of young children, especially in the areas of language, literacy, science, and mathematics. In ECD centres, the application of PCK in mathematics is expected to provide practitioners with the knowledge of how to present the concepts, methods, and rules of the subject (mathematics) to create appropriate learning for babies, toddlers, and

young children and how to evaluate their progress (DoE, 2015). However, practitioners' mathematics knowledge should not only comprise knowing mathematics for themselves, but also have a suitable understanding of how to perform rules correctly for the aim of developing children. Therefore, practitioners should have knowledge and understanding of play as pedagogy for learning used in ECD to enhance mathematics.

Shulman's PCK model also assumes that practitioners in ECD centres should possess both mathematical content knowledge and pedagogical knowledge for them to effectively develop mathematics in children. Furthermore, PCK in practitioners is capable of bringing an understanding that children need interaction and guidance at home and in the centre. Children's interaction with practitioners and other children, both at home and in the centre, make them acquire new knowledge. The newly acquired knowledge changes the behaviour, as children have adopted ideas of others. Practitioners should guide and lead children until they reach the stage where they can reach achievements without being helped (Zone of Proximal Development) (Vygotsky, 1962). In order for practitioners to lead children to their Zone of Proximal Development, they should have a deeper understanding of mathematical content knowledge and pedagogical knowledge. Mofokeng (2018) is of the opinion that practitioners' use of theory (PCK) helps to conceptualise learning communication, promote interpersonal relationships between practitioners and children, helps practitioners to implement professional ethics, and exerts an impact on how they regard themselves.

Hussain (2012) emphasises the provision of opportunities by practitioners to produce children that have their own judgements and interpretations of situations (they come across) based on their prior knowledge and experience. In order for practitioners to provide these opportunities, they should have mathematical knowledge together with pedagogical knowledge, and to understand that children come to the centre having mathematical knowledge from their environments. There must be an understanding that tapping into the minds of the children when enhancing mathematics is vital.

Feza (2012) also conducted a study on early childhood (0-4 years old) practitioners' views on how children learn mathematics. In the study, eighteen practitioners from ECD centres across the different socio-economic backgrounds of Durban in KwaZulu-Natal were selected as participants. Data were generated through the use of a questionnaire to explore how young children learn mathematics. The data analysis was done quantitatively using frequencies, and qualitatively for an in-depth description of the practitioners' views and practices. The findings of the study reveal that most practitioners believe that young children need to be exposed early on to mathematics learning. In addition, practitioners from affluent ECD centres showed a sound knowledge of numbers compared to their counterparts from disadvantaged communities. However, knowledge of shapes challenges all groups, regardless of their background. Discovery learning and mediated learning are pedagogical approaches selected by practitioners, the latter being a preference of practitioners from disadvantaged ECD centres and the first option from affluent centres.

The study is similar to this one based on the context, which includes ECD centres, and in content, which is children's mathematics learning. Both studies have practitioners as information-rich participants. However, the studies differ in their data generation tools and methods of data analysis. Feza (2012) used a questionnaire to generate data and quantitative analysis in which frequencies were used, then qualitative analysis for an in-depth description of the practitioners' views and practices on how young children learn mathematics. The current study uses interviews and observation to generate data, then thematic analysis to analyse data on practitioner conceptions of mathematical knowledge in rural ECD centres of the OR Tambo Inland District in the Eastern Cape Province. Another important difference is that the former study was conducted in both affluent and disadvantaged centres of KwaZulu-Natal; whereas the current study takes place in the rural centres of the Eastern Cape Province. Feza (2012) emphasises the views of practitioners on how children learn mathematics. However, very little is revealed about conceptions of mathematical knowledge practitioners should possess to enhance children's mathematics learning, especially in rural centres.

Feza (2012) also states that for young children to learn mathematics, practitioners should be able to organise the classroom environment and learning activities in particular ways, understanding that particular styles of interactions between adults and children, and between the children themselves, are critical. These factors can make an important contribution in helping children to become independent and self-regulated learners. Hence, practitioners should plan small group sessions in which they will ensure that mathematics has a meaningful context and purposes that children can understand. For this particular study, the researcher is interested in exploring how practitioners in the OR Tambo Inland District, Eastern Cape Province, use their conceptions of mathematical knowledge to organise a conducive environment for mathematics learning activities to enhance broad, high-quality instructional practices which serve as a sound foundation for later learning in mathematics.

Another study conducted by Martin (2015) focused on making visible literacy a social practice in early childhood centres in the Free State Province, South Africa. The study adopted a qualitative research approach in which a purposive sample of two early childhood teachers of children between the ages of three and four years in two early childhood centres was used. Observation, interviews and Foucault's genealogical tools were used to generate data on making visible literacy a social practice in early childhood centres. The findings of the study revealed that teacher-directed and child-initiated pedagogical practices were considered best practice for enhancing child development and learning. Additionally, the discourse of play was rationalised as being important for both the development and learning of young children. However, both the teachers structured play differently, and this was as a result of the context within which teaching and learning occurred.

Martin (2015) embraces similar features to this study because of their context, which includes ECD centres. Both studies use practitioners that are selected as information-rich participants. However, the point of departure in Martin's study and this study lies in the issue of their content. Though both studies are conducted in ECD settings, the disciplines on which the researchers focus are different, and include literacy and mathematics. Moreover, both studies use a qualitative approach in which observations

and interviews are used as data-generating tools. However, the former study also used Foucault's genealogical tools as an additional tool for generating data. Furthermore, the findings of Martin's study places emphasis on pedagogical practices that are considered best practice for enhancing child development and learning, focusing on the field of literacy. Nothing is stated about the importance of these pedagogical practices in the discipline of mathematics.

A study on promoting quality learning environments at ECDs through service learning was conducted by Labuschagne (2015). This was a qualitative study conducted in rural districts of Potchefstroom. Two ECD centres in Potchefstroom, North-West Province, were purposefully chosen to be observed. The study used observations, semi-structured interviews, focus groups, and reflexive journals as tools for data generation. The findings of the study revealed that the lack of sufficient outdoor and indoor learning areas at both centres had a detrimental effect on learning at both ECD centres. Inadequate indoor and outdoor learning and teaching support material, as well as basic facilities such as water and sanitation, posed challenges to the pre-service teachers who were involved in service-learning.

Labuschagne's study is comparable to this study because of the setting in which they are both conducted, which involves ECD centres in rural districts. Similarly, both studies adopted a qualitative research approach. Data generation methods employed in this study are similar to some of the tools that are used in the study by Labuschagne (2015), which includes observations and semi-structured interviews. The distinction between the two studies lies in their areas of investigation. While the former study focused on the learning environment, the focus area for this study is mathematical knowledge. The two studies also differ according to the areas in which they are conducted, which are the North-West Province and the Eastern Cape Province. In addition, in there are extra tools used to generate data in Labuschagne's study, which are the focus group and reflexive journal, and which had a huge effect on the findings. Moreover, the former study focuses more on the impact of service-learning in promoting quality learning environments in ECDs. Little to nothing has been revealed

about the impact of service-learning in promoting learning environments for the development of mathematics in children.

According to Wodon (2016), ECD in the USA has become a central issue in human development, which is essential for children to reach their full potential and capabilities. Additionally, the first 1000 days in the life of children are especially critical for the development of synapses, as well as their future physical, intellectual, socio-emotional, and cognitive development (Wodon, 2016). Brinkman and Thanh Vu (2016) also proclaim that early childhood development is the holistic development of children from conception to about eight years old. They further state that development is the process of change in which children master increasingly complex levels of moving, thinking, feeling, and interacting with people and objects in their environment. Early childhood care and education is described by the Nigerian researcher, Sooter (2013), as the education provided to children who have not yet reached the statutory age for beginning primary school. It is a semi-formal education arrangement, usually outside the home whereby young children from about the age of three years are exposed through play activities in a group setting through mental, social, and physical learning suited to their developmental stages, until the mandatory age of government approved formal schooling (Sooter, 2013).

In Zimbabwe, ECD is mentioned by Madondo (2020) as the programme that prepares children for elementary/primary schools, contributing significantly to the nurturing of young children's physical, social, emotional, intellectual, cultural, and cognitive abilities.

According to Mbarathi, Mthembu & Diga (2016), early child development (ECD) has recently been considered as one of the most crucial sectors of a young child's life in South Africa. Children have rapid cognitive and emotional development during the period from birth up to the start of Grade R in South Africa (Mbarathi et al., 2016). ECD comprises cognitive, emotional, physical, mental, communication, social and spiritual development of children that takes place from birth until formal pre-schooling (Mbarathi et al., 2016). ECD cannot function in isolation; in order for it to function, it needs to be interconnected with other concepts, practitioners being one of them.

Early childhood practitioners are described by Harwood, Klopper, Osanyin & Vanderlee (2013) as caregivers, babysitters, specialists, advocates, teachers, and foundation builders. The role of early childhood development (ECD) practitioners is thus central to the prevention and early identification of developmental delays, in addition to moulding children's early learning outcomes (Smit, Van der Linde, Eccles, Swanepoel & Graham, 2021). In the South African context, practitioners are mentioned by the DBE (2015) as professionals that are able to make decisions based on a specialised body of knowledge, continue to learn throughout their careers, and are committed to providing the best care and education possible for every child. Therefore, early childhood practitioners are the ones who put the ECD programmes, which mathematics forms part of, in place to help children improve their physical, mental, emotional, academic, cultural, and cognitive skills. However, for practitioners to develop and nurture the necessary skills, ECD programmes are needed to guide them in the use of appropriate strategies.

Depending on the context, early childhood learning programmes, which include mathematics, differ in terms of structure, quality, and inequitable access. Therefore, there is a need to increase multisectoral coverage of quality programming that incorporates health, nutrition, security and safety, responsive caregiving, and early learning (Black, Walker, Fernald, Andersen, DiGirolamo, Lu, McCoy, Fink, Shawar, Shiffman, & Devercelli, 2017).

Researchers Yang & Li (2019) mention that ECD programmes in China are designed to improve early childhood professional development and adequately support children's continuous growth in the early years. They also cater for their own inherited values, cultures, and philosophies. These ECD programmes that include mathematics operate well in a learning environment that is specifically designed for young children. In Malawi, Munthali, Mvula & Silo (2014) highlight that exposing children to ECD programmes develops their basic skills, attitudes, behaviours and emphasise values that will last for their lifetime. Play and social interaction are also very important parts of ECD programmes, hence indoor and outdoor play form part of their programmes to allow children a wide choice of activities.

According to Anyaogu (2016), learning environment refers to the diverse physical locations, contexts and culture in which pupils learn; and learning is what a teacher is

able to package for the child from the environment. Additionally, Ogunyemi & Ragpot (2015) refer to learning environments as educational settings for children aged three through five years in preparing their entry into primary school. This includes “ota akara”, popularly named in some parts of the country as the crèche, the nursery, and the kindergarten. According to Sotuku, Okeke and Mathwasa (2016), the environments in which children learn should be physically and psycho-socially safe through the adequate provision of infrastructure facilities and space that meet the minimum health and safety standards. In this way, practitioners can better develop early mathematics by using their mathematical knowledge and understanding the significance of the relationship between the concepts in the field of mathematics.

2.3 REVIEW OF RELATED EMPIRICAL STUDIES

This section is guided by the sub-headings generated from the study’s objectives.

2.3.1 Mathematical knowledge

Practitioners, as advocates for learning, have an obligation to shape the future of children, especially in mathematics, at an early age. They should do so only if they have a proper understanding of what early mathematics entails, with the belief that knowledge of mathematics predicts children’s future learning. The literature on mathematical knowledge shows a variety of ways in which practitioners should understand mathematical knowledge, but in this study, the focus is on the meaning of mathematical knowledge; knowledge of children’s mathematical knowledge development; the importance of early childhood practitioner conceptions of mathematics in enhancing children’s learning of mathematics; uses of mathematical knowledge in the development of early mathematics; challenges confronting ECD practitioners that impact their abilities to adequately conceptualise mathematical knowledge; and some intervention strategies to enhance the practitioners’ ability to conceptualise mathematical knowledge within an ECD context.

2.3.2 The meaning of mathematical knowledge

According to Carrillo-Yañez et al. (2018), mathematics is viewed as a network of systemic knowledge organised according to its own set of principles. Mathematical knowledge is created by understanding the rules and features that enable the teacher

to teach content in a connected fashion, and to validate their own and their learners' mathematical conjectures (Carrillo-Yañez et al., 2018). Thus, the teacher's mathematical knowledge is divided into three sub-domains: mathematics content itself (Knowledge of Topics); the interlinking systems which bind the subject (Knowledge of the Structure of Mathematics); and how one proceeds in mathematics (Knowledge of Practices in Mathematics) (Carrillo-Yañez et al., 2018). Research by Noviyanti and Suryadi (2019) elaborated and asserted that mathematical knowledge is a skill that should be owned by teachers in order to improve their teaching quality in mathematics and is used to carry out the work of teaching.

Mathematical knowledge does not only require knowledge of the content but also the pedagogical knowledge in which teachers are expected to use new curriculum materials; open their classrooms to wider mathematical participation; help learners to succeed in more challenging assessments; and demand substantial mathematical skill (Noviyanti & Suryadi, 2019). Additionally, mathematical teaching for early childhood has a big advantage for their logical intellectual development, as early mathematics predicts both mathematics skills and literacy skills in the future (Noviyanti & Suryadi, 2019).

Jacinto & Jakobsen (2020) mention that mathematical knowledge is referred to as the knowledge that teachers need to carry out their work as teachers of mathematics, which is grounded in Shulman and Sykes' (1986) definition of the knowledge base for teaching. They describe this as the body of understanding and skills, values, character, and performance that together constitute the ability of a teacher to teach mathematics. According to the DBE (2018), mathematics is a language that makes use of symbols and notations to describe numerical, geometric, and graphical relationships. It is a human activity that involves observing, representing, and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves (DBE, 2018). It also helps to develop mental processes that enhance logical and critical thinking, accuracy, and problem-solving that will contribute to decision-making (DBE, 2018). The literature elaborates on all aspects which constitute what mathematical knowledge is. However, little or nothing is stated about mathematics in early childhood development and the category of mathematical knowledge ECD practitioners of rural areas should possess. This

presents an opportunity for investigating this knowledge gap in rural ECD practitioners of the OR Tambo Inland District.

Mathematical knowledge in early years includes main content areas which are mentioned by the National Council of Teachers of Mathematics and the National Association for the Education of Young Children (NCTM, 2000; NCTM & NAEYC, 2002; 2010) and the Common Core State Standards for Mathematics (CCSS-M, 2010) as number sense and operation; patterns and measurement; geometry and spatial awareness; algebra and data analysis; and mathematics processes, such as problem-solving, reasoning, communication, connections, and representations.

Number sense and operations are explained by Cheng & Dindyal (2012) as the capacity to make sense of numbers and magnitude, which is seen as foundational knowledge needed by children to understand and link quantities to our number system, numerical constructs, and mathematical strategies. Children with knowledge of number sense have an understanding of the meaning of numbers and their relationships. They are able to recognise the magnitude of those numbers and the “effects of operating” on numbers and developing “referents” for quantities and measure (Cheng & Dindyal, 2012). Therefore, number sense includes children’s understanding of numbers and the ability to use that knowledge correctly to solve mathematics problems using the four basic operations which are addition, subtraction, multiplication, and division.

Supporting the above notion, Jordan, Glutting & Ramineni (2010) highlight that number sense is relevant to learning mathematics early in life, well before children enter school, and firstly appears to develop without or with little verbal input or instruction. It is present in the infancy stage of development, and it begins with a precise representation of small numbers. Consequently, as children grow, they learn the verbal count list and understand cardinal values for numbers. They then learn to represent larger numbers exactly and see that each number has a unique replacement. Therefore, children are able to identify one, two, or three objects before they can count with understanding at an early age, meaning that they are able to

recognise a number of objects in a small group. As mental power develops, schemas, as mentioned by Piaget (1986), are formed to accommodate new information. This means that a group of four objects can be recognised without counting, and they are able to form mental images of patterns and associate them with a number.

e.g. **IDENTIFICATION** – in which children identify objects



COUNTING – in which children associate objects with numbers

1

2

3

Another content area includes patterns and measurement, which are elaborated on by Montague-Smith, Cotton, Hassen & Price (2012) as areas that help children learn to sequence and to make predictions which lead to mathematical skills, logic structure in algebra, and to establishing order in life. For example, a toddler will sort green blocks from yellow ones as he builds a tower; hence, the child begins to notice things repeat in a certain order by size, shape, or colour. This is what is referred to as adaptation by Piaget (1986), in which the child gains new understanding and information about the repetition of blocks according to size, shape, and colour. Schemas are then altered to assimilate this new information whereby the child understands that things repeat in a certain order by size, shape, or colour.

Thinking about patterns can be centred on some important points, which include that patterns are everywhere, patterns are fixed, patterns repeat, patterns can grow, and patterns can be found in shapes. These patterns include numbers, shapes, and pictures that repeat in a systematic way. In this way, children start to understand what comes next, make systematic connections, and use their reasoning skills. Practitioners should encourage children to investigate the patterns that they find around them in order to make mathematical findings that develop big ideas in mathematics thinking,

for example, clapping out patterns such as clap-clap-clap-pause, clap-clap-clap-pause.

Moving with the notion of content areas, Hirst & Levine (2018) mention measurement as another content area and defines it as a process of finding out the size, length, or amount of something and it also means counting to get the total number of items in a set. In this way, children are able to create units for themselves, like using hands to measure the height of their friends.

Schroeter (2017) came up with spatial awareness and elaborated on it as the understanding of the positions of objects and the self in space, which is an essential skill that children must master for future educational success. Kosur (2010), moving with the above opinion, states that spatial awareness begins to develop immediately after birth as new babies and infants take in their surroundings, including the movement of their own bodies, other people, and objects. This content area is useful as it provides children with pathfinding as a skill.

Sorting, matching, and handling of data as content areas are mentioned by Montague-Smith et al. (2012) as a crucial aspect of mathematics that relates to collecting, representing, and analysing data in order to solve a particular problem or question. Therefore, data representation is part of children's everyday lives and is included in the early years of learning. It allows children to learn the ability to collect and understand that objects can be sorted into sets, depending on various areas of interests. For example, when children are very young, they often start sorting for one area, e.g. the yellow blocks, but then become confused when they spot something more appealing, e.g. red blocks (Montague-Smith et al., 2012). Supporting the above opinion, Harris (2013) states that classifying and sorting involves three steps which include deciding which characteristic to sort, physically sorting the objects, and providing and describing the rationale for the classification. More specifically, early mathematical concepts, such as classifying and sorting, are the foundation for later mathematics thinking for completing complex sums. In this way, logical thinking is

applied to everyday objects, which is important for later mathematics, as well as all decision making.

These content areas should form part of a mathematics curriculum. Therefore, the instructional practices should be based on the understanding of mathematics for the development of young children. Encouraging children's communication and how they explain their thinking as they interact with mathematics is of vital importance to practitioners; hence, the need for practitioners who are fully developed and equipped in mathematics and the development of young children. This is in line with the aim of this study; to explore how these practitioners use their conceptions of mathematics in the early years to instil the above-mentioned content areas in young children with the purpose of developing early mathematics.

As mentioned in Chapter 1 (1.3), Bruce (2010) supporting the idea of content areas, reveals that children are born into a mathematical world, and the earliest interactions are mathematical as they explore the shapes, spaces, and patterns of their world. Bruce (2010) further states that at home, children develop the ability to tune into the mathematics of their home environment, which will be meaningful to them. They learn about their number world, and understanding and contexts for numbers develop gradually, which means that mathematical knowledge and skills provide building blocks for success in many areas of life and work (Bruce, 2010). At that point, before children start school, most of them develop an understanding of addition and subtraction through everyday interactions. This enables them to think reasonably, tactically, creatively, and in ways that will help solve abstract problems in later grades at school.

In agreement with the notion by Bruce (2010), Anthony & Walshaw (2009), state that the development of mathematical competencies begins at birth, whereby young children of diverse socioeconomic and cultural contexts are immersed in a world of mathematics. Simply stated, in the early months of life, babies are busy learning about mathematics, for example, observation of their eating times as part of the explorations necessary for the process of becoming members of the community. Stressing the

importance of knowledge and skills, Selmi (2015) highlights that mathematics skills do not only concern learning numbers and methods of linking them. A large portion of early mathematics focuses on a far-reaching understanding of abstractions and generalisations that assist young children in connecting ideas, developing logical thinking, and analysing events that occur in the world around them. Linking numbers may not be the core, but the practical side of learning to acquire mathematics is a gateway to better understand mathematics and, at this stage, practicality matters more. Therefore, the abstractions include mathematics concepts in which children are able to add one or two objects. This suggests that mathematics in children might not be a problem, as they apply the mathematical knowledge they gained from early childhood level to other similar situations in higher grades.

Gifford (2016) mentions the idea that young children are natural problem setters and solvers, and that is how they learn. In this light, problem-solving is an important form of mathematical knowledge, as it encourages children to link previous knowledge with new circumstances and develop flexibility and creativity in the process. It is therefore important that children should see themselves as successful problem solvers who like a challenge and who can survive even in tricky situations. Piaget (1986) stresses object permanence as a cornerstone of children's intelligence in which they understand that an object continues to exist, even if it is not there. At this point, children continue to search for objects as a way of problem-solving. Therefore, the problem-solving skills children acquire at the early stages of development, if linked to mathematical knowledge and ability, are most influential in predicting their later success. Supporting the notion of flexibility and creativity, NCTM (2013) shows that research on children's learning in the first six years of life demonstrates the importance of early experiences in mathematics. These positive experiences help children to develop dispositions such as curiosity, imagination, flexibility, inventiveness, and persistence, which contribute to their future success in and out of school. An engaging and encouraging climate for children's early encounters with mathematics is therefore essential to develop their confidence in their ability to understand and use mathematics.

According to De Jager (2014), at playschool, nursery school, or in kindergarten, a child learns to discover and experience through playing, and at nursery school, the child does not only sit still and listen or write, but actual objects are touched and handled. This is followed by periods of drawing on paper, painting, cutting and pasting, and reading books. There are also times when experiences are discussed and reasoned out, without the aid of concrete objects or examples on paper or on screen. He further states that learning at the abstract level is easy, but only if it is preceded by concrete and semi-concrete experiences. The above statement suggests that mathematics cannot be looked at in isolation, but instead should be viewed in the context of other activities taking place in the learning environment and interacting with others. How children generate new knowledge from the activities taking place in the learning environment is determined by their interaction with others, which includes the theories of learning discussed below.

Theorists Tucker (2010), Haylock & Cockburn (2008), reveal that children learn mathematical concepts best through play both at home and in a nursery school. They also believe that children learn best through practical, meaningful experiences that are purposeful to the child. Similarly, Wood & Attfield (2005), maintain that the early years are particularly important for developing children's ability and enthusiasm in mathematics, and the more practical activities children experience, the more successful they will be in becoming what they call "real-world mathematicians". There is also a belief amongst these researchers that the key to children's learning through play is having a skilled workforce. It is the responsibility of practitioners to possess knowledge of play and to support children's learning by extending their thinking and building on what they know. McClintic & Petty (2015) are of the opinion that practitioners believe that supervision during outdoor play is paramount, and it is where practitioners display an adherence to rules or a "philosophy-reality" conflict. Furthermore, supervision makes them believe that the appropriate time for practitioners to apply their knowledge to develop young children's mathematics skills is during outdoor play.

2.3.3 Knowledge of children's mathematical knowledge development

Developing mathematics with understanding in young children is about helping learners to understand the principles and relationships of conceptual knowledge. Lema (2019) states that many activities involved in the enhancement of mathematics in the early years include linking everyday experiences to abstract ideas. Practitioners have the power to equip and influence young children, which means they need to have adequate knowledge and skills if quality teaching is to be expected (Lema, 2019). A need for effectively trained practitioners who are competent in high-quality early childhood programmes is therefore crucial. Although the literature discusses mathematical teaching in the early years at length, less is said about how practitioners use conceptions of mathematics to develop high-quality mathematics learning in rural early childhood centres in South Africa.

Rittle-Johnson (2017) states that competency in mathematics requires practitioners to develop conceptual knowledge, procedural knowledge, and procedural flexibility in young children. Conceptual knowledge is defined by Rittle-Johnson (2017) as knowledge of abstract concepts and general principles, such as cardinality and numeric magnitude. According to Hurrell (2021), procedural knowledge is the capacity to follow steps in sequence to solve mathematical problems or reach a mathematical goal. Procedural knowledge is also often defined as knowledge of procedures which shows what steps or actions to take to accomplish a goal (Rittle-Johnson, 2017). Both conceptual and procedural knowledge promote procedural flexibility, which is knowing more than one procedure and applying them adaptively to a range of situations. For example, mathematicians know and use more procedures than novices, appreciate efficient and elegant solutions to problems, and identify the most appropriate procedure for a given problem based on different factors (Rittle-Johnson, 2017).

Ribeiro, Mellone & Jakobsen (2016) highlight interpretative knowledge as a competence that practitioners should have in order to help children develop their mathematics skills. According to Ribeiro et al. (2016), interpretative knowledge, being part of mathematical knowledge, is defined as the knowledge that allows teachers to give sense to learners' non-standard answers (i.e., adequate answers that differ from

the ones teachers would give or expect), or to answers containing errors. Moreover, the content of interpretative knowledge shapes teachers' ability to make informed choices in contingency moments in order to respond to and deal with non-planned situations. This corresponds to teachers' knowledge that supports the development of learners' mathematical knowledge, having as a starting point the learners' own possible reasoning (Ribeiro et al., 2016).

Additionally, Nguyen, Watts, Duncan, Clements, Sarama, Wolfe, & Spitler (2016) mention counting competence as part of the knowledge practitioners should possess. This is defined as the ability to recognise that numbers represent quantities and have magnitudes, as well as mastery of one-to-one correspondence (understanding that each element in one set is paired with exactly one element from the other set), fixed order (number names and numerals are in a fixed order), and cardinality (the last number names the set and indicates the size of the set). Children's ability in this competency area serves as the capstone of early numerical knowledge, and the necessary building block for all further work with number and operations (Nguyen et al., 2016). Numerous studies have been conducted on the mathematical knowledge needed for teaching mathematics, but there has been much less interest in the knowledge needed for teaching mathematics in early childhood development. It is therefore important to investigate how to facilitate the development of such knowledge of practitioners that are teaching in disadvantaged centres of the OR Tambo Inland District.

2.3.4 Importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics

The consensus that learners should learn how to create mathematical connections does not extend to how they should be supported in doing so. As advocates for learning, practitioners have a responsibility to develop mathematics in such a way that learners become numerate. In addition, Nguyen et al. (2016) assert that not only is it important to know what the key competencies are for these children, but it is also important to know what competencies predict later success in mathematics. The assessment of the competencies can help practitioners in identifying children that

struggle with mathematics, so that more attention can be targeted towards those children (Nguyen et al., 2016). Mathematical knowledge is important, as it identifies the skills found to be predictive of later mathematics achievement with the aim of designing interventions to teach those skills (Nguyen et al., 2016).

Mathematical knowledge that practitioners possess is also very important as it provides the skills needed to design learning environments that are conducive for the development of mathematics in young children. Sotuku et al. (2016) opine that poorly designed ECD physical environments not only present health and security hazards to little children's learning, but also affect the learning and freedom children should be enjoying. The study by Sotuku et al. (2016) reveals a lot about the the physical environment of the ECD centres and the potential they have for children to develop and learn at an early age. However, not much has been revealed regarding how practitioners in rural ECD centres use their conceptions of mathematical knowledge to create a physical environment that is conducive for the development of children's mathematics. The importance of the learning environment in developing children's learning is supported by Tadesse (2016), who argues that young children develop and learn about their world (e.g. people, nature, objects) by interacting with people, and manipulating and examining objects with their five senses. Therefore, it is important that the physical environment supports children's curiosity to explore, play, and learn. Tadesse (2016) emphasises the importance of learning environments in children's learning, but does not state how practitioners in disadvantaged rural area centres can create learning environments that enhance mathematics through exploring, play, interacting with people, and manipulating and examining objects with their five senses. Hence, there is a need to explore practitioner conceptions and understanding of the creation of a conducive environment for teaching and learning mathematics in rural areas, specifically in the OR Tambo Inland District.

It is important that children see practitioners as encouraging and helpful. Children rely on adults to keep them safe, secure, loved, and respected, as well as to make them feel like they belong. By using their mathematical knowledge, practitioners are able to create relationships with children. Daries (2017) argues that when practitioners have

a healthy relationship with their learners, they can provide them with the opportunity to grow, learn, and thrive as active participants in their learning. This connection should be established during professional development training, including fostering proper knowledge on the development of children, identifying and addressing children's problems, connecting their potentials, moulding their characters, enhancing their learning, and equipping them for life so that their actions are directed towards positive personal, communal, and global development (Daries, 2017). Based on this information, it is clear that practitioners should become sensitive to children's needs and be agents for social justice in early childhood centres. Professional development training for practitioners enhances the holistic development of children's needs; hence, the study explores how practitioners of the OR Tambo Inland District use their conceptions of mathematical knowledge acquired during professional development training to address their connections which cater to the holistic development of children.

In addition, effective educational practices for improving children's academic achievement need strong partnerships between parents and schools, therefore, the importance of practitioner knowledge of relationship formation extends to parents. Epstein (2013) points out that early childhood practitioners are most effective when young children are viewed in the context of their families and culture, and it is within the family that children's attitudes towards learning and their understanding of the world begin. Language and culture that children bring with them to the early learning environment is the prism through which they view the world around them, and through which they interpret and learn (Epstein, 2013). Through continuous communication with families, early childhood practitioners need to upsurge on what children are learning in their homes and view the development of families as equal partners in the children's mathematics education. Concurring with the above author, Bruce (2010) declares that mathematical knowledge and skills provide building blocks for success in many areas of life and work. Therefore, this calls for practitioners who have the ability to help children use mathematics to think reasonably, tactically, creatively, and in ways that will help solve abstract problems in later grades at school. This means that how practitioners in rural ECD centres use their mathematical knowledge to create

healthy relationships with the parents of the children in their care will also need to be investigated for this study.

Practitioners should understand that providing children with early mathematics content knowledge and experience assists in preparing them for various mathematics subjects they will meet in school, as well as in interpreting and understanding their world numerically. The mathematical knowledge practitioners have is important in including teaching activities that are from multiple content areas whereby the understanding of the concept of numbers and operations helps create the foundation of young children's understanding of mathematics (Frye, Baroody, Burchinal, Carver, Jordan & McDowell, 2013). It is important for practitioners to identify the knowledge children already hold and build on that knowledge to help them reach the next developmental level. This will enable them to explore their environment in order to solve problems, design things, and create their own questions (DBE, 2015). Practitioners also need mathematical knowledge to comprehend that early mathematics is about children exploring mathematics, developing an understanding of how to solve problems, how to reason, and how to use mathematical concepts found in their environment (DBE, 2015).

Sitabkhan, Davis, Earnest, Evans, Ketterlin-Geller, Lutfali, Ngware, Perry, Pinto, Platas, Ralaingita, Smith & Srikantiah (2019) mention the importance of the knowledge of a developmental progression thinking-framework in the classroom, which includes knowing where children are in their development, understanding where they came from, and how to support them in the future. The framework helps practitioners to support and meet children where they are, guided by content standards and research on children's learning, and allows practitioners to sequence learning activities based on how children's thinking about a particular concept develops over time (Sitabkhan et al., 2019).

According to the National Council of Teachers of Mathematics (2013), practitioners have an obligation to actively introduce mathematical concepts, methods, and language through a variety of appropriate experiences and research-based strategies. In light of this, it is important for practitioners to possess solid mathematical

knowledge, as mathematics enhancement is a major concern starting from early childhood, which is the foundation for education. For this reason, practitioners who plan and organise activities that support children's developmental and mathematics learning needs are desirable. Through mathematical knowledge, ECD practitioners need to understand what children know (previous capital and cultural knowledge) and what they need to learn (new concepts/knowledge), and then motivate and assist them in learning it well. The literature reveals a lot about the importance of mathematical knowledge practitioners hold and how it should be utilised in the development of mathematics in children in general. However, little is known about the mathematical knowledge that practitioners, particularly those in rural ECD centres, possess and how this knowledge contributes to the mathematical development of children in OR Tambo Inland District ECD centres.

2.3.5 Types of mathematical knowledge that enhance the development of early mathematics

Children are engaged in structured cultural surroundings from birth, with a strong desire to communicate in a diverse cultural background. Worthington & van Oers (2016) mention that children naturally engage in cultural practices that incorporate mathematical language and representations, and parents introduce counting and numbers to infants and young children through toys, songs, games, and birthday numbers. In this study, the mathematical knowledge discussed includes cultural knowledge, knowledge of curriculum, pedagogical content knowledge, disciplinary knowledge, and knowledge of play.

2.3.5.1 Cultural knowledge

Quality ECCE acknowledges the parents or guardians (primary caregivers) as the child's first educators. For this reason, the centre should affirm the family's cultural norms and values, as these are pivotal in forming the child's identity, especially in a multicultural society. Cultural knowledge, according to Bennett, Gunn, Evans, Peterson and Welsh (2013), is the knowledge that includes a set of practices, beliefs, and values that give order and meaning to the life of a group, with learned language, beliefs, values, and behaviours infused into every aspect of their lives. Consequently,

continuity between cultural knowledge in its diversity should form the foundation for instructional practices. Practitioners have to be aware of different cultures of children, making connections with them that build an understanding of children's experiences as they learn the cultural practices and language used by their families and communities (Bennett et al., 2013). Cultural knowledge embraces knowledgeable practitioners who understand that children benefit from a learning environment that increases the connection between home and school culture by involving families and the broader community. The knowledge possessed by practitioners is the basis for a healthy mathematics development environment. The aspect of cultural knowledge in transmitting mathematical knowledge is another important feature being observed in this study of rural ECD centres in the OR Tambo Inland district, Eastern Cape Province.

In line with this, van As, Excell, Magadala. & Gqoli, (2020) assert that young children in multicultural settings need to be secure in their own cultural identity to feel protected with their peers, and develop self-esteem. In order to optimise the holistic wellbeing and development of children, teachers should have a sound insight into culturally relevant knowledge and pedagogies based on the realisation that young children have to learn to navigate the different worlds between home and school (Van As et al., 2020).

Cooper & Hedges (2014) argue that as children learn the cultural practices and language used by their families and communities, the practitioner should be motivated to understand children's cultural knowledge and adjust to their understanding. This will assist the practitioner to form trustworthy connections with the children. Practitioners who fail to capitalise on children's learning gained in informal settings overlook a rich source of children's prior knowledge, experience, and interests. This may have far-reaching implications for practices, as instructional practice discourse is not rooted in the practical experiences of children. In concurring with the above author, Worthington (2018) makes an interesting comment about the central role of culture, revealing that the understanding of the abstract symbolic language of mathematics is social and cultural in nature. Hence, competency develops as a continuum, revealing how

children's early understandings take shape, are embedded, and prepare young children for ensuing grades. Adding to the debate, he further states that social play is better understood for supporting children's interests and for its mathematical potential, prioritising children's mathematics in early childhood curricula so that the existing competencies are valued and understood.

This calls for practitioners who understand children and families in their settings and who can use this information to make learning more enjoyable and rewarding for all children. By doing so, it could help children develop a sense of identity and belonging in the setting through actively engaging with and finding out about family values, traditions, and beliefs. Practitioners should also build on these concepts to benefit from parents' skills and expertise and in doing so provide a more secured environment for children. In urban areas where ECD centres function in more favourable conditions, practitioners have expertise and knowledge of children and families in their settings. This means that they can provide an emotionally secure environment. The environment includes the physical environment, its surroundings, and a specific setting that develops a sense of identity and belonging in children. The literature places a lot of emphasis on safe and secure environments in which children develop self-esteem, yet little is mentioned about how children develop self-esteem in learning environments that are not at all conducive, like the ones in the OR Tambo Inland District. It is therefore necessary to investigate how practitioners in this environment use their conceptions of mathematical knowledge, which includes an understanding of children's cultural knowledge, to enhance mathematics in their ECD settings. Geary (2013) states that children's early mathematics learning is likely to support their later achievement in mathematics. In agreement with the above opinion, practitioners should understand how cultural concepts relate to mathematics, and children's learning and know-how, to incorporate these into their instructional practices to enhance mathematics learning for children's later achievement.

Howells (2014) argues that it is the role of the practitioner to build on children's informal knowledge and maintain the interest and enjoyment of mathematics that they bring with them from home. For practitioners to build on children's informal knowledge, a

need for culturally competent practitioners who contextualise or connect to learners' everyday experiences and integrate classroom learning with out-of-school experiences and knowledge is vital. This calls for practitioners who will be able to help children make the link between their culture and the new knowledge and skills they encounter inside the school, which is at the heart of ensuring that all children achieve at a high level. Therefore, it is important for practitioners to develop children's mathematical skills in the early years to lay a foundation for mathematics learning in the future. Since knowledge and skills are mentioned among foundation builders for mathematics, it is of great interest to explore how practitioners in the OR Tambo Inland District develop children's mathematical knowledge and skills for learning in the future.

2.3.5.2 Mathematics curriculum knowledge

According to the DBE (2015), the curriculum for early childhood is about all the experiences that children from birth to four years old will have in different settings, and it includes what children feel, do, hear, and see in their early childhood setting. A full curriculum should therefore contain details about what children should know and scaffold approaches and sequences to help children gain skills and knowledge. The aim is to help every child develop knowledge, skills, attitudes, and behaviours for life, which are done through prescription, materials, and methods (DBE, 2015). In accordance with the above opinion, the curriculum should include experiences that are planned for young children wherever they are being cared for. These experiences should be created by children themselves in order to make sense of their world, as children bring much knowledge from their home experiences to early childhood education. Furthermore, in order for practitioners to have knowledge of the ECD curriculum, they should undergo professional development training related to mathematics in the early childhood sector. The training will assist in appropriate curriculum planning that facilitates meaningful learning for children, contributing to the practitioner's confidence and professional growth (DBE, 2015). The National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC) (2010), affirms that high-quality, challenging, and accessible mathematics education for three to six-year-old children is a vital foundation for future mathematics learning. Therefore, in every early childhood setting, children's mathematics should be enhanced through the use of research-based

curriculum and instructional practices. For the curriculum to be effective, it requires suitable resources that enable practitioners to do this challenging and important work of developing mathematics in children.

Daries (2017) highlights the importance of practitioners' personal and professional knowledge, and how this is used during curriculum decision-making in early childhood centres. The findings reveal that practitioners are shaped by this knowledge mix because the unstructured, informal nature of early education means that practitioners are key curriculum decision-makers who employ a range of knowledge and understandings when working with children below five years of age. Kaul (2010) mentions the aspect of parents as caregivers who are critical in providing a stimulating learning environment for the child. The NCF (2015) acknowledges the significant involvement of parents, families, and communities in the ECD curriculum. To ensure the basic development of children, a need to create a planned curriculum framework that encompasses the suitable knowledge and skills with flexibility and contextualisation is vital. Compatible with what Kaul (2010) has mentioned, a planned curriculum should address connected areas of full development through an integrated play-based approach that focuses on the development of life skills. It should, however, be noted that play differs according to the environment. In urban areas, professional early childhood practitioners who are aware of and understand developmental theories of play are better prepared to use play as a background for instruction and assessment. Nothing is however stated about rural areas, where practitioners are underdeveloped and lack a thorough understanding of play theories, preventing them from incorporating play into their mathematical instruction.

(Dooley, Dunphy & Shiel, 2014), agreeing with the notion of the play-based approach, stresses that mathematics pedagogy includes a number of meta-practices (i.e. overarching practices) which include the promotion of math talk, the development of a productive disposition, an emphasis on mathematical modelling, the use of cognitively challenging tasks, and formative assessment. Thus, practitioners should incorporate the above elements to support the vision of mathematics for all children, and develop good mathematics practices that engage children in a variety of mathematically related

activities arising from children's interests, questions, concerns, and everyday experiences. Practitioners need to understand how mathematics learning is promoted through young children's engagement in play and how best they can support that. Learning through play is fundamental to good mathematics pedagogy in early childhood.

Room arrangement plays an important role in children's social and language interactions. Poorly designed ECD settings can cause disruptions and negative social interactions between children and practitioners. The NCTM (2013), also states that young children in every setting should experience mathematics through effective, research-based curricula that should foreground mathematics learning and development as dependent on children's active participation in social and cultural experiences. Such practices, in turn, require practitioners to have the support of policies, organisational structures, and resources that enable them to succeed in this challenging and important work. This calls for practitioners with positive experiences that will help children develop some characteristics like curiosity, imagination, flexibility, creativity, and persistence. These characteristics should be promoted through play-based learning that will contribute to their future success in and out of school. It is therefore necessary to investigate how practitioners in rural the OR Tambo Inland District use their curriculum knowledge to develop the characteristics mentioned by the NCTM (2013) in mathematics learning through a play-based approach.

2.3.5.3 Pedagogical content knowledge of mathematics

Understanding and having techniques for developing mathematics is important in learning and in building the foundation of young children. Early childhood practitioners should build the basic foundation in mathematics as required by the education system. However, it remains ambiguous whether practitioners of the disadvantaged OR Tambo District have the same knowledge and understanding of mathematical development in young children. It is therefore necessary to explore their conceptions of mathematics knowledge. The literature has shown that practitioners need to have proper knowledge and understanding of early mathematics for the development of young children. Together with early mathematics knowledge, it is of great importance for practitioners

to also have knowledge in child development. It is also stated that toddlers and young children continue to develop mathematics concepts in the early years through, for instance, exploring objects with their mouths, tracking objects and people visually, and finding their fingers in order to suck them. These basic actions are important emerging mathematical insights for the growing child. To reiterate, it is of utmost importance that practitioners should have knowledge and skills to support young children's learning of mathematics, to give all children a better chance of fulfilling their academic potential. The above authors however did not consider whether practitioners in rural settings have acquired the knowledge and skills mentioned, and how they use them to develop mathematics in ECD settings.

Mathematical knowledge for instructional practises is defined by Haylock & Cockburn (2008) as mathematical knowledge needed to carry out the work of developing mathematics. It is important to note that the definition begins with instructional practice, not practitioners. Therefore, it is concerned with the tasks involved during enhancement and the mathematical demands of these tasks. As mathematics enhancement involves showing children how to solve problems, answering children's questions, and checking children's work, it demands an understanding of the content of the curriculum. Beyond these obvious tasks, it is of great importance to identify other aspects of the work, and to analyse what these aspects reveal about the content demands of mathematics development. Practitioners need to have a deeper understanding of child development and early education issues. They should also provide richer educational experiences for all children, including those who are vulnerable and disadvantaged, and engage children of varying abilities and backgrounds. Practitioners should therefore undergo professional development training, which will provide them with the necessary deeper understanding of child development and early education issues.

Shulman (1987) concurs and further identifies pedagogy and content knowledge as components of professional knowledge for practitioners. This implies that the teacher should not only possess academic knowledge, which includes mathematics content, but should also be able to impart it in an understandable manner. It is vital that the

vehicle of the practitioner's thoughts and knowledge should be clear and vibrant to the children. Steinbring (1998:159) asserts that a new kind of professional knowledge for practitioners is needed, a kind of blend between mathematics content knowledge and pedagogical knowledge.

2.3.5.4 Disciplinary knowledge of early mathematics

Practitioners, as implementers of mathematics in children, should develop children's understanding of all elements of problem solving and reasoning. Coe, Aloisi, Higgins & Major (2014) state that mathematics as a discipline involves broad subject knowledge, including the understanding of how children handle mathematics as a subject with the purpose of having evidence of impact on their outcomes. This means that practitioners should have expertise and skills in mathematics that will provide them with opportunities for using their instructional practices to develop mathematics with confidence in a way that allows mathematics learning in ensuing grades. They should also acquire expertise and skills during professional development training, whereby they gain confidence in their own abilities during development and implementation. For the proper development of children's mathematics skills, practitioners also need understanding and knowledge of the brain and cognitive development of a young child, and how it relates to mathematical development. This will also help develop the skills needed to support mathematics skills in young children (MacDonald, 2018). Mathematics, as a discipline, provides knowledge and skills that need to be nurtured, practised, and developed for the advancement of a child's reasoning; hence, practitioners need proper training in various aspects of mathematics and child development.

Wang's (2012) research has shown that children benefit from activities relevant to their daily life. Working in partnership with families, linking mathematics from home to centre is another effective strategy, as learning is seen as a social process (Peters & Rameka, 2010). In this discourse, the role of parents is vital in facilitating learning and instructional practices. Parents are the most important people in their children's early lives, and it is where children learn about the world through conversations, play activities, and routines with parents and families. Parents can support their children's

learning in crèches, playgroups, pre-schools, and primary schools. Furthermore, practitioners are more effective when they view children in the context of their families and communities. It is within this partnership that practitioners link the new information by tapping into the minds of the children. Through working together, parents and practitioners can strongly enhance children's mathematics learning and development.

Although the partnership with families is of great importance, as families know their children best, it needs respect to maximise co-operative involvement. Practitioners should be able to expand on what children are learning in the home and support the development of families as equal partners in the child's education. While the above literature is clear on the partnership with families, it does not cater for practitioners of disadvantaged rural areas. The conceptions of practitioners of the disadvantaged OR Tambo Inland District on developing a partnership with families and communities for the enhancement of mathematics in their children therefore warrants investigation.

Practitioners should understand that their role in mathematics teaching in the early years, according to Linder, Ramey & Zambak (2013), is to make children's observations of mathematics in their natural world more obvious. The important thing is to make connections and expand what children already know (Baroody, Eiland & Thompson, 2009). The best way for practitioners to connect to and understand what children already know, and their observations of mathematics, is to pay close attention when children are engaged in play. According to Strauss (2015), this is the way children build ideas and how they make sense of their experiences and feel safe. Consequently, practitioners in early childhood settings need a sound understanding of mathematics to effectively capture the learning opportunities within the child's environment, and make available a range of suitable resources and challenging activities. Using their knowledge effectively, practitioners will be able to provide scaffolding that extends the child's mathematical thinking while concurrently valuing the child's contribution. In a well-established ECD centre, parents are able to fully support their children's education. This study therefore aims to explore how parents from low socio-economic areas of the rural OR Tambo Inland District support their children's mathematics learning.

In order to develop mathematics in early childhood settings, practitioners must be prepared to create a welcoming environment for children from different backgrounds (Hughes & Kwok, 2007). Supporting the view of a welcoming learning environment, Vinales (2015) mentions that the learning environment is a key mathematics factor for children's learning, it provides crucial exposure for young children, helping them to develop their range of skills, knowledge, attitudes, and behaviours in order to meet the expected competencies. In the same vein, Lerman (2014) mentions that early mathematics teaching includes providing activities or creating learning environments by professionals, such as practitioners and caregivers, that offer young children experiences aimed at stimulating the development of mathematical skills and concepts. In support of the above author, practitioners should create an early learning environment that provides young children with rich chances of discovering fundamental mathematical concepts. This is important because children's mathematical development can also be driven by gatherings and activities that take place both inside and outside an educational setting. These settings include the indoor and outdoor environments, and children's home environment in which children can develop some basic ideas about numbers by playing games with their siblings. Epstein (2013) also believes that children need a challenging and interesting environment with a balance of adult-led and child-initiated activities in order to solve problems and investigate through their play. It is the practitioner's role to create and maintain a conducive environment so that children can develop their communication and create their skills.

The practitioner's role in learning, according to Walshaw & Anthony (2008), is in creating a sense of belonging and engagement in the classroom. Researchers, Bobis, Clarke, Clarke, Thomas, Wright, Young-Loveridge & Gould (2005), and Gifford (2004), confirm that young children do better when they feel comfortable in a relationship with their practitioner, and when the practitioner discusses mathematical concepts based on the child's interests. Teacher-child relationships play a prominent role in the development of competencies in the early school years. Studies have shown that positive teacher-child relationships can lead to a warm classroom environment that facilitates successful adaptation in school and thereby increases children's motivation to learn (Koca, 2016)

2.3.5.5 Knowledge of play

Among the early researchers who explored the use of play for early development is Piaget (1962), whose constructivist theory identified play as a means by which individuals can integrate new information into their already existing schemas. Vygotsky (1967) also regarded play as the leading source of development in the pre-school years. It can then be argued that professional early childhood practitioners who are aware of and comprehend developmental theories of play are better prepared to use play as a context for instruction and assessment (Mofokeng, 2018). These practitioners understand the importance of play in social, emotional, cognitive, physical, and motor domains of development. It follows then that it is extremely important that professional practitioners have a strong academic background in the study of play to best evaluate problems and offer appropriate support to children who have a hard time playing, like children with physical disabilities (Mofokeng, 2018). Contrariwise, in rural areas, the researcher observed that most practitioners are not professional early childhood practitioners; they lack an academic background in the study of play, which would enable them to evaluate problems and offer appropriate support to children. Wood & Hedges (2016) assert that the longstanding claims about learning through play become subject to cultural interpretation and some policy revisionism, with the result that educational play, or eduplay, has become an instrumental means for delivering academic outcomes.

Kotsopoulos & Lee (2014) state that young children are naturally curious in their first five years. Research also shows that the best time to introduce mathematics to young children is at this time, while their brain is rapidly developing. Learning in early childhood helps children develop critical thinking and reasoning skills early on, and it is the key to the foundation for success in their formal schooling years. Therefore, practitioners and parents of young children should understand that mathematics learning can be taught through play, and that it can be easy when the learning involves toys, games, songs, and books that are already a part of the child's everyday learning experience.

2.3.6 Uses of mathematical knowledge in the development of early mathematics

According to Clark, Henderson & Gifford (2020), having knowledge of mathematics is beneficial in assisting children in gaining skills, conceptual understanding, and factual knowledge across a range of topic areas, including quantity and number, operations, shape, and space. In addition, it involves forming connections between concepts, such as understanding that addition is the inverse of subtraction, as practitioners plan daily activities targeting specific maths concepts and skills (Clark et al., 2020). It is important that practitioners provide time for purposeful mathematics engagement, strengthening mathematical language, and provide chances for mathematics discussions on a daily basis. Practitioners should seize chances to reinforce mathematical vocabulary (Clark et al., 2020). This can be achieved by encouraging children to use informal language to explain mathematical concepts, and after they are comfortable with this, they can introduce more formal mathematical vocabulary. Clark et al. (2020) also state that practitioners can use their mathematical knowledge to create a variety of tools to enable children to explore all aspects of mathematics, as well as possibilities for outdoor provision for the development and reinforcement of mathematical ideas. They should use their knowledge of mathematics to instil mathematical language and stimulate problem-solving through observing children's play. These practitioners may find it useful to think about mathematics concepts, discussion points, and vocabulary related to the different play areas and activities so they can use them when appropriate moments arise (Clark et al., 2020).

Mathematical knowledge, according to Sitabkhan et al. (2019), is useful in forming connections between formal and informal mathematics, which is crucial in the early years. Moreover, these connections provide a way for curriculum developers and practitioners to validate and recognise that children come to school with mathematical knowledge (Sitabkhan et al., 2019). Practitioners should understand that children are already solving mathematics problems when they first start school, whether at the primary or pre-primary level. Additionally, practitioners should use their mathematical knowledge in understanding that knowing, recognising, and building upon the knowledge they have developed is key, especially in making mathematics relevant to children's lives, which can increase motivation and interest (Sitabkhan et al., 2019).

2.3.7 Challenges confronting ECD practitioners that impact their abilities to adequately conceptualise mathematical knowledge

Practitioners' mathematical knowledge has an impact on the development of mathematics in young children. However, practitioners face various challenges that impede them from fully enhancing mathematics in young children. Muraya & Wairimu (2020) mention teacher quality as one of the challenges that impact practitioners' abilities to conceptualise their mathematical knowledge. By maximising the benefits of learning in every classroom for every child, practitioners play a critical role in reducing the gap between poor and good quality education (Muraya & Wairimu, 2020). The focus should therefore be on teacher quality in order to attain quality education, as many unqualified teachers are unable to match the educational objectives of the twenty-first century. Although the literature emphasises the importance of teacher quality as a determinant in student learning, less is known about the specific characteristics of teacher quality required to develop mathematics in rural early childhood development centres.

Machaba (2019) highlights language proficiency as a barrier to practitioners improving mathematics skills. Based on this, it is important for teachers to have knowledge of various ways in which language is used, because of the important role language plays in early mathematics learning experiences (Machaba, 2019). Teachers should be able to distinguish between what is said and what is meant in order to effectively use language in the classroom; in other words, language should be kept as simple as possible. Clements, Baroody, & Sarama (2013) also state that language, including number words and quantitative terms, is critical for the development of verbal-based number concepts and skills. Additionally, verbal subitizing, which is the key foundation for other verbal-based number, arithmetic concepts and skills, recognises the total (cardinal value) of a collection without counting and labelling that total with an appropriate number word (Clements et al., 2013). The issue, however, is that many children, particularly those from disadvantaged areas, arrive at school with minimal knowledge of the language of learning. Therefore, it is necessary to investigate how language proficiency is a challenge for practitioners of ECD centres in the OR Tambo Inland District, Eastern Cape Province.

Lack of teachers' knowledge regarding interpretations of play-based learning is identified by Fesseha & Pyle (2016) as a challenge that teachers face, resulting in misunderstandings of their role during play. Fesseha & Pyle (2016) discovered that while practitioners state that they incorporated play in their classrooms, their practices did not match true play practices. Instead, play in their classrooms was fixed to specific circumstances and objects, and was used separately from actual learning. However, many kindergarten practitioners support the use of play-based learning, but how this play is implemented lacks consistency and clarity (Fesseha & Pyle, 2016). This piqued the researcher's interest in exploring how practitioners in the OR Tambo Inland district ECD centres incorporate play into their mathematics development.

2.3.8 Some intervention strategies to enhance the practitioner's ability to conceptualise mathematical knowledge within the ECD context

Muraya & Wairimu (2020) assert teacher professional development as an intervention strategy to enhance the quality of early childhood teachers. Professional development includes the activities that develop a teachers' knowledge, skills, expertise and other desirable characteristics, and is acknowledged as one of the important strategies for addressing the challenge of teacher quality. Other strategies include evidence-based programmes and practices through regular communication and events; providing training and professional development for practitioners on how to improve practice; supporting schools and settings to develop innovative ways of improving teaching and learning; and providing them with the expertise to evaluate their impact (Muraya & Wairimu, 2020) The important thing is that practitioners need to have the skills that will allow them to work with and motivate young children while finding joy and success in each day in the centre.

Machaba (2019) mentions intervention strategies for enhancing mathematical knowledge as teacher-led interaction with children and the context of interaction. Further, in teacher-led interaction, the teacher guides the children in their development and understanding, which can be important in the children's induction into discourses associated with the particular knowledge domains (Machaba, 2019). Additionally, the context of interaction in which spoken language can be related to the learning of

mathematics in schools, is that of peer group interaction. Therefore, by working in pairs or groups, children become involved in interactions that are more “symmetrical” than those of teacher–pupil discourse, and provide different kinds of opportunities for developing reasoned arguments and describing events (Machaba, 2019). Sitabkhan et al. (2019) provide two strategies that can support teachers in building connections between formal and informal mathematics, which are bridging and teacher-led discussions, where teachers explicitly connect a problem in class with an out-of-school problem. In addition, practitioners should understand that humans are born with an innate sense of quantity, such as differences in quantities of small sets and an approximate number line that is refined and developed as children interact with their world (Sitabkhan et al., 2019). As they go about their day and encounter problems to solve, these interactions allow children to build on their innate sense of quantity to create informal mathematics.

2.4 SUMMARY OF LITERATURE REVIEW

This chapter examines the mathematical knowledge practitioners should possess and how knowledge affects the development of mathematics in young children. Reflections on Pedagogical Content Knowledge theory were also discussed. In this study, PCK suggests that practitioners need to familiarise themselves with mathematical content knowledge together with pedagogical knowledge for them to properly enhance mathematics learning in pre-school children. The collection of evidence from various researchers reported in this chapter suggests that ECD practitioners need to be capacitated with ECD mathematical content knowledge. It is important to equip these practitioners with skills and knowledge of how to impart the content knowledge to children (pedagogical knowledge). Furthermore, knowledge of child development is vital to practitioners. In addition, practitioners must be equipped with mathematics content areas for young children that are clear and precise, materials and guidance to make mathematics teaching and learning vibrant and fun for the children.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter reflects on the methodological choices made that are linked to research practitioner conceptions of mathematical knowledge in early childhood development. Thereafter, the research paradigm and research approach, including the design of the study, are outlined. Next, a description of the sampling process, how the sites and participants were selected, and the reasons for the choices made are presented. The chapter further explains the data collection techniques, which include observation and interviews, and the rationale for using these techniques is elaborated on. An explanation of the data analysis processes that were used to make sense of how practitioners use their conceptions of mathematical knowledge to enhance mathematics in rural ECD centres in the OR Tambo Inland District, Eastern Cape Province is provided. The chapter concludes by highlighting how ethical requirements were observed, which is important for all researchers.

3.2 RESEARCH PARADIGM

According to Okeke (2014), a research paradigm is a sort of 'camp', to which a researcher belongs in terms of assumptions, propositions, thinking and approach to research. Research paradigms are therefore important, because they are the philosophical bases for researchers that inform their choices of which research questions to address and what methodology to employ. Punch and Oancea (2014) define a research paradigm as a set of assumptions about the world and techniques for enquiring into that world.

Ramrathan & Grange (2017) reveal that a paradigm is the search for truth and is dependent on the positionality a researcher takes in constructing knowledge. This positionality is referred to as a paradigm, the set of lenses one assumes when viewing the world in search of the truth. In other words, it is our way of understanding the reality of the world and studying it (Alharti, 2016). Alharti (2016) mentions two types of paradigms, positivism and interpretivism. Positivist methodology, according to Alharti (2016), relies heavily on experimentation and hypotheses are put forward in

propositional or question form about the causal relationship between phenomena. Its purpose is to measure, control, predict, construct laws, and ascribe causality (Cohen, Manion & Morrison, 2013). Interpretivism is mentioned by McMillan & Schumacher (2014) as the use of systematic procedures with socially constructed realities. Kawulich (2012) reveals that the purpose of interpretative research is to understand people's experiences and that people are creative and actively construct their social reality. Kawulchi (2012) further states that the purpose of the study expresses the assumptions of the interpretivist researcher in attempting to understand human experiences. Furthermore, interpretivism notes that the social world should be studied in the natural world, through the eyes of the participants, without the intervention of the researcher.

This study uses an interpretivist paradigm (also known as a constructivist paradigm) to investigate practitioner conceptions of mathematical knowledge in early childhood development in rural ECD centres in the OR Tambo Inland District in the Eastern Cape Province. Therefore, those social phenomena (practitioner conceptions of mathematical knowledge) are understood through the eyes of participants (Cohen et al., 2007). Through conversations with the practitioners, the researcher was able to construct the meaning of participant's real-world understandings and experiences of using their conceptions of mathematical knowledge.

3.3 RESEARCH APPROACH

Creswell (2018) defines the research approach as a plan and the procedure for research that spans the decisions from broad assumptions to detailed methods of data collection and analysis. Punch & Oancea (2014) mention two types of approaches in which research can be conducted - qualitative and quantitative research approaches. They further define the quantitative research approach as an approach where the researchers typically conceptualise the world in terms of variables (which can be measured) and study the relationships between the variables; whereas a qualitative research approach typically involves studying cases and processes rather than variables.

This study is situated within a qualitative research approach, which is described by McMillan & Schumacher (2014) as a type of approach that refers to an in-depth study using face-to-face interviews or observation techniques to collect data from people in their natural settings. Creswell (2018) concurs with the view and adds that, in a qualitative research approach, the researcher seeks to establish the meaning of a phenomenon from the views of participants. Simply put, qualitative research sets out to penetrate the human understanding and construction. The approach was used in the study because it allowed the researcher to keep the focus on learning the meaning that the participants hold about the phenomenon (conceptions of mathematical knowledge), not the meaning that the researcher brings to the search (Creswell, 2018). The approach is also relevant to the study because it provided the opportunity to go out and interact with the participants (the practitioners) to understand their experiences in using conceptions of mathematical knowledge to enhance mathematics in ECD centres in the OR Tambo Inland District in the Eastern Cape Province. Nieuwenhuis (2010) reveals a more vibrant understanding of qualitative research, arguing that this approach to research typically studies people or systems by interacting with and observing the participants in their natural environment, and focusing on their meanings and interpretations. Since this research is about establishing how practitioners use their conceptions of mathematical knowledge to enhance mathematics, it was important to consider a study design that would best yield the desired answers (Creswell, 2018).

3.4 DESIGN OF THE STUDY

Research design is defined by Punch & Oancea (2014) as the basic plan for a piece of research that connects research questions to data and shows from whom and how data will be collected and analysed. The research design is thus a general plan or a blueprint and structure of the investigation, which the researcher employs to obtain evidence for answers to the research questions (De Vos, Strydom, Fouché & Delpont, 2011). In this study, the researcher used a multiple case study design as a basic plan. According to Nieuwenhuis (2016a), a multiple or a collective case study, as opposed to a single case study, allows for comparisons and identifying of patterns and common features in and between cases. The multiple cases in this study included five ECD centres in the OR Tambo Inland District which were selected as information-rich

cases. With a multiple or collective case study, data is produced as whole entities, which are forthcoming from the participants in a much freer, more natural, and less controlled environment. Yin (2014) shows how this method led to a number of in-depth cases in which five rural ECD centres were researched with the aim of learning as much as possible about the context and phenomenon, which included practitioner conceptions of mathematical knowledge.

3.5 STUDY SITE

The study site is defined by McMillan & Schumacher (2014) as the best sites to gather data and in which specific events are expected to occur. This study is conducted in the OR Tambo Inland District located in the King Sabata Dalindyebo (KSD) municipality in the Eastern Cape Province. The King Sabatha Dalindyebo local municipality is one of seven local municipalities within the Oliver Reginald (OR) Tambo District Municipality. In the KSD municipality, most of the ECD centres are infused in schools as grade R. Additionally, there are ECD centres that are independently registered under Social Development. Five (05) independent rural ECD centres were conveniently selected for this study. The ECD centres were selected on the basis of being accessible and available (McMillan & Schumaker, 2014).

3.6 PARTICIPANT SELECTION

Participants for this study were selected using sampling According to Ramrathan et al. (2017) sampling is a process of extracting objects, subjects, or participants from the identified particular category of objects and its process is determined largely by the nature and purpose of the study. Participants in the study were selected by means of purposeful sampling, as the intention was to select participants who would suit the purpose of the study (Mukherji & Albon, 2011).

Purposeful sampling is mentioned by Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood (2015) as sampling that is widely used in qualitative research for the identification and selection of information-rich cases related to the phenomenon of interest. The researcher purposefully selected practitioners who were teaching in five

(5) ECD centres in the rural OR Tambo Inland District with the belief that they would provide in-depth information around their experiences of conceptions of mathematical knowledge in enhancing mathematics. According to Patton (2015), the main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which will best enable the researcher to answer his/her research questions

The researcher's reason for using purposive sampling is best described by Kumar (2014), who says that the researcher normally seeks those participants who, in his/her own opinion, have relevant information and are willing to share it. Etikan, Musa & Alkassim (2016) affirm that the purposive sampling technique, also called judgement sampling, is the deliberate choice of a participant due to the qualities the participant possesses. Therefore, the researcher had to select practitioners who were information-rich participants.

3.7 INSTRUMENTS FOR DATA COLLECTION

According to Leedy & Ormrod (2013), research instruments provide a basis on which the whole study effort rests. The study employed two types of research instruments to collect data, which were interviews and observations. Semi-structured interviews with open-ended questions were conducted to collect valuable information about practitioner conceptions of mathematical knowledge to enhance the mathematics skills of young children (Cohen et al., 2013). Doyle, Sheridan & Treacy (2015) define semi-structured interviews as a meeting in which the interviewer does not strictly follow the order of questions. In other words, the interviewer may prepare a list of questions but does not necessarily ask them all or touch on them in any particular order.

The researchers Cohen et al. (2011), Greef (2011), & Nieuwenhuis (2016) reveal advantages of using semi-structured interviews in the study to facilitate special kinds of conversations that helped to explore practitioner conceptions of mathematical knowledge, experiences, and the interpretations thereof. The semi-structured interviews allowed for the probing of certain ideas, thus, acquiring a deep understanding of the practitioners' thoughts and feelings, as well as what they experienced during enhancement of mathematics in the ECD settings (Cohen et al.,

2013). The participants (practitioners) then expressed such knowledge and experiences in their own words. The researcher attempted to capture the world of the participants without being prescriptive. In semi-structured interviews, the structure is loose enough to allow leeway to bring in unexpected aspects. Probing and redirecting also becomes easier. During the interview process, the researcher tape-recorded the interviews with practitioners.

Another data collection instrument used in the study was observations. Observations are stated by McMillan & Schumacher (2014) as a way for the researcher to see and hear what is occurring naturally in the research site. Creswell (2010) explains observation as a systematic process of recording the behavioural patterns of participants, objects, and occurrences without necessarily communicating with them. The observational method relies on a researcher's seeing and hearing of things, and recording these observations rather than relying on the subjects' self-report responses to questions or statements. The researcher also conducted observations on the learning environment to investigate how practitioners used their conceptions of mathematical knowledge to enhance mathematics. In this study, the researcher acted and assumed the role of a non-participant observer when investigating different ECD centres. The researcher sat at the back of the classroom, taking field notes using an observation guide. Furthermore, the researcher wanted to explore practitioner conceptions of mathematical knowledge during the enhancement of mathematics in ECD settings.

3.8 INSTRUMENT CREDIBILITY, TRIANGULATION AND TRUSTWORTHINESS

The researcher used credibility, trustworthiness, and triangulation to check the trustworthiness of the findings.

3.8.1 Instrument credibility

Credibility is described by McMillan & Schumacher (2014) as the extent to which the results of an approximate study mimic reality and are thus judged to be trustworthy and reasonable. Credibility is involved in establishing that the results of the research

are believable (Huffman, 2011). In this study, the credibility of findings was achieved through the use of research methods and design that fitted the research questions for the study and were aligned with the theoretical underpinnings (Nieuwenhuis, 2016). Data was carefully analysed

3.8.2 Instrument triangulation

According to Ghafouri & Ofoghi (2016), triangulation is the use of various data sources in a study to overcome the intrinsic bias. The study used different data collection methods in the form of interviews and observations to allow for data triangulation, which is important to reduce the bias and interest of the researcher.

3.8.3 Instrument trustworthiness

During data collection, the researcher used a tape recorder to collect data on the conceptions of mathematical knowledge. Probes were also used during interviews to allow participants to provide detailed information and to obtain an answer that fits within each of the questions asked that were related to practitioner conceptions of mathematical knowledge. During observations, the researcher took field notes relating to how practitioners use their conceptions of mathematical knowledge to enhance mathematics.

3.9 DATA COLLECTION PROCEDURES

The researcher used a semi-structured interview which comprised a list of questions for this study. Making use of semi-structured interviews was the most suitable tool for the study, as the researcher allowed the participants to respond as they saw fit. During the interviews, the researcher created a relaxed atmosphere to make the participants feel more comfortable. The researcher also allowed them to use their home language when answering questions, if they felt comfortable doing so. They were also encouraged to speak freely without having the pace of the interview pushed or having words put in their mouths. The principal aim of the semi-structured interview was to obtain the participant's objective responses to a known situation from his or her lived

world (Datko, 2015). In this way, the researcher was able to acquire descriptions of the practitioner conceptions of mathematical knowledge in enhancing mathematics.

As previously stated, the researcher recorded the data using a tape recorder.. Participants were asked for their permission to be recorded prior to the interview. Semi-structured interviews allowed for a set of leading questions to be asked from the participants, with the possibility of including unplanned questions that allowed the researcher to ask further questions based on the responses of the participants to gain more information and clarity (Ramrathan et al., 2017). The researcher spent two hours at each centre. Consequently, the researcher was able to gain understandings of practitioners' worlds from their points of view and unfold the meanings of their experiences on conceptions of mathematical knowledge.

The following questions were asked:

1. For how long have you been a practitioner at this centre?
2. Can you please describe your specific role in the centre?
3. Have you received any training on Early Childhood Development? If yes, what qualifications do you hold?
4. Have you received any training in early mathematics? If yes, can you elaborate on the training you had?
5. Is there any specified mathematics curriculum that is used in the centre? Could you please explain it?
6. How well has your education and training programme prepared you in relation to mathematics content areas that are relevant to early childhood development?
7. What is your role as a practitioner in the mathematics classroom?
8. How do you enhance parental and/or guardians' involvement in their children's development and mathematics learning?
9. How do you take into account the diversity of children's backgrounds or how this impacts their learning of mathematics?
10. How do you use mathematical knowledge to enhance children's learning in ECD class?

11. How do you design an environment and make it conducive to mathematics learning?
12. How do you use play and its theories to enhance mathematics in the ECD classroom?
13. How do you guide children during play in order to enhance mathematics?

Observations were also used as another data collection method. The classroom environment was observed to determine its contribution and impact on mathematics teaching. The classroom environment observation included resources and organisation. During observations, the researcher was a non-participant observer, who was sitting at the back of the classroom taking field notes during the teaching of mathematics. Teaching activities that are important variables which influence successful teaching and learning, including teacher-child interaction, child participation, and child-to-child interaction, were also observed. Techniques used by practitioners to enhance mathematics concepts, which are regarded as the major determinant of successful learning in ECD, were also observed for their effectiveness in children's successful learning.

Following is the observation schedule used:

- The classroom environment was observed to determine if it contributed to mathematics development, which included:
 - Classroom resources, and
 - Classroom organisation.
- Teaching activities, which are important variables that influence successful teaching and learning, were observed. These included:
 - Teacher-child interaction,
 - Child participation, and
 - Child-to-child interaction.
- Methods used to enhance mathematics concepts are regarded as the major determinant of successful learning in ECD. The methods used were observed for their effectiveness regarding children's successful learning.

3.10 DATA ANALYSIS PROCEDURES

Abraham (2016) states that qualitative data analysis is the rigorous process of selecting qualitatively distinct data, articulating the qualitative meaning ascribed to those units, and commenting on the qualitative similarities and differences noted between and among these distinct units of data. The data was transcribed and converted into a textual format. In addition, transcription of data was based on the trends of participant perspectives (Vaismoradi, Jones, Turunen & Snelgrove, 2016). The study used thematic analysis in which Creswell's (2009) steps for data analysis are used. For this study, the data was organised into three steps as follows:

Step 1: Organise the data and define the codes. The data collected was read through to gain a general sense of the information and reflect on the overall pattern. Generating a description of the setting or people and identifying themes from the coding was also vital.

Step 2: Developing the categories and codes. Open coding was used in which the researcher looked at and read the data over and over again in order to create labels to establish meaning from the information given by participants. Then, the specific words of the participants were looked at carefully and categorised. Categories emerged from the text and, in this way, meaning was created. The relationships, commonality, and connection among the open codes' meaning were observed (Abraham, 2016).

Step 3: Developing themes and sub-themes during coding of the data. Passages in the data were marked to group them according to patterns that emerged from the research literature and from what practitioners said. Then, the data was grouped into themes, keeping literature in mind. After a long working process of moving back and forth between the data and the literature, themes were identified, which form the basis of the data analysis chapter.

3.11 ETHICAL CONSIDERATIONS

Resnick (2011) defines ethics as norms of conduct that distinguish between acceptable and unacceptable behaviour.

3.11.1 Gaining entry

For this study, the researcher gained entry by completing the ethical clearance form at the University of Free State Ethics Committee at the Faculty of Education, asking permission to conduct the research. A letter was written to the Department of Social Development to be allowed to visit the ECD centres to conduct research. Letters to the managers of five (5) ECD centres asking for permission to be allowed to visit the early-childhood centres to conduct the research were written. The letters clearly stated the purpose of the study and who will participate in the research.

3.11.2 Participants' rights

Participants were fully informed regarding the purpose of the study, the research process, and the research activities. They were informed that their participation was voluntary, and that there was no penalty or loss of benefit for non-participation. The researcher also informed them that they have the right to withdraw from participating in the research if they saw wished to do so.

3.11.3 Informed consent

According to Nijhawan & Janodia (2013), informed consent is an ethical and legal requirement for research involving human participants. Furthermore, it is the process whereby a participant is informed about all aspects of the research, which are important for the participant to make a decision, and after studying all aspects, the participant voluntarily confirms his or her willingness to participate. McMillan & Schumacher (2014) refer to informed consent as the process of obtaining permission from individuals to participate in research before the research begins. The researcher applied for ethical clearance from the Ethics Committee of the University of Free State and specifically the Faculty of Education. The Ethics Committee granted clearance with the ethical clearance number UFS-HSD2020/0354/1908. An application asking

for permission to do the research was made to the Department of Social Development and to the managers of five selected centres. In the letters, the purpose of the study was explained, along with the context, where the data collection will take place, the unit of analysis, and the duration of the data collection. Participants were fully informed regarding the purpose of the study, the research process, and the research activities. The participants needed to be assured of confidentiality and the right to withdraw without disadvantage. If they decided to take part, they were given this information sheet to keep in which the conditions of participating in the study are tabulated. They were also asked to sign a written consent form.

3.11.4 Confidentiality

The researcher assured the participants that their names were not recorded anywhere and that no one was connected to the answers they give. Their names and that of the centre were not used, but pseudonyms were used instead. Participants are referred to in this way in the data and in any other research reporting methods, such as conference proceedings. Furthermore, the participants were informed that the transcriber, external coder, and members of the Research Ethics Committee may check their responses to ensure that the research is conducted correctly. Otherwise, records that identify them would be available only to people working on this study, unless they give permission for other people to see the records. Finally, a report of the study might be submitted for publication, but individual participants will not be identifiable in such a report.

3.11.5 Protection from harm

The participants were assured that interviews were not harmful, and if they felt like they were not safe, they were free to withdraw at any time without any grudge. The researcher was aware that they might be vulnerable, and the issue of vulnerability was discussed with the gatekeepers and participants prior to the interviews. Should any difficult personal issues arise during this research, the researcher would endeavour to ensure that a qualified expert is contacted and able to assist them. The contact numbers of the researcher, as well as those of the research supervisor, appeared on the cover page of this request.

3.11.6 Achieving anonymity

Anonymity was achieved by assuring the participants that their names would not be recorded anywhere, and no one would connect them to the answers they give. Hard copies of answers would be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in the office for future research or academic purposes. Electronic information would be stored on a password-protected computer

3.11.7 Maintaining professionalism

The research followed the University of Free State's ethical principles and professional standards, which are critical for doing research responsibly.

3.11.8 Participants' vulnerability

The participants were informed that the interviews would not harm them, and that they might leave at any point if they felt unsafe. The researcher was aware that certain participants would be susceptible, which could be due to the fact that they were not used to interviews. As a result, the researcher had discussed this with the gatekeepers and the participants themselves. They were also promised that if any unpleasant personal difficulties arose throughout the research, a competent expert would be contacted and would be able to help.

3.12 CHAPTER SUMMARY

This chapter provided a description of the research methodology used in the study to answer the main research question. The study used the qualitative approach, as it was suitable for the theoretical ideas gathered from the interpretivist paradigm. The rationale behind the use of semi-structured interviews, sampling procedures, data generation methods, data analysis, and issues of ethical considerations was also provided. Semi-structured interviews and observations enabled enhanced flexibility when generating data on how practitioners used their conceptions of mathematical knowledge in enhancing mathematics at the ECD centres.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter is a discourse on the findings of the research in relation to practitioner conceptions of mathematical understanding in Early Childhood Development centres in the OR Tambo Inland District in the Eastern Cape Province. The presentation of the findings focuses on the analysis of data that was collected through semi-structured interviews and observations from the participants. Data produced was also designed to answer the primary research question: *How do early childhood practitioners' conceptions of mathematical knowledge enhance children's learning in mathematics?*

The following five themes emerged for the data analysis:

- Knowledge, importance, and the development of early childhood practitioner conceptions of mathematical knowledge;
- Kinds of mathematical knowledge practitioners draw on to develop mathematics in children;
- Challenges confronting practitioners within early learning;
- Intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children; and
- Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics.

Sub-themes were generated were generated by data emanating from the main themes.

Observations were also conducted, and photographs were taken. The photographs display the classroom arrangement as well as outdoor learning environments. Furthermore, they served as evidence of what had been witnessed in order to expand on the interviews. For anonymity purposes, pseudonyms were used for practitioners as stated in chapter three: for instance, P1 for practitioner one, P2 for practitioner two, etc. The following are discussions on the emerging themes and sub-themes, which

were introduced in order to address research questions according to the study objectives.

4.2 DEMOGRAPHICAL INFORMATION OF PARTICIPANTS

As is evident from Table 4.2.1, the participants of the study involved practitioners from five rural ECD centres in the OR Tambo Inland District, Eastern Cape Province. The demographic data of the five participants are presented in the table on the following page and are then discussed in the subsequent paragraphs.

PARTICIPANT	GENDER	LANGUAGE	AGES IN YEARS	OCCUPATION	QUALIFICATION	YEARS IN THE CENTRE
1.	FEMALE	ISIXHOSA	32	PRACTITIONER	LEVEL 4	3
2.	FEMALE	ISIXHOSA	44	PRACTITIONER	LEVEL 4	8
3.	FEMALE	ISIXHOSA	35	PRACTITIONER	LEVEL 4	5
4.	FEMALE	ISIXHOSA	43	PRACTITIONER	LEVEL 3	4
5.	FEMALE	ISIXHOSA	33	PRACTITIONER	LEVEL 4	3

Table 4.2.1: Demographic details of participants

The participants from the five centres who participated in the study were all females whose language of communication was IsiXhosa. Although IsiXhosa was the primary language, the researcher observed the use of English in some areas of instructions. The ages of the practitioners ranged between 30 and 45 years. The education qualifications of the practitioners were as follows: four practitioners had level four certificates and one had level three. These were obtained from different NGOs and the Department of Education. The participant with level three indicated that due to financial constraints, she was unable to obtain her level four certificate. The years of experience of each of the participants differed; some ranging between three to eight years.

4.3 OBJECTIVES OF THE STUDY

This research was guided by the following objectives:

- Understanding the meaning ECD practitioners ascribe to mathematical knowledge;
- Understanding why knowledge of children's mathematical knowledge development matters within the ECD learning of mathematics;
- Understanding the importance of early childhood practitioners' conceptions of mathematical knowledge in enhancing children's learning of mathematics;
- Explaining the kind of mathematical knowledge ECPs draw on to develop early mathematics;
- Exploring ECPs' use of the mathematical knowledge in the development of early mathematics;
- Establishing the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning;
- Highlighting some of the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children; and
- Enable a new understanding of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge.

4.4 RESEARCH QUESTIONS

To answer the main research question: *How do early childhood practitioners' conceptions of mathematical knowledge enhance children's learning in mathematics?*

The following critical sub-research questions were identified:

- What meaning does ECD practitioners ascribe to mathematical knowledge?
- Why does the knowledge of children's mathematical knowledge development matter within the ECD learning of mathematics?
- What is the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics?
- What kind of mathematical knowledge do Early Childhood Practitioners (ECPs) draw on to teach early mathematics?
- How do ECPs use mathematical knowledge in the development of early mathematics?
- What are the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning?
- What are the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children?
- What are the new understandings of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge?

4.5 DESCRIPTION OF STUDY SAMPLES

As previously stated, the population of the study included a group of practitioners from five (5) selected ECD centres in the OR Tambo Inland District in the Eastern Cape Province. The sample comprised of one practitioner from each of the five (5) centres and were purposefully selected as information-rich participants related to the phenomenon of interest (practitioner conceptions of mathematical knowledge).

4.6. DATA ANALYSIS RESULTS

THEME	SUB-THEME
1. Knowledge, importance and the development of early childhood practitioner conceptions of mathematical knowledge	1.1. Specific roles of the practitioners in the centre 1.2. Professional development of the practitioners 1.3. Training of practitioners in early mathematics
2. Kinds of mathematical knowledge practitioners draw on to develop mathematics in children	2.1. Practitioner knowledge of mathematics curriculum 2.2. Mathematics content and pedagogical knowledge practitioners gained during education and training programmes 2.3. Practitioner knowledge of designing mathematics learning environments 2.4. Practitioner knowledge of play theories in mathematics
3. Challenges confronting practitioners within early learning	3.1. Lack of mathematical language proficiency 3.2. Conducive learning space for children's mathematics learning 3.3. Infusion of play in the teaching of mathematics
4. Intervention strategies to adequately enhance the practitioner's ability to conceptualise mathematical knowledge to facilitate learning in children	4.1. Workshops and training 4.2. Enhancement of parental and/or guardian's involvement in their children's development of mathematics

5. Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics	5.1. Use of mathematical knowledge in the class 5.2. Guidance of children during indoor and outdoor play
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Table 4.6.1: The themes and sub-themes that emerged from data analysis

The next part of this chapter deliberates on different themes with their corresponding sub-themes, accompanied by direct quotes from participants.

THEME 1: Knowledge and importance of early childhood practitioner conceptions of mathematical knowledge and child development

This theme arose during the semi-structured interviews with the practitioners. The knowledge and importance of practitioner conceptions of mathematical knowledge is elaborated through the practitioners' specific roles in the centre, their professional development, and training in ECD, mainly focusing on early mathematics.

Sub-theme 1.1: Specific roles of the practitioners in the centre

Practitioners play multiple roles in an ECD environment. These roles may vary slightly, depending on the children's ages (Howard, 2010). For children in day-care centres, practitioners must be able to understand and respond appropriately to their basic needs, such as feeding and toilet training in a clean, safe, and secure environment. This is evident, as practitioners confirmed:

P1: "The duty that I do is to change nappies for the babies, feed them, and teach other children that are three and four years old."

P5: "In the centre, I teach children and monitor them when they are writing and during their eating time."

In some of the centres, practitioners are aware of the fact that children come to the centre having knowledge gained from their background environments (cultural knowledge) and practitioners have to tap into the minds of the children and develop what they already know. This is confirmed by practitioners who stated:

P2: *“I help to develop the skills of the children and to make sure what they have and know [knowledge] is developed. I teach children.”*

P3: *“The work that I do is to collect the minds of the children through play and scribbling until they write something and understand that they are learning. I also teach them about colours and about toys like shapes and structure formation.”*

According to the findings, practitioners in rural ECD centres understood their roles in the centre. In addition, they acknowledged the need to develop mathematical skills and abilities in children, understanding the significance of guiding them in their play-based learning activities.

Sub-theme 1.2: Professional development of the practitioners

The findings indicated that early childhood development centre practitioners had undergone some sort of early childhood education preparation. These participants indicated their qualifications as follows:

P1 said: *“I had a level four certificate obtained from an NGO.”*

P2 indicated: *“I also had level four training from the Department of Education in 2019, but the certificate is not yet issued.”*

P3 stated: *“I obtained a level three certificate from an NGO and couldn’t study further due to financial constraints.”*

And she felt that not having a level four certificate reduced her chances of having deeper knowledge.

P4 had a level four certificate obtained from an NGO.

P5 also had a level four certificate from an NGO.

While there were some expectations originating from introducing practitioners to professional competency, professional practice, and ways of improving children's mathematics learning, they thought that the training they received was insufficient. Hence, the study suggests that equipping them with professional development programs can help increase their knowledge and change their instructional practises.

Sub-theme 1.3: Training of practitioners in early mathematics

In order for practitioners to have knowledge and understanding of early mathematics content and pedagogy, they need to attend special training or workshops. These workshops and special training provide practitioners with ECD programmes, which are stated in the NCF (DBE, 2015) as planned activities designed to promote the physical, mental, emotional, spiritual, moral, and social development of children from birth to nine years old. However, the findings from the study indicated that in all five centres, practitioners had not received any training or workshops based on early mathematics. This is a matter of concerns as training is instrumental in providing learners with basic skills.

The lack of training is seen in the responses of the practitioners when asked about their training in early mathematics:

P1: "There is no mathematics training or workshops received except the one I got during the level four certificate training and a crash course I got from the neighbouring centres."

P2: "I didn't get any mathematics training or workshops except the one I gained when studying a level four certificate whereby mathematics was one of the subjects. I usually get crash course training from neighbouring centres."

P3: “I didn’t gain any training in mathematics except during the time I was in level three training, where we were taught how to use bottle tops to teach counting in mathematics.”

P4: “No mathematics training gained, and the only one I got was during the level four training, in which mathematics was one of the subjects taught.”

P5: “The only training in mathematics I got was during my level four training, in which mathematics was one of the courses.”

Training is essential to equip practitioners with the knowledge, abilities, beliefs, and attitudes necessary to help children develop their mathematics skills, motivating them to solve problems and think critically.

THEME 2: Kinds of mathematical knowledge practitioners draw on to develop mathematics in children

This theme is about the knowledge early mathematics practitioners gained during their professional development training and how they have used it to improve centre-based practices. In addition, practitioners, as early mathematics implementers in children, should have a proper understanding of what early mathematics is, with the perception that mathematical knowledge predicts the future learning of children.

Sub-theme 2.1: Practitioner knowledge of mathematics curriculum

The aim of the early mathematics curriculum is to help every child to develop knowledge, skills, attitudes, and behaviours for life, which is done through prescription, materials, and methods (DBE, 2015). Moreover, a full curriculum contains details about what children should know, and scaffolding approaches and sequences to help children gain skills and knowledge. When the researcher asked the practitioners about their knowledge of early mathematics curriculum, they revealed that there is no specific curriculum for early mathematics:

P1: "There are guidelines, but they are not clear, and I am not sure about where they come from. I just got them from the centre. Most of the time, I use the knowledge that I got during the training from the NGO."

P2: "Yes, there is a guide I use for mathematics, but it was extracted from Grade R mathematics. There is no guide or curriculum specific for ECD (0 to 4 years)."

P3: "No curriculum except copying from other practitioners of the nearby centres what is taught and when it is taught."

P4: "I use Grade R guidelines and crash course training and advice we get from other practitioners. Otherwise, there are no guidelines and curriculum, especially for pre-schools."

P5: "I use guidelines that were used during the level four training and no workshop and curriculum I had."

The DBE (2015) states that a curriculum is used to plan teaching or training. However, the practitioners' responses indicated that there was no mathematical curriculum, which caused them to be uncertain about what they were supposed to be doing in the centres.

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Sub-theme 2.2: Early mathematics content and pedagogical knowledge practitioners gained during education and training programmes

Lema (2019) states that many activities involved in the enhancement of mathematics in the early years include linking everyday experiences to abstract ideas. Hence, early mathematical content and pedagogical knowledge practitioners have is vital for the development of early mathematics in children. Shulman (1987) stressed the importance of content and pedagogical knowledge in mathematics as the knowledge that should be transformed in such a way that practitioners' content knowledge is appropriate for instructional practices in early mathematics settings. Moreover, pedagogical content knowledge should include practitioner conceptions of mathematical knowledge of how to represent the concepts, methods, and rules of the subject (mathematics). Following are the responses of practitioners on the issue of mathematical content and pedagogical knowledge:

P1: *“The training I got from the NGO helped to broaden my content mathematics knowledge and gave me a clue on how and what to teach in mathematics in the early years, but it is not easy to apply it because the centre lacks space and a conducive environment. It is difficult to form play areas and outdoor games because of lack of space, as the centre is renting in a yard that is also used by residents that are renting.”*

P2: *“During the training by the Department of Education, I was taught about play areas and their relationships in which mathematics is part of those areas. Like if I teach about shapes, I understood that they fall under the mathematics area. I gained knowledge of counting corners of the shape like three corners and four corners. I also gained knowledge about colours in shapes. Also, I gained knowledge of differentiating between mathematics area and phonics area. I learnt that when doing mathematics, you do it for at least a week or two to ensure that they understood before moving to another area like phonics. When teaching phonics, I introduce animals in which counting forms the part of teaching the phonics, e.g. a cow has four legs, 1, 2, 3, 4, and then children count the number of legs. Then I understand that there is an integration amongst the areas, which helped me a lot when doing my preparation.”*

P3: *“As I have mentioned before, in training, we were shown how to use bottle tops to teach children counting from 1-5 and how to add. Boys are to use blue coloured bottle tops and girls red coloured bottle tops.”*

P4: *“During my level four training, I was taught how to design a learning environment for mathematics, but since the centre lacks space, has congested classrooms and lacks resources, I am unable to design according to the training sessions. The only thing that is helping in mathematics are the charts that are hung on the wall.”*

P5: *“When I was doing my level four training, I was taught about the importance of the play areas, which included the mathematics play area. It is not easy to apply that due to lack of space in the centre.”*

Practitioner responses show that the pedagogical content knowledge they have was acquired during their training and was insufficient for developing mathematics fully in children attending the centres where they are teaching.

Sub-theme 2.3: Practitioner knowledge of designing mathematics learning environments

Regarding the issue of practitioner's knowledge on designing the learning environment, Lerman (2014) revealed that early mathematics teaching includes providing activities or creating learning environments in order to offer young children experiences aimed at stimulating the development of mathematical skills and concepts. However, in the ECD centres, practitioners were not trained on how to use the few available learning materials efficiently, and the conditions in which the ECDs are housed or run, both indoor and outdoor environments, are typically not up to scratch. This is revealed by practitioners in their responses, which included:

***P2:** "The centre is standing on its own, but the building is unable to accommodate children according to their ages. Indoor learning areas consist of play areas in which mathematics is included. In the mathematics play area, there are a few mathematics toys and objects, which include shapes, numbers, maps, charts, etc. The outdoor learning environments is an open space with swings, ladders which are not in good condition, and sand. All these children use them when playing, in which I direct the play activities."*

***P4:** "The centre does not have enough space as it is in the house also used as a residential area so, it is not easy, but we have some toys like swings, slides, and tyres used by children during outdoor play."*

***P5:** "I was taught about indoor and outdoor during my level four training, but the centre does not have enough space, so it is not possible to apply that knowledge."*

It would seem that one of the biggest issues practitioners in these centres face when designing a conducive learning environment is the space they are in.

Sub-theme 2.4: Practitioner knowledge of play theories in mathematics

Newton & Jenvey (2011) maintain that through play, children develop competence as they acquire skills of social engagement, co-operation, interaction, and sharing.

The practitioners had the following to say about play theories in mathematics:

P1: “I monitor children during play, especially during outdoor play. I am not aware of the theories of learning mathematics; I just watch them so that they must not endanger themselves.”

P2: “I direct and control indoor and outdoor play. I make sure that when playing, they don’t get hurt, and I know nothing about mathematics learning theories...”

P4: “I don’t monitor children when they are playing. They play swing and hoola hoops games on their own, and I only attend them when they fight. I know nothing about theories.”

Practitioner’s replies indicated that they lacked knowledge of play theories, thus they let children play while they worked on their own tasks.

THEME 3: Challenges confronting practitioners within early learning

Even though practitioners face a variety of problems and hurdles in ensuring that young children have access to high-quality early mathematical learning opportunities, the mathematical knowledge they possess influences the development of mathematics in young children. From this theme, three sub-themes developed which included lack of mathematical language proficiency, conducive learning space for children’s mathematics learning, and knowledge of infusing play in the teaching.

Sub-theme 3.1: Lack of mathematical language proficiency

Clements, Baroody & Sarama (2013) mention that for the development of verbal-based number concepts and skills, language, especially number words and quantitative phrases, is essential. Children coming to the centres for the first time, and coming from disadvantaged communities, face language barriers which negatively affect their learning of mathematics. Furthermore, to make the situation worse, some come into contact with the language of teaching for the first time at school. When

practitioners were asked about the difficulties they had while teaching at the centres, their responses revealed that they did have some difficulties:

P1: “I find difficulty in engaging children in the language of learning because these children don’t know how to communicate and I have to teach them for a long time because they don’t listen in class, they also forget very easily.”

P2: “During the training, we did not enter deep into mathematics and some of the mathematics terms were not explained further. I am struggling to translate some of the mathematics terms to the learners and to create mathematics language learning opportunities within mathematics content.”

P3: “As children come to school, they speak and understand their mother tongue. Then, as a practitioner, I have to teach them how we use the mathematics they have from their environment in the classroom. Some children will understand but others will start by being confused but during play they learn mathematics language from others.”

P4: “There are no workshops or training that are conducted to remind us of what we have done during our training. When I am going to teach a new concept, I visit the nearby centre to copy how certain concepts are introduced in the class.”

Practitioners did not receive any training or workshops, which is alarming because training could refresh their knowledge on mathematical subject and pedagogy, allowing them to feel more confident in their work in the centres.

Sub-theme 3.2: Conducive learning space for children’s mathematics learning

One of the most important aspects of a conducive learning environment is having a physical area where learners can sit comfortably, see and understand what their teacher is saying, and interact with their peers. Following are the responses of practitioners about conducive learning space for children’s mathematics learning:

P1: “As I have mentioned, the centre is renting in a yard used by other people, there is not enough space for indoor and outdoor learning. In the indoor learning environment, there are few toys and charts on the wall, and the lack of resources is the main problem as the centre does not get funding from the Dept. of Social Development. The outdoor learning environment comprises only a ladder with some broken steps on which the children climb up and down, and a swing painted in different colours.”

P2: “The training I got from the NGO helped to broaden my mathematical content knowledge and gave me a clue on how to teach mathematics in early years, but it is not easy to apply it because the centre lacks space and a conducive environment. It is difficult to form play areas and outdoor games as the centre is renting in a yard that is also used by residents that are renting.”

P3: “The centre has its building, but it is not maintained, and we don’t even have learning material to create the indoor learning environment and the few that we had we lost during the burglary that took place. For the outdoor learning environment, the few materials we have, like swings and seesaws that are damaged, need repairs.”

The learning environment for mathematics varies depending on the location of the centre. Further, a favourable mathematics learning environment promotes critical thinking, and students require a learning environment that accommodates a variety of learning styles. However, in the OR Tambo Inland district of the Eastern Cape, the situation is different. There are many reasons cited by practitioners in their responses, proving that the environment does not allow them to establish a conducive learning environment.

Sub-theme 3.3: Infusion of play in mathematics teaching

Playing with numbers helps children to get a broader knowledge of the subject. It encourages children to communicate, think, and reason as they work through mathematics problems, instilling a feeling of curiosity in children. In some centres, practitioners had little to no idea of how to infuse play in their teaching, which is seen in their responses:

P1: "I direct the activity during the outdoor play. Children climb up and down the ladder in turn and they count the number of steps as they are climbing. Then, when they are playing the swing game, they count how many times each will swing."

P2: "In the indoor play, children go to the mathematics area in which I direct the activity and give instructions, e.g. sitting on the mat with numbers. Then, I ask children to name the number written on the mat she/he is sitting on."

Outdoor games - *They play the swing game in which they count how many times each child swings. They also play a game in which they form a circle and one will touch them e.g. duck, duck, duck, goose and the one touched as goose will run around the circle and the first one to reach the destination is a winner. In this game I am doing physical activity and the game involves calculation as they calculate three times duck and the fourth one goose."*

P5: "In the classroom, I direct the play, and children learn according to the rules of what I am teaching. During the break, they play outside to swing and slide; I don't monitor them; I find time to do other things."

P3: "I know nothing about learning theories, and during outdoor play, children play on their own, and I find time to do my own things like preparing for the next day."

In other centres, practitioners had no knowledge of how to integrate play in their teaching and learning. It was observed that during outdoor play, they used the time to do their own things.

THEME 4: Intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children

On the matter of intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children,

practitioners' responses indicate that they urgently require intervention from a variety of stakeholders. Furthermore, bridging and teacher-led discussions, in which teachers openly connect a difficulty in class with an out-of-school problem, are two ways. Sitabkhan et al. (2019) discovered that instructional strategies can help teachers develop linkages between formal and informal mathematics.

Sub-theme: 4.1: Workshops and training

Teacher professional development, according to Muraya & Wairimu (2020), is identified as one of the major ways of addressing the challenge of teacher quality. It includes activities that increases teacher's knowledge, skills, expertise, and other desired attributes. This is how practitioners responded when asked about the suitable intervention strategy they needed:

P2: "The government should provide training on how to teach mathematics to children that are in rural centres where children are coming from low socio-income environments."

P4: "Regular workshops that train practitioners on early mathematics, exposing them to different techniques on how to implement mathematics concepts for young children. Also, guidelines and curriculum for early childhood are essential as they will provide methods and specific concepts to be introduced to children."

P5: "I think that visits and monitoring of centres by the Department of Education are necessary. The centres should be clustered so that practitioners can meet and talk about the problems they encounter and how to solve them."

Practitioners' comments suggested that, in order to be effective in their teaching, they require training that offers sound content and subject knowledge, as well as the ability to learn new concepts and methods. Furthermore, the training should highlight the creation of learning environments that allow children to improve their classroom performance.

Sub-theme 4.2: Enhancement of parental and/or guardians' involvement in their children's development of mathematics

Kaul (2010) considers the role of parents and caregivers as people who are critical in providing the child with a stimulating learning atmosphere. The NCF (DBE, 2015) also recognises the importance of the effective participation of parents, families, and communities in the ECD curriculum. However, when practitioners were asked about how they enhanced parental engagement in the learning of children's mathematics, the responses of practitioners suggested that the concept of parental involvement is missing:

P3: "Parents are very difficult, but we are trying, and we even put books in the child's school bag and ask the child to show it to the mother at home. It is then that the parent will show care, maybe by covering the book. Even if they are called to come and see the work of their children, only a few will come, and they don't even bother asking about the progress of their children. They don't even accompany their children to school; children use their scholar transport to and from school."

P5: "Parents are not at all caring about the education of their children. In the centre, we do our own things, and those interested will just attend some activities like excursions."

Practitioners in other centres were working hard to encourage parental involvement with the understanding that it provides a positive environment for the little one, and makes him/her do better in school when parents encourage learning at home. The results of the study also indicate that practitioners are doing their best to involve parents in their children's education, which includes early mathematics. This encouragement is seen in their responses:

P1: "I give children a little homework on what has been done in the class to make parents see that their children are learning in the centre. At times parents come to the centre with some things written or drawn by their children. By giving children

homework, I want them to be committed, even in their homes, and I also want their parents to help them.”

P2: *“When parents drop children off at the centre, we draw their attention by doing some activities like greeting activities, and the parent will see how we greet each other. I also communicate with parents through a message book in which we write announcements and some messages. When I see that the child is no longer coming to the centre, I make time to visit the home to check the problem. I also invite parents to parents’ tea meetings, and we discuss the progress of their children and some important issues that affect the centre. I also communicate with parents through a newsletter at the beginning of the year, which stipulates what is done in the centre and even in the learning areas. The newsletter also entails the activities that will take place during the year, like excursions and cultural days in which parents ask for notification of the events so they are able to provide support.”*

P4: *“As they have books for writing on, I call parents to an open day so that they can see the work of their children. I also write messages in their message books. We usually honour activities like cultural days and excursions in which parents accompany their children.”*

Practitioners’ responses showed that they were aware of the importance of parental involvement in their children’s education and how it affects academic achievement. While some parents may be unsure of how to assist their children with homework, guidance, and support, they can be actively involved in home learning activities and have the opportunity to teach, model, and guide their children. Furthermore, increased parental participation could lead to greater academic performance, school attendance, and child behaviour at home and in school.

THEME 5: Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics

Frye et al. (2013) mention that early mathematics teaching includes activities that are from multiple content areas, whereby the understanding of the concept of number and operations helps in creating the foundation of young children's mathematics understanding. Therefore, it is important for practitioners to have knowledge and understanding of concepts, operations, and the language used in early mathematics together with instructional practises.

Sub-theme 5.1: Use of mathematical knowledge in the ECD class

This sub-theme is about the instructional practises (pedagogy) of the practitioners in early mathematics development. When practitioners were asked how they use early mathematical knowledge in their classes, they responded as follows:

P1: "I give children books to draw mathematics drawings in, and most of them usually draw shapes. I also give them flashcards with numbers, throw flashcards on the floor and ask them to pick the number I have called. Again, I direct the activity."

P2: "Not at all times have children understood what you were teaching, but I am trying to teach through directed play activities. Children forget, as some of the activities I feel are of a higher level than children and the rural environment has a huge impact as some of the activities are done in English, which is not their mother tongue, e.g. when doing reversal, i.e. subtraction... there were five little ducks on the tree... one little duck fell... rollover. I have to teach this for a week or two as this is an operation that needs focus, understanding, and attention."

P3: "As I have already mentioned, I give them bottle tops and shapes and tell them what to do in the classroom like... count the bottle tops in the container... count the sides of the shape you are holding... then as they differ according to their thinking, I can see that others understand easily and can do counting practically and then focus

on those that don't understand easily to make them also understand as they learn differently."

P4: *"There is no mathematics play area because of space, and I just use charts to teach them counting. Then, they write numbers in their books. We also use fingers to count."*

P5: *"In mathematics, we don't enter deeply; we just use fingers to calculate. Numbers and counting are found during story time when asked... how many animals... then they count."*

Practitioners in some centres had an idea of how to direct activities during their instructional practices, but practitioners in other centres used traditional teaching methods to prepare children for formal schooling.

Sub-theme 5.2: Guidance of children during indoor and outdoor play

This sub-theme arose during the talk with practitioners about how they incorporated play-based mathematics activities for learning and growth. The researcher found that a relationship was made with free play when practitioners spoke about play and learning, and this was further classified into free-play indoor and outdoor activities. This may be due to a lack of understanding of the relationship between learning and play. These are the responses the researcher got when asking about playing:

P2: *"In the indoor play, children go to the mathematics area in which I direct the activity and give instructions, e.g. sitting on the mat with numbers. Then, I ask children to name the number written on the mat she/he is sitting on. They also write in their books."*

Outdoor games- *They play on the swing game in which they count how many times each child swings. They also play a game in which they form a circle, and one will touch them, e.g. duck, duck, duck, goose, and the one touched as goose will run around the circle and the first one to reach the destination is a winner. In this game, I*

am doing physical activity, and the games involve calculation as they calculate three times duck and the fourth one goose.”

The practitioner believed that learning and stimulation should take place at all times and that the practitioner has to incorporate different types of learning experiences inside the classroom.

P1: *Talked about the learning area that she creates where children play indoors: “Children go to the mathematics learning area, and I give children books to draw mathematics drawings, and most of them usually draw shapes. I also give them flashcards with numbers, throw flashcards on the floor and ask them to pick the number I have called. Again, I direct the activity.”*

Research on the value of outdoor play focuses on specific aspects like social, mental, and physical development (Gray, Gibbons, Larouche, Sandseter, Bienenstock, Brussoni & Tremblay, 2015). Also, the value of outdoor play is of vital importance to the practitioners, and this was associated with the development of motor skills.

P3: *“I just let them play swing and see-saw on their own, and I only attend when they quarrel.”*

P4: *“During outdoor play, children play on their own, and I find time to do my own things like preparing for the next day.”*

The responses revealed that practitioners at the OR Tambo Inland District ECD centres saw the outdoor play as a way to find time to do their own things while children played.

4.7 OBSERVATIONS

The researcher also carried out learning environment observations with the aim of establishing how practitioners used their conceptions of mathematical knowledge to develop mathematics in the classroom. The observation was conducted as a way of

seeing what is occurring naturally at the research site (McMillan & Schumacher, 2014). Moreover, the researcher wanted to witness how practitioners used their conceptions of mathematical knowledge during their instructional practices. Photos were taken of the learning environments. The findings obtained from the observations below are related to the learning environment, class activities, and instructional practices.

4.7.1 Learning environment

Limited space made it difficult for the practitioners to form play areas, as the centres were operating in areas also used for tenants' residences. Against the walls were different charts, counting blocks, numbers, shapes with the names, days of the week, months of the year, alphabets, seasons of the year, and some examples of the children's work.



Figure 4.7.1.1: Indoor learning environment (1)

The first centre was operating in the area that was also used by tenants. The outdoor play area had swings and slides that were congested and constructed with painted tyres. There was no grass in the outdoor area, making it very sandy and dusty.



Figure 4.7.1.2: Outdoor learning environment (1)

The outdoor play area in the second centre had jungle gyms, swings, slides and playing areas constructed with painted tyres. Although the centre had these resources, some facilities were in dire need of repair.



Figure 4.7.1.3: Outdoor learning environment (2)

The outdoor space had different types of material for the children to use, such as tyres, swings, and a jungle gym which were all in bad condition.



Figure 4.7.1.4: Outdoor learning environment (3)

The third centre was operating in a stand-alone building with very small rooms, which became inadequate when all the furniture was laid out. The mathematics play area was created, but it was congested due to a lack of space.



4.7.1.5: Mathematics play area

The fourth centre was operating in a standalone site with a building designed for ECD. There was a carpet on the floor with no furniture, and children would sit on the floor.



Figure 4.7.1.6: Carpet floor

Various pictures were hung on the wall with no mathematics learning area created.



Figure 4.7.1.7: Pictures hung on the wall

The fifth centre was operating in a house of the practitioner with tenants residing in the same yard. There were small rooms with furniture arranged for children to sit facing one direction. There were no play areas because of space, and the outdoor play environment consisted of swings, a slide, and painted tyres.



Figure 4.7.1.8: Outdoor play area

4.7.2 Class activities

Class activities were directed by the practitioners, and children learn according to the rules of the activity. During mathematics time, children would be allowed to use mathematics objects and toys; then, the practitioner would tell them what to do. They were given books to write some of the numbers as per the practitioner's instructions.

CHAPTER 5: DISCUSSION OF FINDINGS AND CONCLUSIONS

5.1 INTRODUCTION

This study aimed to explore how practitioners used their conceptions of mathematical knowledge to enhance mathematics in rural ECD centres in the OR Tambo Inland District, Eastern Cape Province. The following sub-questions were identified in order to make sense of the various dimensions of the main research question:

- What meaning does ECD practitioners ascribe to mathematical knowledge?
- Why does the knowledge of children's mathematical knowledge development matter within the ECD learning of mathematics?
- What is the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics?
- What kind of mathematical knowledge do Early Childhood Practitioners (ECPs) draw on to teach early mathematics?
- How do ECPs use mathematical knowledge in the development of early mathematics?
- What are the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning?
- What are the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children?
- What are the new understandings of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge?

5.2 DISCUSSION OF THE FINDINGS

This part of the study focuses on the discussions of findings obtained from the data collected through semi-structured interviews and observations to explore practitioner conceptions of mathematical knowledge in ECD settings. The data generated was also structured to answer the main research question: *How do early childhood practitioners*

use their conceptions of mathematical knowledge to enhance mathematics in ECD centres?

Demographic information of the participants and themes that emerged from an analysis of data are discussed. The themes included: *Knowledge, importance and development of early childhood practitioner conceptions of mathematical knowledge; kinds of mathematical knowledge practitioners draw on to develop mathematics in children; challenges confronting practitioners within early learning; intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children; practitioners' use of conceptions of mathematical knowledge to enhance early mathematics.*

5.2.1 Demographic information of the participants

5.2.1.1 Gender

All participants were women. No male participants were working as practitioners in the five ECD centres.

5.2.1.2 Language

The language of communication at all the ECD centres is IsiXhosa. However, the researcher noticed the use of English in some areas of instruction. This was evidence that the children are taught in IsiXhosa and English.

5.2.1.3 Qualifications

Four practitioners have level four certificates obtained from different organisations, which included NGOs and the Department of Education. Another practitioner obtained a level three certificate from an NGO and was unable to obtain level four due to financial constraints.

5.2.1.4 Occupation

Participants are practitioners in the ECD centres and are involved in the actual engagements with children.

5.2.1.5 Years in the centre

The participants have various years of experience at ECD centres ranging from three years to eight years. This is an indication that participants have experience in ECD centres; therefore, their views indicated in the findings are from persons who have experience in this field.

5.2.2 Themes and sub-themes

This part of the study discusses four themes and their sub-themes that emerged from the analysis of the data.

THEME 1: Knowledge, importance and development of early childhood practitioner conceptions of mathematical knowledge

Yadav (2017) states that mathematics has assumptions that include rules, procedures, and their application to give properties. Moreover, mathematics follows the logical method in its application for discovering new knowledge. Therefore, practitioners should have mathematics knowledge in the early years, which comprises main content areas that are mentioned by the National Council of Teachers of Mathematics and the National Association for the Education of Young Children (NCTM, 2000; NCTM & NAEYC, 2002, 2010) and the Common Core State Standards for Mathematics (CCSS-M, 2010) as number sense and operation; patterns and measurement; geometry and spatial awareness; and algebra and data analysis. Similarly, mathematical processes, such as problem-solving, reasoning, communication, connections, and representations, are vital.

Carrillo-Yañez et al. (2018) view mathematics as a network of systemic knowledge organised according to its own set of principles. For this reason, the early

mathematical content knowledge practitioners possess is seen in the correct application of rules and procedures. The theory of content pedagogical knowledge by Shulman (1986), which stresses that content and pedagogy (instructional practises) cannot be separated, underpins this study. Therefore, knowledge, importance, and the development of early childhood practitioners' conceptions of mathematical knowledge is depicted through sub-themes which are: *Practitioners' specific roles in the centre, their professional development, and training in ECD mainly focusing on early mathematics.*

Sub-theme 1.1: Specific roles of the practitioners in the centre

In an ECD environment, practitioners play multiple roles that may vary slightly, depending on the children's ages. For children in day-care centres, practitioners are expected to understand and respond appropriately to their basic needs, such as feeding and toilet training in a clean, safe, and secure environment. This was evident in the voices of practitioners when they indicated that their primary duties were to change nappies, feed babies, and teach young children aged between three and four years old.

P1: "The duty that I do is to change nappies for the babies, feed them and teach other children that are three and four years old."

P5: "In the centre, I teach children and monitor them when they are writing and during their eating time."

It is evident that they had various ways of looking at or interpreting the positions they were expected to perform in early childhood centres. According to the DBE (2015) the National Curriculum Framework emphasises self-perceptions of the roles of practitioners as observing children in their care, planning, and delivering services that support children's developmental learning needs and expectations. How practitioners viewed their roles in early childhood centres was therefore in agreement with the perception that they were acting *in loco parentis*. They all agreed that they played an important role in the early childhood education centres.

Cooper & Hedges (2014) mention that as children learn the cultural practices and language used by their families and communities, for a practitioner to form trustworthy connections with them, one should be motivated to understand children's cultural knowledge and adjust to their understanding. In some of the centres, practitioners are aware of the fact that children come to the centre having knowledge gained from their background environments (cultural knowledge). This means that practitioners have to tap into the minds of the children and develop what they already know. This is confirmed by practitioners who stated:

P2: *"I help to develop the skills of the children and to make sure what they have and know is developed. I teach children."*

P3: *"The work that I do is to collect the minds of the children through play and scribbling until they write something and understand that they are learning. I also teach them about colours and about toys like shapes and structure formation."*

Bennett et al. (2013) reveal that cultural knowledge includes a set of practices, beliefs and values that give order and meaning to the life of a group, with learned language, beliefs, values, and behaviours infused into every aspect of their lives. Thus, continuity between cultural knowledge in its diversity should form the foundation for instructional practices. Practitioners have to be aware of different cultures of children, making connections with them, which builds an understanding of children's experiences. The practitioners also talked about the professional development training they received; in which most of them have a level four certificate from various organisations.

While there were some expectations originating from introducing them to professional competency, professional practice, and ways of improving children's mathematics learning, the practitioners thought that the training they received was insufficient. They view the training they received as limited as it did not focus on how to use conceptions of mathematical knowledge to enhance mathematics in ECD. The concept of professional development of practitioners is mentioned by Mofokeng (2018), who states that it is extremely important that professional practitioners of young children have a strong academic background in the study of play. This is necessary to best

evaluate problems and offer appropriate support to children who have a hard time playing, such as children with physical disabilities. Consequently, the practitioners in the five ECD centres have undergone some sort of early-childhood education preparation, which is revealed in their responses.

Sub-theme 1.2: Professional development of the practitioners

Practitioners were also asked about special training they received in early mathematics, with the understanding that in order for practitioners to have knowledge and understanding of early mathematics content and pedagogy, they need to have special training or workshops. Noviyanti & Suryadi (2019) stressed that practitioners need to possess mathematical knowledge, which is a skill, in order to improve their teaching quality in mathematics. Moreover, Jacinto & Jakobsen (2020) mention that practitioners need to understand that mathematical knowledge is needed to carry out their work as teachers of mathematics. It is also grounded in Shulman & Sykes' (1986) definition of the knowledge base for teaching, which they describe as the body of understanding and skills, values, character, and performance that together constitute the ability of a teacher to teach mathematics. The knowledge of content and pedagogy is prioritised by Shulman (1987) in his PCK theory as a special combination of early mathematics content and pedagogy, a combination that is unique to the field of practitioners in ECD and their own special form of professional understanding.

These workshops and special training should provide practitioners with ECD programmes that are stated in the DBE (2015) as planned activities designed to promote the physical, mental, emotional, spiritual, moral, and social development of children from birth to nine years. However, the findings from the study indicate that in all five centres, practitioners had not received any training or workshops based on early mathematics. The lack of training is not in line with the DBE (2018) whereby mathematical knowledge provides practitioners with the understanding that mathematics is a language that makes use of symbols and notations to describe numerical, geometric, and graphical relationships. Practitioners should not only possess academic knowledge that includes mathematics content provided during early mathematics training or workshops, but also pedagogical knowledge that helps to develop children's mental processes, enhance logical and critical thinking,

accuracy, and problem-solving contributing to decision-making (DBE, 2018). The findings indicate that the little knowledge of early mathematics practitioners received was gained during their professional development training. This lack of early mathematics training resulted in children lacking a proper foundation and background in mathematics, which might be the cause of poor performance in mathematics in ensuing grades.

THEME 2: Kinds of mathematical knowledge practitioners draw on to develop mathematics in children

This theme is about the knowledge acquired by early mathematics practitioners through their training, workshops, and seminars in professional development they attended and how they used it to enhance centre-based practices. Mathematical knowledge development, according to Lema (2019), includes a variety of activities that provide practitioners with the ability to mathematically equip and influence young children, which necessitates that they have basic knowledge and skills, as well as the ability to connect everyday experiences to abstract ideas. Furthermore, Rittle-Johnson (2017) emphasises the necessity for practitioners to have competency in mathematics, which includes conceptual knowledge, procedural knowledge, and procedural flexibility in young children, in order to appropriately develop mathematics in young children. Nguyen et al. (2016) revealed another branch of knowledge practitioners need for development of mathematics as counting competence, which is the ability to recognise that numbers represent quantities and have magnitudes, as well as mastery of one-to-one correspondence (understanding that each element in one set is paired with exactly one element from the other set).

Practitioners should have a proper understanding of what early mathematics is, with the perception that knowledge and understanding of early mathematics by children predicts their future learning. Under this theme, four sub-themes emerged, which included practitioner's knowledge of mathematics curriculum; early mathematics content and pedagogical knowledge gained during education and training programmes; practitioner knowledge of designing the mathematics learning environment; and practitioner knowledge of play in mathematics.

Practitioner responses on the issue of knowledge of mathematics curriculum indicate that, in all five centres, there was no well-defined curriculum and guidelines specific for early mathematics in ECD, especially in rural pre-schools. Furthermore, practitioners enhanced mathematics using different knowledge and information they gathered from different sources. One practitioner stated:

“Yes, there is a guide I use for mathematics, but it was extracted from Grade R mathematics. There is no guide or curriculum specific for ECD (0 to 4 years).”

Other responses reveal that the lack of curriculum had caused practitioners to discover various plans of teaching which might be out of context, as they responded:

“No curriculum except copying from other practitioners of the nearby centres what is taught and when it is taught.”

“I use Grade R guidelines and crash course training and advice we get from other practitioners. Otherwise, there are no guidelines and curriculum, especially for pre-schools.”

The responses from practitioners indicate the non-availability of early mathematics curriculum in rural ECD centres, which is worrisome. Practitioners have different ways of developing mathematics, as most of them mentioned, through the knowledge they gained during their professional development training. Davies (2017) asserts that practitioners are shaped by the knowledge mix that influences their instructional practises, which is caused by the unstructured, informal nature of early education. Yet, they are key decision-makers in the curriculum who use a variety of knowledge and understanding of early childhood development focusing on mathematics. This indicates that the training practitioners had received in early mathematics was obsolete and out of context. Training assists in the occurrence of appropriate curriculum planning and also facilitates meaningful learning for children, contributing to the practitioners' confidence and professional growth (DBE, 2015).

The inappropriate training practitioners received made them feel unsure of what they should do in the centres, especially regarding mathematics. This resulted in a lack of confidence and professionalism in teaching mathematics concepts to young learners. Therefore, the researcher is of the opinion that the poor-quality teaching in the early grades has a direct impact on learner performance in later grades. The present study therefore advocates that the practitioners should be encouraged to develop their skills and knowledge through in-service training, workshops, and seminars. The importance of curriculum for early childhood is elaborated by the DBE (2015), which states that the curriculum is about all the experiences children will have in different settings, and includes what children feel, do, hear, and see in their early childhood settings. Furthermore, its aim is to help every child to develop knowledge, skills, attitudes and behaviours for life, which are done through prescription, materials, and methods (DBE, 2015).

Regarding the content and pedagogical knowledge, practitioners' responses depicted that they had learned a lot about early mathematics content, but only during their professional development training. During their training, practitioners grasped the core facets of early mathematics, like mathematics play area and counting. The knowledge they received was content mathematics knowledge, and very little pedagogical knowledge is reported. Mishra & Koehler (2008) explain content knowledge (CK) as teachers' knowledge about the subject matter to be learned or taught, and pedagogical knowledge (PK) as teachers' deep knowledge about the processes and practices or methods of teaching and learning. Therefore, the two cannot be separated. However, early mathematics pedagogical knowledge of practitioners of rural ECD centres in the OR Tambo Inland District is not in line with Shulman's (1986) theory of Pedagogical Content Knowledge (PCK), in which the study is embedded. Shulman (1986) also stresses that PCK should be transformed in such a way that practitioners' subject-matter knowledge (SMK) should be appropriate for instructional purposes (PK) in mathematics in early childhood settings.

Pedagogical content knowledge for early mathematics should include practitioner conceptions of the mathematical knowledge on how to represent the concepts,

methods, and rules of the subject (mathematics). However, the missing pedagogical knowledge of practitioners resulted in them being unable to confidently develop early mathematics in children. Pedagogical content knowledge for early mathematics is vital in that it also provides the knowledge and understanding of how children learn and understand mathematics as they develop. Through this knowledge, the practitioner will gain skills to support young children's learning of mathematics, providing them with a better chance of fulfilling their mathematics academic potential. The importance of child development is mentioned by Kühne et al. (2013), who assert that babies start to make sense of the world in mathematical ways from birth, recognising the difference between small numbers of objects and identifying familiar shapes and patterns in the environment around them. Lema (2019), as previously stated, asserts that many activities involved in the enhancement of mathematics in the early years include the linking of everyday experiences to abstract ideas. Early mathematical content and pedagogical knowledge practitioners have is therefore vital for the development of early mathematics in children. Practitioners should understand that mathematical pedagogical knowledge is necessary to carry out the work of developing mathematics in children (Haylock & Cockburn, 2008).

On the issue of practitioners' knowledge of designing the learning environment, Lerman (2014) revealed that early mathematics teaching includes providing activities or creating learning environments by professionals, like practitioners and caregivers, aimed at offering young children experiences that stimulate the development of mathematical skills and concepts. Children are sensitive and easily impacted by their surroundings, so the environment in which they are located affects them. Therefore, the physical setting of ECD centres has a great impact on the actions of children and also affects their behavioural patterns. The results of the analysis show that the learning resources in all five ECD centres were minimal, and the few that were available were not in good condition. Additionally, practitioners were not equipped at all on how to use the few learning resources available effectively due to the conditions under which the ECDs were housed or operated, resulting in indoor and outdoor environments that were typically not up to scratch.

These findings correlate with the study conducted by Sotuku et al. (2016) in the Eastern Cape Education District where physical environments in the centres not only present health and security hazards to little children learning in such environments, but also affect the learning and freedom children should be enjoying. Vinales (2015) recognises the learning environment as a central factor in children's learning that provides young children with important exposure, enabling them to improve their repertoire of abilities, awareness, attitudes, and behaviours to meet the expected competences. Therefore, the present study advocates that practitioners should be encouraged to equip themselves with knowledge and skills on how to create a learning environment that is safe and secured. As mentioned by Strauss (2015), a safe and secure learning environment is an area in which young children build ideas and make sense of their experiences.

Early researchers who investigated the use of play for early development include Piaget (1962), whose constructivist theory identified play as a means by which individuals can integrate new information into their already existing schemas; and Vygotsky (1967:62), who regarded play as the leading source of development in the preschool years. Newton & Jenvey (2011) maintain that through play, children develop competence as they acquire skills of social engagement, co-operation, interaction, and sharing. Early childhood professionals who are familiar with and understand developmental theories of play will be better equipped to use play as a setting for instruction and assessment (Mofokeng, 2018).

The practitioners' responses to play theories revealed that they lack knowledge and understanding of play and theories related to educational play. It is evident that planning procedures are teacher-directed, where the practitioner chooses the activities, their purposes, and their design, and then implements them. However, Epstein (2012) believes that children are able to solve problems and investigate through their play. Hence, it is crucial for practitioners to be encouraged to equip themselves with knowledge and skills through in-service training and workshops. Kotsopoulos & Lee (2014) also believe that young children are naturally curious during their first five years, and research shows that the best time to introduce mathematics

to young children is during this time, when their brain is rapidly developing. Thus, math in early childhood helps children develop critical thinking and reasoning skills early on, and it is the key to the foundation for success in the future. It is evident then that practitioners need to understand that mathematics learning can be taught through play, and it can be simple when the learning involves toys, games, songs, and books that are already a part of the child's daily learning experience.

THEME 3: Challenges confronting practitioners within early learning

Practitioners, as advocates for learning, have an ability to bring mathematics into practice utilising the mathematical skills they acquired during their professional development. However, they encounter a number of challenges that prevent them from fully developing mathematics in young children. Muraya & Wairimu (2020) mention teacher quality as one of the problems practitioners face, and it has an impact on their ability to conceptualise their mathematical knowledge. Unqualified teachers are unable to fulfil the educational objectives of the twenty-first century, thus significant effort should be concentrated on teacher quality in order to achieve quality education for children. Although the relevance of teacher quality as a determinant of student learning has been highlighted in the literature, the findings of the study revealed that practitioners of ECD centres in the OR Tambo Inland District lack specific characteristics of teacher quality required to develop mathematics in young children.

Language proficiency, according to Machaba (2019), is another barrier preventing practitioners from developing mathematics properly. It is vital for practitioners to comprehend the various ways in which language is used in the development of mathematics. Mathematics language, which includes number words and quantities, is important for the development of verbal based number concepts and skills, according to Clements et al. (2013).

The findings of the study on language proficiency as a barrier revealed that the OR Tambo Inland District practitioners had difficulty in engaging children in the language of learning mathematics. Furthermore, a practitioner in one of the centres complained about the lack of in-depth knowledge offered during their training, which made it

difficult for the practitioner to translate some mathematical concepts and construct mathematics language learning. Clements et al. (2013) mention subitizing, which recognises the total (cardinal value) of a collection without counting and labelling that total with an appropriate number word, which is the key foundation for other verbal-based number, arithmetic concepts, and skills.

According to Labuschagne (2015), children learn best in a well-designed, conducive environment. Sotuku et al. (2016) proclaim that poorly built ECD physical environments not only pose hazards to young children's learning in such settings, but also have an impact on the learning and freedom that children should have. It is important that practitioners are able to create a conducive mathematics learning environment.

The study found that practitioners in the OR Tambo Inland District ECD centres struggle to create a conducive learning environment due to a lack of space, as some of the centres were renting in yards that were also utilised by residents that are renting.

P1: "As I have mentioned, the centre is renting in a yard used by other people there is not enough space for indoor and outdoor learning. Space and lack of resources is the main problem."

Young children develop and learn about their world (e.g., people, nature, objects) by interacting with others, manipulating, and examining objects with their five senses (Tadesse, 2016). However, the study's findings reveal that, due to a lack of space and resources, the OR Tambo District practitioners experience difficulty in constructing indoor and outdoor play areas.

Fesseha & Pyle (2016) identify one of the challenges that teachers face as a lack of knowledge about play-based learning interpretations, resulting in misunderstandings about their role during play. Furthermore, Fesseha and Pyle (2016) also discovered that, while teachers claim to incorporate play in their classrooms, their practices do not

match true play practices; rather, play in their classrooms is linked to specific objects and is used separately from actual learning. Piaget (1962), whose constructivist theory identified play as a mechanism for children to integrate new knowledge into their previously existing schemas, was one of the first academics to investigate the use of play for early development. Through play in mathematics, children gain a broader understanding of the subject matter. Additionally, playing with numbers helps youngsters to talk, think, and reason while solving arithmetic problems, developing in them a sense of wonder. Nonetheless, the findings of the study revealed that infusing play in mathematics teaching was a problem for the OR Tambo Inland District practitioners. Furthermore, throughout both indoor and outdoor play, practitioners always direct the play and no free play is allowed. Mofokeng (2018) affirms that professional early childhood practitioners, who are aware of and comprehend developmental theories of play, are better prepared to use play as a context for instruction and assessment. Wood & Hedges (2016) also stress that learning through play has been subjected to cultural interpretation and policy revisionism, resulting in educational play, or eduplay, which is an important method for achieving academic objectives.

THEME 4: Intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children

Teacher professional development, according to Muraya & Wairimu (2020), is recognised as one of the major ways for tackling the challenge of teacher quality. According to them, it includes activities that increases teacher's knowledge, skills, expertise, and other desired attributes.

Machaba (2019) mentions teacher-led interaction as a strategy in which the teacher guides the children in their development and understanding, which can be important in the children's induction into discourses associated with the particular knowledge domains. Bridging and teacher-led conversations, according to Sitabkhan et al. (2019), are two tactics that can help teachers make linkages between formal and informal mathematics. Bridging and teacher-led discussions occur when teachers clearly relate a difficulty in class with an out-of-school problem.

The findings revealed that practitioners required intervention strategies namely workshops and training to improve their knowledge, skills, expertise, and other desired teaching attributes. It is also advised that the government arrange frequent mathematics workshops to introduce alternative approaches for putting mathematical concepts into practice.

Kaul (2010) considers the role of parents as caregivers who are critical in providing the child with a stimulating learning atmosphere. The DBE (2015) states that the effective participation of parents, families, and communities in the ECD curriculum is recognised. However, when practitioners were asked about how they enhanced parental engagement in the teaching of children's mathematics, the responses of practitioners suggested that the concept of parental involvement is missing. All the practitioners in all the centres indicated that they were working hard to encourage parental involvement with the understanding that it provides a positive environment for the young learners and makes them do better in school when parents encourage their children to learn at home. Despite the practitioners' hard work in involving parents in the education of their children, the results of the study indicated that parents were difficult and showed little interest in their children's education, which includes early mathematics.

Another option advised was for parents and guardians to become more involved in their children's mathematics development. In establishing a dynamic learning environment for their children, Kaul (2010) emphasises the responsibility of parents as caregivers. Effective parental, family, and community participation in the ECD curriculum is also valued, according to the DBE (2015). Despite the findings of the study, which revealed that practitioners made a concerted effort to involve parents, the majority of parents demonstrated a lack of concern for their children's education.

THEME 5: Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics

According to Frye et al. (2013), early mathematics instructional practices include activities from a variety of content areas, with the understanding of number and

operations assisting in the development of young children's mathematical understanding. As a result, knowledge and understanding of concepts, processes, and the language used in early mathematics, as well as instructional practices, are critical for practitioners. Therefore, this theme's sub-themes are covered in detail below.

Sub-theme 5.1: Use of mathematical knowledge in the ECD class

In this sub-theme, the focus is on practitioner's instructional practices (pedagogy) in early mathematics development. From the findings of the study, it is evident that the practitioners do have content knowledge and the skills on how to incorporate play in teaching and learning in early-childhood centres. Therefore, practitioners, as implementers of mathematical knowledge, have the power to equip and influence young children. Further, the DBE (2015) states that practitioners should identify the knowledge children already possess and build on that knowledge to help them reach the next developmental level and be able to explore their environment in order to solve problems, design things, and create their own questions. Despite that, literature suggests that practitioners perceive children as empty vessels that need to be filled, and this is where the use of children's cultural knowledge is missing. Additionally, for many of the practitioners, teaching and learning are about preparing the children for emergent literacy and becoming school-ready. Consequently, the current study supports that practitioners should be encouraged to equip themselves with knowledge of child development and early childhood programmes through professional development training and seminars.

Sub-theme 5.2: Guidance of children during indoor and outdoor play

This sub-theme came up during a discussion with practitioners about how they used play-based mathematics activities to help children understand more. When practitioners talked about play and learning, the researcher noticed that there was a misconception regarding the relationship between free play and learning, which was further separated into indoor and outdoor free play activities. The practitioners believed that learning and stimulation should not take place at all times and that the practitioner has to incorporate different types of learning experiences inside the classroom. However, research on the value of outdoor play focuses on specific

aspects like social, mental, and physical development and is of vital importance to the children as it is associated with the development of motor skills (Gray et al., 2015). The results showed that practitioners at the OR Tambo Inland District ECD centres saw outdoor play as a way to find time to do their own things while children played aimlessly. This is shown by their responses:

“I just let them play swing and see-saw on their own, and I only attend when they quarrel.”

“During outdoor play, children play on their own, and I find time to do my own things like preparing for the next day.”

The above findings indicate the lack of context and content, especially with regards to outdoor play in enhancing early mathematics. However, practitioners who possess knowledge of early mathematical content and instructional practices are able to understand how to infuse play (indoor and outdoor) in their activities and interpret children’s developing mathematical thinking (Ball, Thames, & Phelps, 2008). This study calls for practitioners who are knowledgeable in the content and pedagogy of play (indoor and outdoor play) to share their knowledge and best practices with their colleagues.

5.3 OBSERVATIONS

During observations, the emphasis was focused on interactions that took place during the development of mathematics by practitioners. Therefore, the researcher was a non-participant observer and did not participate in the class activities, offer suggestions about how to provide instruction, or interact with the learners. In addition, the researcher wanted to see how practitioners used their conceptions of mathematical knowledge during their instructional practices and took pictures. The findings from the observations were based on the learning environment, class activities, and instructional practices.

The learning environment was also observed, which is mentioned in the NCF (2015) as the environment that consists of the indoor and conducive outdoor environment

that is suitable for children's learning and development. In the indoor learning environments of some centres, the researcher observed that the class arrangements were in a formal manner, and children were seated at the desks facing in one direction. Moreover, limited space made it difficult for the practitioners to form play areas, as the centres were operating in areas also used for the residing of the tenants. This made it difficult for practitioners to enhance mathematics properly. One of the centres was operating in the area that was also used by tenants, the outdoor play area had swings and slides that were congested and constructed with painted tyres. There was no grass in the outdoor area, making it very sandy and dusty. The situation in these centres made it difficult for practitioners to create activities to develop mathematics during indoor and outdoor play.

In other centres, there was a carpet on the floor with no furniture, and learners would sit on the floor. There were no indoor play areas because of lack of space, and the outdoor play area had jungle gyms, swings, slides and playing areas constructed with painted tyres. Although the centre had these resources, some facilities were in dire need of repair. Classroom arrangement had children sitting facing in one direction. Furthermore, mathematics class activities were directed by the practitioners, and children learn according to the rules of the activity. Additionally, they were given books to write some of the numbers as per the practitioner's instructions. The findings of the study depicted that the condition in these centres made practitioners use traditional ways of instructional practises when enhancing mathematics. These traditional ways of teaching were revealed when children listened attentively to the instructions from the practitioner and responded as a group. Whole class teaching was used, and it resulted in the development of difficulties because no individual attention took place, and it was also difficult to identify problems using this method. These traditional methods of teaching showed that practitioners lack mathematics pedagogical knowledge of early mathematics.

5.4 SUMMARY OF FINDINGS

The discussion that follows presents reflections on the key findings and possible meanings.

THEME 1: Knowledge, importance and development of early childhood practitioner conceptions of mathematical knowledge

During the semi-structured interviews with the practitioners, this theme arose. The knowledge, importance, and development of early childhood practitioner conceptions of mathematical knowledge are elaborated through the practitioners' specific roles in the centre, their professional development and training in ECD, mainly focusing on early mathematics. Though practitioners seem to understand their roles in the centre, proper early mathematics training is lacking, preventing them from executing their roles properly. The DBE (2015) stresses that training practitioners should assist in the occurrence of appropriate curriculum planning and also facilitate meaningful learning for children, contributing to the practitioners' confidence and professional growth. Kaul (2010) also reveals that a planned curriculum should address connected areas of full development through an integrated play-based approach that focuses on the development of life skills. This has significant implications for in-service training programmes for practitioners where re-thinking should occur about how conceptions of mathematical understanding can be used to enhance learning in early childhood centres.

THEME 2: Kinds of mathematical knowledge practitioners draw on to develop mathematics in children

This theme is about knowledge of early mathematics practitioners gained during their professional development training, and how they have used it to improve centre-based practices. Practitioners as early mathematics implementers in children, should have a proper understanding of what early mathematics is, with the perception that mathematics knowledge predicts the future learning of children. However, it was discovered through contact with the practitioners that they lacked knowledge in the areas of curriculum, content, and pedagogy, as well as knowledge of how to build a healthy and stable learning environment. The concept of curriculum knowledge is supported by NCTM (2013), who mentions that young children in every setting should experience mathematics through effective, research-based curricula that should foreground mathematics learning and development as dependent on children's active participation in social and cultural experiences.

THEME 3: Challenges confronting practitioners within early learning

Under this theme the lack of mathematical language proficiency and incapacity to create a conducive learning environment for children's mathematics learning were among the challenges faced by practitioners of rural ECD centres. Labuschagne (2015) describes the learning environment as a place where children learn best if it is conducive and well-designed. Tadesse (2016) also supports the opinion of a conducive environment for children's learning, stating that young children develop and learn about their world (e.g. people, nature, objects) by interacting with people, manipulating, and examining objects with their five senses.

There was no understanding of mathematics play theories, making it difficult to develop mathematics in both indoor and outdoor play areas. For the proper development of children's mathematics skills, practitioners also need understanding and knowledge of the brain, and cognitive development of a young child, and how it relates to mathematical development, which will also help develop the skills practitioners need to support maths skills in young children (MacDonald, 2018).

THEME 4: Intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning in children

This theme discovered that, despite the difficulties faced by practitioners in the development of mathematics, intervention techniques might be used to overcome these difficulties. Machaba (2019) mentions the importance of mathematical language in the development of verbal based number concepts and skills. Teacher professional development is mentioned by Muraya et al. (2020) as the major strategy to overcome teacher quality by providing knowledge, skills, expertise and other desirable attributes of teachers. Bridging and teacher-led discussions, which take place when teachers relate the difficulties they experience in the class with out-of-school problems, were suggested by Sitabkhan et al. (2019) as another strategy.

THEME 5: Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics

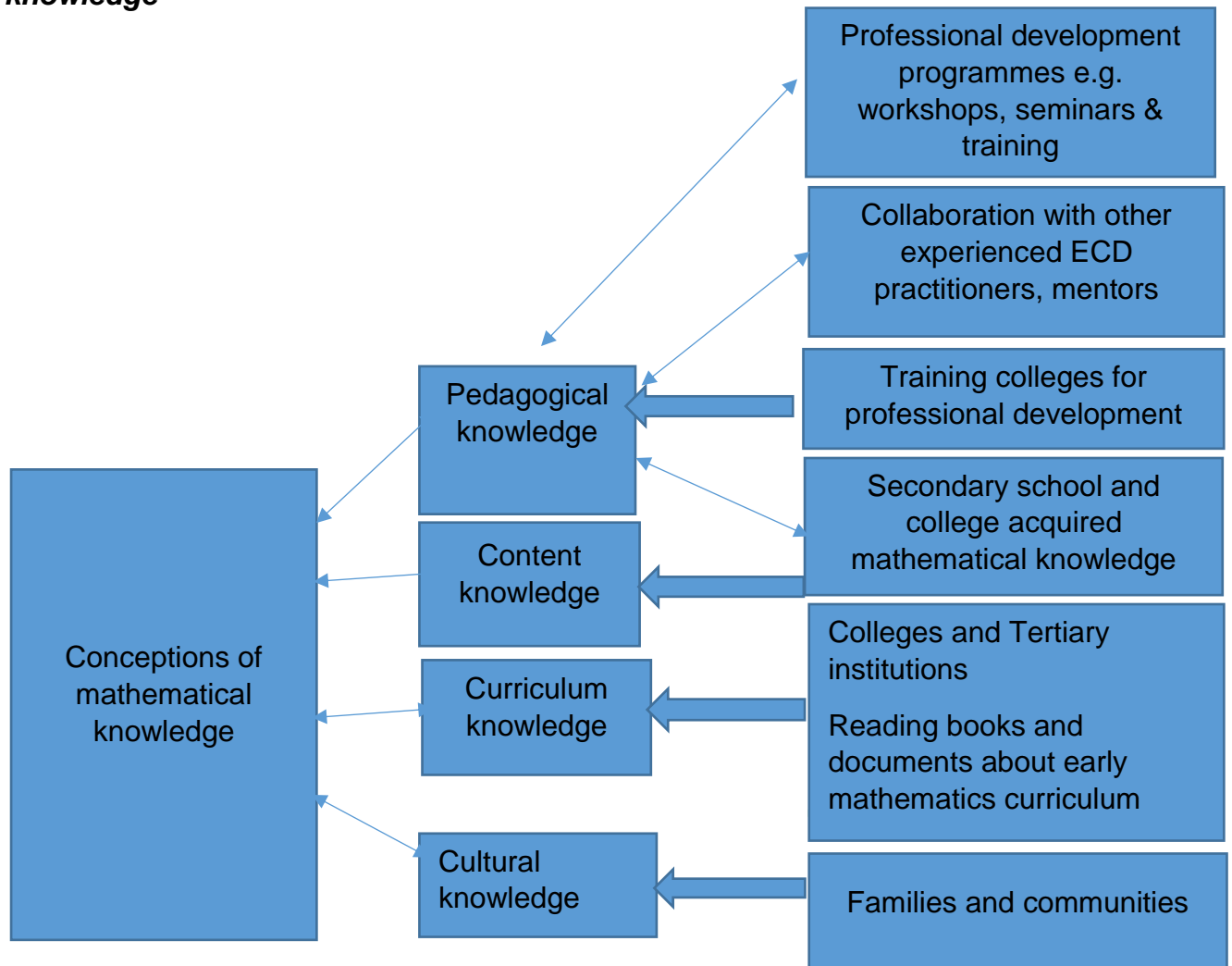
When asked how they integrate play into teaching and learning in early-childhood centres, practitioners stated that they guided the activities during indoor play and let children play on their own during outdoor play. Additionally, practitioners were trying very hard to involve parents in the education of their children. Peters & Rameka (2010) highlight the importance of working in partnership with families, linking mathematics from home to centre, as being another effective strategy, as learning is seen as a social process. Furthermore, Peters & Rameka (2010) stress the issue of the role of parents as of vital importance in facilitating learning and instructional practices.

In this study, the summary of the findings indicated that practitioners in the OR Tambo Inland District in the Eastern Cape Province lack conceptions of mathematical knowledge to enhance mathematics in the ECD centres. One solution is that practitioners should attend regular workshops in order to be properly empowered with the necessary skills in terms of content and pedagogy. The study concludes that early mathematics content and pedagogy are intertwined in the process of instructional practices. This implies that, while early mathematics content cannot be separated from the ability to develop it, mathematics content alone does not guarantee effectiveness in developing the subject. In light of the above discussions, and findings of the study, Figure 5.4.1 below is a proposed model designed to improve practitioner conceptions of mathematical knowledge.

The model below shows that the components from the right-hand side of the model develop the cultural knowledge, content knowledge (CK), pedagogical knowledge (PK), and curriculum knowledge of practitioners. The study establishes that the PCK of the practitioners should be developed from professional development programmes, which include workshops, seminars, and conferences. Again, practitioners should gain their mathematics subject matter knowledge from high schools and colleges. The fact that practitioners lack knowledge of early mathematics curriculum shows that their knowledge of the curriculum should come from self-study, such as reading school documents concerning the curriculum, in addition to college acquired knowledge.

Practitioners should also possess cultural knowledge based on partnership with families and communities of children.

Figure 5.4.1: Proposed model for practitioner conceptions of mathematical knowledge



5.5 IMPLICATIONS OF THE STUDY

The implications of the study are discussed below and include implications for the participants, implications for the policy, and implications for the practice.

5.5.1 Implications for the participant

This study highlights that practitioners in ECD centres in the OR Tambo Inland District lack conceptions of mathematical knowledge in their enhancement of mathematics in young children. This is due to particular types of formal knowledge and their related

practices being controlled. These practices are based on universal principles of best practice for teacher-education in early childhood, which was normally developed through the lenses of how practitioners were trained in early mathematics content and pedagogy. Therefore, accuracy created many exclusions for practitioners performing in vulnerable contexts. Yet, it is revealed by the DBE (2015) that a reflective ECD practitioner facilitates learning, and also observes all children in their care and offer activities that support their developmental learning needs and interests. Moving with the notion by the DBE, Selmi (2015) divulges that mathematics skills include a large portion of early mathematics that focuses on a far-reaching understanding of abstractions and generalisations that assist young children in connecting ideas, developing logical thinking, and analysing events that occur in the world around them. The focus of practitioners should therefore be put on conceptions of mathematical knowledge, which include content and pedagogy, which are the important aspects of teacher development.

The aspect of content and pedagogy is elaborated on by Mishra & Koehler (2006), who revealed that Pedagogical Content Knowledge exists at the intersection of content and pedagogy, as it goes beyond a simple consideration of content and pedagogy in isolation from one another. Empowering and validating the work practitioners do through sharing their early mathematics knowledge with others is crucial. This gives the practitioners the opportunity to see that their early mathematics knowledge is relevant to the policy and in their real-life context.

Results of this study revealed that the practitioners in the disadvantaged context could convert difficulties they encounter in the centres by creating different combinations to make early childhood education workable for the children in their care. The findings also indicated that practitioners in ECD centres in the OR Tambo Inland District currently possess minimum qualifications of level four certificates. The researcher, therefore, advocates that practitioners should be encouraged to empower themselves with mathematical content and pedagogical knowledge and skills through workshops, seminars, and conferences. Additionally, they should consider programmes leading to

qualifications in higher education in ECCE (birth-to-four) for teachers, which is a gateway to further qualifications.

5.5.2 Implications for policy

This study comes at a time when rapid changes are being affected, whereby attention has been drawn to the value of ECD in South Africa. In White Paper 5 (2001), it is stipulated that the democratic government wishes to redress the inequalities of the past by increasing access to Early Childhood Development (ECD) programmes, and putting in place an action plan to address the early learning opportunities of all children, including the disadvantaged ones. Moreover, it is stated in the National Integrated Early Childhood Development Policy (2015) that a focus has been placed on Early Childhood Care and Education in which the South African sustainable development goal focuses on a quality provision of education in early childhood. The National Integrated Early Childhood Development Policy (2015) also states that the Government of the Republic of South Africa has prioritised ECD within its National Development Plan 2030: Our Future – make it work. The policy aims at transforming Early Childhood Development service delivery in South Africa in particular, to address critical gaps and ensure the provision of comprehensive, universally available, and equitable Early Childhood Development services. However, the findings of the current study reveal that practitioners in the five centres in the OR Tambo Inland District did not have sufficient training in early mathematics content and pedagogy, which is a requirement for developing mathematics in children to accomplish the aims of the NDP 2030. This was perceived during their instructional practices in the centres, which were not aligned with the policy, as they used traditional ways of enhancing early mathematics in children. It is stated by the DBE (2015) that early childhood practitioners make decisions based on a specialised body of knowledge, continue to learn throughout their careers, and are committed to providing the best care and education possible for every child.

The implication of the Department of Education not providing proper professional development training is that the performance of the practitioners leaves much to be desired. Instead of using current ways of enhancing early mathematics in children,

practitioners are stuck on traditional ways of instructional practises as the Department of Education does not expose them to the policies and does not monitor the implementation as expected. This lack of involvement has far-reaching implications in terms of the quality of children's mathematical knowledge and understanding when they enter into another phase, which impedes children's future performance in mathematics. Based on information gained from this study, the researcher is of the opinion that the Department of Education should intervene by using properly qualified practitioners in the content and pedagogy of early mathematics to cater for the NDP 2030 in terms of quality and stability for the current society.

5.5.3 Implications for practice

The roles and responsibilities of teachers are multiple and varied. The implementation of the National Curriculum Statement by the DBE (2015) is one of the implications for teachers' development. The NCF is flexible in nature and facilitates the autonomy of the practitioners through their conceptions of mathematical knowledge, which becomes practical in the SA context. Through the implementation of the framework, the participatory rights of the child come to the fore to be acknowledged by the practitioners as not being a threat, but where the practitioner and child are collaborators in a co-structor relationship. Therefore, the collaboration will be of good quality in a community of practice if practitioners consider cultural knowledge as the foundation for their instructional practices. Cooper and Hedges (2014) state that when children learn the cultural practices used by their families and communities, a practitioner should be inspired to understand the cultural knowledge of children and respond to their understanding in order to develop trustworthy relationships with them.

Moving to the issue of curriculum knowledge, a flexible curriculum allows for conclusions to be taken by practitioners in a disadvantaged context in order to plan for responsive practice that adheres to their needs according to their context. Additionally, the aim of the curriculum is to help every child to develop knowledge, skills, attitudes, and behaviours for life, which are done through prescription, materials, and methods (DBE, 2015). All the necessities of the curriculum can be accomplished by practitioners who have sufficient knowledge and understanding of the early

mathematics curriculum. The study suggests that ECD practitioners should be encouraged to furnish themselves with the knowledge and understanding of the early mathematics curriculum. Moreover, curriculum knowledge will assist practitioners in appropriate curriculum planning and also facilitates meaningful learning for children, contributing to the practitioners' confidence and professional growth (DBE, 2015).

Another implication is that thorough mathematics subject and pedagogical knowledge can lead to deeper engagement with children through advanced scaffolding techniques. Frye et al. (2013) stress that early mathematics teaching includes activities that are from multiple content areas whereby the understanding of the concept of number and operations acquired from the content knowledge help in creating the foundation of young children's mathematics understanding. Practitioners should therefore acquire various kinds of mathematical knowledge, knowledge of child development, and theories of early childhood education through different ways and even a higher qualification, which can supplement the knowledge of early mathematics they already have.

5.6 CONCLUSION

This chapter presented the discussion of findings of the data, which were thematically analysed to answer the research question by establishing how practitioners use their conceptions of mathematical knowledge to enhance mathematics in rural ECD centres in the OR Tambo Inland District, Eastern Cape Province. Furthermore, the themes that emerged from analysed data included: knowledge, importance and development of early childhood practitioner conceptions of mathematical knowledge; kinds of mathematical knowledge practitioners draw on to develop mathematics in children; challenges confronting practitioners within early learning; intervention strategies to adequately enhance the practitioner's ability to conceptualise mathematical knowledge to facilitate learning in children; and practitioners' use of conceptions of mathematical knowledge to enhance early mathematics. These themes were endorsed by sub-themes. Implications of the study on participants, policy and practise are also discussed.

CHAPTER 6: FINDINGS, RECOMMENDATIONS, AND FURTHER RESEARCH

6.1 INTRODUCTION

The aim of this study was to explore practitioner conceptions of mathematical knowledge in early childhood development. The major objective of the study was to explore how practitioners use their conceptions of mathematical knowledge to enhance mathematics in ECD settings. The purpose of the study was also to investigate whether the use of conceptions of mathematical knowledge was available to bring improvements to the mathematical knowledge and classroom practices, to clarify the kinds of mathematical knowledge practitioners draw on to develop mathematics and to enable new understandings of the use of mathematical knowledge. The study sought to answer the following research questions:

- What meaning does ECD practitioners ascribe to mathematical knowledge?
- Why does the knowledge of children's mathematical knowledge development matter within the ECD learning of mathematics?
- What is the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics?
- What kind of mathematical knowledge do Early Childhood Practitioners (ECPs) draw on to teach early mathematics?
- How do ECPs use mathematical knowledge in the development of early mathematics?
- What are the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning?
- What are the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children?
- What are the new understandings of ECPs' use of mathematical knowledge based on their conceptualisation of mathematical knowledge?

6.2 ANSWERING RESEARCH QUESTIONS

6.2.1 Sub-research question 1

What meaning does ECD practitioners ascribe to mathematical knowledge?

According to the findings of the study, practitioners did not receive any early mathematics training or workshops, leaving them unsure of what knowledge they needed to fully teach mathematics to children. In addition, the lack of a mathematics curriculum caused them to be unsure of what to teach, since they stated that they copied from nearby centres.

6.2.2 Sub-research question 2

Why does the knowledge of children's mathematical knowledge development matter within the ECD learning of mathematics?

The mathematical knowledge practitioners encompass should assist in understanding that teaching young children mathematics is about guiding them in making connections between conceptual knowledge and pedagogical knowledge. In addition, the mathematical knowledge practitioners possess is significant since many activities involved in the enhancement of mathematics in the early years entail relating everyday experiences to abstract ideas (Lema (2019). However, the study indicated that the knowledge that practitioners had gained during their professional development was insufficient for fully developing children to realise their full potential. As a result, they lacked confidence because they were unsure of what they were doing.

6.2.3 Sub-research question 3

What is the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics?

It is crucial for practitioners to acquire mathematical knowledge because they are

responsible for developing mathematic literacy so that children become numerate. Furthermore, Nguyen et al. (2016) state that it is important to understand the children's key competencies of mathematics understanding since this is a good predictor of later mathematics success. The findings of the study revealed that practitioners' lack of professional development training resulted in reduced productivity in the classroom, which was caused not only by the magnitude of effects that teachers' knowledge had on children's learning, but also by the types of teacher knowledge that matter most in producing children's learning outcomes. Therefore, teachers were expected to collect new knowledge that was important to their core professional activity, as well as to keep their professional knowledge base up to date on a regular basis for the full development of mathematics in young children.

6.2.4 Sub-research question 4

What kinds of mathematical knowledge do Early Childhood Practitioners (ECPs) draw on to teach early mathematics?

The kind of mathematical knowledge that practitioners should possess, according to Rittle-Johnson (2017), is crucial in developing their full competence. In order for practitioners to teach mathematics to young children efficiently, mathematical thinking should incorporate conceptual knowledge, procedural knowledge, and procedural flexibility. The results of the study showed that there was no early mathematics curriculum in any of the five ECD centres. As a result, practitioners had limited understanding of early mathematics; hence, they developed mathematics in different ways, as most of them highlighted the minimal knowledge received during their professional development training. This also suggested that practitioners' early mathematical training was obsolete and out of context.

6.2.5 Sub-research question 5

How ECPs use mathematical knowledge in the development of early mathematics?

From the above, it is evident that the practitioners do not have content knowledge and the skills on how to incorporate play in teaching and learning in early-childhood centres. Children, as previously mentioned, are seen as empty vessels that need to

be filled, and the use of children's cultural knowledge is missing. Further, for many of the practitioners, teaching and learning were about preparing the children for emergent literacy and becoming ready for school.

6.2.6 Sub-research question 6

What are the challenges confronting practitioners/teachers that impact their abilities to adequately conceptualise mathematical knowledge within early year learning?

According to MacDonald (2019), the key challenge confronting practitioners is increasing their knowledge of early childhood mathematics in order to offer children high-quality mathematical education. According to the findings of the study, the problem in all five centres is a lack of professional development of practitioners, which is necessary to provide them with a fundamental understanding of early mathematics and knowledge of how to develop mathematics in young children.

6.2.7 Sub-research question 7

What are the intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children?

Sitabkhan et al. (2019) discovered that bridging and teacher-led dialogues, in which teachers explicitly relate a challenge in class with an out-of-school problem, are two methods that can assist teachers in developing linkages between formal and informal mathematics. The findings of the study show that for practitioners to improve their knowledge, abilities, experience, and other desired teaching attributes, they require intervention strategies like workshops and training. The findings also suggest that the government should conduct regular mathematics workshops to promote new ways of placing mathematical concepts into practice.

6.2.8 Sub-research question 8

What are the new understandings of ECPs' use of mathematical knowledge based on

their conceptualisation of mathematical knowledge?

Due to lack of training, practitioners utilised the minimal mathematical knowledge they obtained during their professional development training and copying from the neighbouring centres. Furthermore, the class sizes were too big and it was difficult to pay attention to all of the children during instructional practices. Due to the overcrowding in the centres, practitioners were obliged to use the lecture or question-and-answer method instead of current ECD instructional practices that emphasise play-based pedagogy. Children learn considerably more by touching, seeing, smelling, and tasting than by simply listening, so the use of teaching aids can be extremely beneficial in assisting children in their learning. However, teaching aids appeared to be in short supply in rural areas in the OR Tambo Inland District, and those that were accessible were old and in need of repair.

The circumstances forced practitioners to direct activities during indoor learning while allowing children to play on their own during outdoor activities. In addition, inside the classroom, peer learning, hands-on activities, and other modern teaching approaches were not used to teach mathematics. According to the DBE (2015), different strategies and instructional methods should be employed, and individual plans should be modified to match the needs of the children in that particular centre. However, due to a lack of early mathematics content knowledge, pedagogical knowledge, cultural knowledge, and awareness of play theories in the OR Tambo Inland District's centres, existing instructional practices are much more traditional and less participatory. Existing instructional practises at the centres are highly dependent on the performance of the practitioner only.

6.3 RECOMMENDATIONS

The findings, followed by recommendations, are discussed below.

Finding 1:

Understand the meaning ECD practitioners ascribe to mathematical knowledge.

Recommendation 1:

The Department of Basic Education, in partnership with the Department of Social Development, should make it compulsory for all ECD practitioners in South Africa to receive the appropriate training, capacity building, and an appropriately designed qualification to ensure that they are competent in the teaching of emergent mathematics in the early grades.

Finding 2:

Practitioners in rural centres in the OR Tambo Inland District lack understanding of knowledge of children's mathematical development within the ECD learning of mathematics.

Recommendation 2:

There needs to be quality education for practitioners and in-service programmes that focus on the following:

- Early mathematics content and pedagogy;
- Developing play-based mathematics programmes; and
- Supporting children's learning through play, which includes indoor and outdoor play.

To this end, the current wave of curriculum developers have to undertake the task of designing curriculum materials that will not only provide practitioners with guidance for classroom practice, but also foster practitioners' learning as they use them.

Finding 3:

The findings of the study reveal that practitioners lacked understanding of the importance of early childhood practitioner conceptions of mathematical knowledge in enhancing children's learning of mathematics.

Recommendation 3:

The study proposes that practitioners should equip themselves with knowledge and skills by attending workshops, conferences, and seminars to gain a better understanding of how children learn early mathematics. Furthermore, the knowledge that practitioners should possess should enable them to generate meaningful activities for mathematics that promote the development of learning communities.

Finding 4:

The study revealed that the practitioners experienced difficulties in explaining the kind of mathematical knowledge they draw on to develop early mathematics. It is also evident that practitioners used teacher-directed methods when enhancing mathematics in children due to a variety of factors, which include, lack of proper knowledge of early mathematics content and pedagogy, a lack of guidelines or curriculum for early mathematics, lack of cultural knowledge, and a lack of expertise about how to build learning environments.

Recommendation 4:

In order to effectively develop mathematics in children, practitioners should be encouraged to equip themselves with a variety of mathematical knowledge and strategies that are both intriguing and challenging to the mind. For example, encouraging children's mental activity with a metacognitive approach. Moreover, families can be educated and made fully aware of the importance of mathematical education. In this regard, schools may be expected to devote time to family involvement programs in order to improve their cooperation with families.

Finding 5:

The findings of the study indicate that practitioners have little understanding of how to use mathematical knowledge gained during their professional development in the development of early mathematics. In addition, practitioners lack knowledge and understanding of ideas, processes, and the language utilised in early mathematics, as well as instructional approaches that are crucial for practitioners.

Recommendation 5:

The researcher suggests that practitioners should collaborate with other centres to share ideas on how to develop mathematics in children. It is also recommended that training support and pedagogical orientation that encourages use of technology in the teaching and learning of mathematics be provided.

Finding 6:

Based on the findings of this study, there are challenges confronting practitioners that impact their abilities to adequately conceptualise mathematical knowledge within early year learning. Among the most prominent issues highlighted in the study were lack of mathematical language, conducive space for children's mathematics learning, and lack incorporation of play in mathematics teaching.

Recommendation 6:

The researcher suggests that bridging and teacher-led conversations, which are mentioned by Sitabkhan et al. (2019), be implemented as two strategies that can help teachers make linkages between formal and informal mathematics. Further, practitioners should be equipped with knowledge on the development of mathematics language, especially in the early years.

Finding 7:

The findings of the study reveal that there are some intervention strategies that can be employed to adequately enhance the practitioners' ability to conceptualise mathematical knowledge in ways to facilitate learning in children.

Recommendation 7:

According to the current study, professional development, which includes the activities that develop teachers' knowledge, skills, expertise, and other desirable characteristics of a teacher, is recommended. Additionally, the government should provide

intervention techniques for implementing the DBE's National Curriculum Framework (2015) in ECD centres.

Finding 8:

Through this research it has been discovered that practitioners lack knowledge and understanding of early mathematical concepts, operations, and language, as well as teaching practices. They were unable to conceptualise mathematical knowledge as a result of this deficiency, leading to the utilisation of traditional teaching methods that are not acceptable in the ECD sector.

Recommendation 8:

It is suggested that practitioners be provided curriculum development strategies to aid in the development of active classroom teachers and so improve their mathematical self-efficacy.

6.4 LIMITATIONS OF THE STUDY

The study used a small sample of five ECD centres and five participants; therefore, generalisations to include the wider population are difficult to make. However, whilst the study only included five early-childhood practitioners, they were chosen from different early-childhood centres in the district of the OR Tambo Inland District, Eastern Cape Province. This assisted with addressing issues of trustworthiness and allowed the researcher to make sense of how practitioners use their conceptions of mathematical knowledge in the context within which they work. The study focuses on practitioners only as units of analysis, and the findings are only applicable to the sample, which included the five practitioners at the five early-childhood centres. Another limitation is that the study needs more quantitative components to get further insight into the knowledge and practice of ECD practitioners' use of their conceptions of mathematical knowledge to enhance mathematics in children. Future research should be undertaken using mixed research approaches to provide population-level evidence. The limitations of this study were a result of time and financial constraints.

It is also an individual study for a qualification, and there were certain requirements that had to be fulfilled in terms of the scope of a focused study.

6.5 AREAS FOR FURTHER STUDY

The following suggestions for further research are put forward:

- A study on the importance of mathematical knowledge among ECD practitioners is recommended.
- A study that focuses on the professional development of practitioners, with an emphasis on early mathematics.
- A study into how early mathematical founts of knowledge can assist practitioners in developing early mathematics in children.
- An investigation into parental participation in their children's early mathematics education.
- A study of the various methods that practitioners may use to help young children in their learning and understanding of mathematics.
- A study of the challenges ECD practitioners encounter in the development of children's mathematics skills.

6.6 CONCLUDING REMARKS

The teaching and learning of mathematics has always been a complex and challenging endeavour globally, and the situation is no different in South Africa. First, that the improvement in the learning of mathematics in the classroom is related to

practitioner conceptions of mathematical knowledge. The study, therefore, presented an opportunity for the researcher to investigate how practitioners use their conceptions of mathematical knowledge to develop mathematics in ECD settings. The data collected through interviews and observations revealed a lot about practitioner conceptions of mathematical knowledge, and thereby enabled the researcher to offer some recommendations to address the situation.

One key aspect gained from this study was that practitioners are working very hard in unfavourable conditions to enhance mathematics. However, the lack of mathematical knowledge is very concerning, as ECD is the foundation for future learning of mathematics in children. The findings of the study revealed that for practitioners to successfully enhance early mathematics in children, they need to draw heavily on their own knowledge of early mathematics, which is lacking in rural ECD centres. Moreover, the findings of the study showed that the lack of conceptions of mathematical knowledge of practitioners made them use traditional methods when enhancing early mathematics in which activities are directed by the practitioner. Additionally, the traditional methods of transmitting early mathematics content and drilling information resulted in children who play a more passive role, increasing their reliance on the teacher's expertise and actions.

Since the emphasis was on ensuring correct information amongst children through teaching and learning, many opportunities for children to express their knowledge and wisdom were missed. In summary, many teaching and learning activities have taken place under strict practitioner control, with a focus on preparation for formal schooling. The *what* (content) and the *how* (method) of learning was scaffolded through the traditional techniques of telling, direct instruction, and demonstrations in these centres. A lack of mathematics knowledge and wisdom in children might lead to poor performance in mathematics in the ensuing grades. Further research on early mathematics knowledge practitioners should possess in developing mathematics is suggested to equip practitioners with relevant knowledge and understanding of little children.

6.7. OVERVIEW OF THE STUDY

Chapter 1 of the study provides the background and orientation as a way of introducing the study to the reader. The chapter reflects briefly on the problem statement, the study question, the aim of the study, i.e. to explore how practitioners use their mathematical knowledge to enhance the learning of early mathematics, and the study objectives, to justify the need for a strategy. The reader is also introduced to the method and design, as well as the theoretical framework chosen to underpin the study.

In **Chapter 2**, a range of literature was searched in order to appropriate the constructs of the current study within the existing research literature. The chapter reflects extensively on Pedagogical Content Knowledge theory as the underlying theoretical framework that underpins this study. The operational concepts of the study are discussed, which include the definition of mathematics, cultural knowledge, pedagogical content knowledge of mathematics, curriculum knowledge, and disciplinary knowledge of mathematics. The literature indicates that, although much research has been conducted on the use of conceptions of mathematical knowledge, little has been done on how these conceptions of mathematical knowledge are used to enhance mathematics in rural ECD centres, specifically in the OR Tambo Inland District in the Eastern Cape Province.

Chapter 3 describes the qualitative methodological approach used in the case study to present five cases at early childhood centres. The chapter provides an outline and justification of the purposive sampling method that was used to explore practitioner conceptions of mathematical knowledge to enhance mathematics. In addition, the study outlined the data generation methods that were used. Next, the analytical data procedures are described that are employed to make meaning of practitioner conceptions of mathematical knowledge.

The following themes emerged from the analysis of the data:

- Knowledge, importance and development of early childhood practitioner conceptions of mathematical knowledge;
- Kinds of mathematical knowledge practitioners draw on to develop mathematics in children;
- Challenges confronting practitioners within early learning;
- Intervention strategies to adequately enhance the practitioners' ability to conceptualise mathematical knowledge to facilitate learning; and
- Practitioners' use of conceptions of mathematical knowledge to enhance early mathematics.

In **Chapter 4**, the research data is presented to describe practitioners' experiences of conceptions of mathematical knowledge in developing early mathematics. These results are embedded in the relevant themes and sub-themes that emerged from the data.

In **Chapter 5**, the findings of the study are presented in respect of the themes and sub-themes that emerged in chapter four. The chapter also makes use of the themes to provide further analysis of the stories in chapter four, by discussing how each of the practitioners provided information with regards to conceptions of mathematical knowledge to enhance the learning of mathematics.

Finally, **Chapter 6** presents a summary of findings, recommendations, and conclusions. In addition, an outline of the recommendations and directions for future research is provided.

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APPENDIX A: PERMISSION LETTER TO THE DEPT. OF SOCIAL DEVELOPMENT

Researcher

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02 July 2020

The Senior Officer
Dept. of Social Development
Bisho
Eastern Cape

Dear Sir/Madam,

RE: REQUEST TO CONDUCT RESEARCH IN ECD CENTRES OF OR TAMBO INLAND DISTRICT

This letter serves as my request to conduct observations and interviews with practitioners in five centres of OR Tambo Inland District. I, Neliswa Gqoli, student number 2017320611, am a registered student at the University of the Free State pursuing the degree, PhD in Early Childhood Development. Currently, I am busy with a research project aimed at exploring practitioner conceptions of mathematical knowledge in early childhood development. Hence, the preliminary topic of my study is:

Practitioner conceptions of mathematical knowledge in Early Childhood Development.

As part of my project, I need to conduct interviews and observations with practitioners in early childhood centres. I, therefore, humbly request your permission to conduct interviews with practitioners in five ECD centres of OR Tambo Inland District. I believe their expertise in the field of Early Childhood Development would add value to my study, and it will enable me to achieve the aim of this project.

Interviews are completely voluntary; that is, participants are free to choose whether or not to participate. Participants are also free to withdraw from the interview at any time should they feel that they cannot continue. Also, interviews are confidential, and data generated will be handled with the utmost care to protect participants' identities and that of the schools they are affiliated with. To ensure confidentiality, I will use pseudonyms.

Let me further assure you that participant participation in the study will not be harmful to anyone or their schools and that as a researcher, I will try my best to protect both and to treat them with utmost respect and dignity. Interviews will be tape-recorded as a way of capturing all the information, and the interview will be approximately thirty minutes long. Furthermore, the interviews will be conducted at a time and a place that is convenient for the participants. However, it will not disrupt activities at any centre. I promise to answer any questions that you might have during or after the interviews as honestly as I can. My contact numbers, as well as those of my supervisor, appear on the cover page of this request. Please feel free to contact any one of us should you need more information.

I am waiting in anticipation of your response.

Sincerely

.....

Neliswa Gqoli

APPENDIX B: ETHICAL CLEARANCE



GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

26-Aug-2020

Dear Ms Neliswa Gqoli

Application Approved

Research Project Title:

PRACTITIONER CONCEPTIONS OF MATHEMATICAL KNOWLEDGE IN EARLY CHILDHOOD DEVELOPMENT

Ethical Clearance number:

UFS-HSD2020/0354/1908

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis

Chairperson: General/Human Research Ethics Committee

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APPENDIX C: PERMISSION LETTER TO THE CENTRE MANAGERS

No 9 Gijana Street
Mayden Farm Loc
Mthatha
5099
31 July 2019

The Manager
XX ECD Centre
Mthatha

Dear Sir/Madam,

RE: REQUEST TO CONDUCT RESEARCH IN YOUR SCHOOL

This letter serves as my request to conduct interviews with practitioners in five centres in Mthatha District.

I, Neliswa Gqoli, student number 2017320611, am a registered student at the University of the Free State pursuing the degree, PhD in Early Childhood Development. Currently, I am busy with a research project aimed at exploring practitioner conceptions of mathematical knowledge in early childhood development. Hence, the preliminary topic of my study is:

Practitioner conceptions of mathematical knowledge in Early Childhood Development.

As part of my project, I need to conduct interviews with practitioners in early childhood centres. I therefore humbly request your permission to conduct interviews with

practitioners in five ECD centres of the Mthatha District. I believe their expertise in the field of Early Childhood Development would add value to my study, and it will enable me to achieve the aim of this project.

Interviews are completely voluntary; that is, participants are free to choose whether or not to participate. Participants are also free to withdraw from the interview at any time should they feel that they cannot continue. Interviews are confidential, and data generated will be handled with the utmost care to protect participants' identities and that of the schools they are affiliated with. To ensure confidentiality, I will use pseudonyms.

Let me further assure you that participant participation in the study will not be harmful to anyone or their schools and that as a researcher, I will try my best to protect both and to treat them with utmost respect and dignity. Interviews will be tape-recorded as a way of capturing all the information, and the interview will be approximately thirty minutes long. Interviews will be conducted at a time and a place that is convenient for the participants. However, it will not disrupt activities at any centre. I promise to answer any questions that you might have during or after the interviews as honestly as I can.

My contact numbers, as well as those of my supervisor, appear on the cover page of this request. Please feel free to contact any one of us should you need more information.

I am waiting in anticipation of your response.

Sincerely

Neliswa Gqoli

APPENDIX D: INTERVIEW SCHEDULE FOR PRACTITIONERS

14. For how long have you been a practitioner at this centre?
15. Can you please describe your specific role in the centre?
16. Have you received any training in Early Childhood Development? If yes, what qualifications do you hold?
17. Have you received any training in early mathematics?
18. Is there any specified mathematics curriculum that is used in the centre?
19. How well has your education and training programme prepared you in relation to mathematics content areas that are relevant to early childhood development?
20. What is your role as a practitioner in the mathematics classroom?
21. How do you enhance parental and/or guardians' involvement in their children's development and mathematics learning?
22. How do you take into account the diversity of children's backgrounds or how this impacts their learning of mathematics?
23. How do you use mathematical knowledge to enhance children's learning in ECD class?
24. How do you design an environment and make it conducive to mathematics learning?
25. How do you use play and its theories to enhance mathematics in the ECD classroom?
26. How do you guide children during play in order to enhance mathematics?

Thank you for your valued time and input

APPENDIX E: OBSERVATION SCHEDULE

- The classroom environment will be observed to determine if it contributed to mathematics development, this includes:
 - Classroom resources
 - Classroom organisation
 - Teaching activities, which are important variables that influence successful teaching and learning, will be observed. These include:
 - Teacher-child interaction
 - Child participation
 - Child-to-child interaction
 - Methods used to enhance mathematics concepts are regarded as the major determinant of successful learning in ECD. The methods used will be observed for their effectiveness as regards children's successful learning.

APPENDIX F: CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable). I am aware that the findings of this study will be anonymously processed into a research report, journal publications and/or conference proceedings.

I agree with the recording of the *insert specific data collection method*.

I have received a signed copy of the informed consent agreement.

Full Name of Participant:

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s):

Signature of Researcher: _____ Date: _____

APPENDIX G: PROOF OF EDITING CERTIFICATE



23 September 2021

To whom it may concern

RE: Proofreading and academic editing of the PhD Thesis of Neliswa Gqoli.

This letter serves as confirmation that I, Cindy Schoeman of CS Language Solutions, completed the proofreading and academic editing of the PhD Thesis: '*Practitioner conceptions of mathematical knowledge in Early Childhood Development*' and that it was done so without any outside assistance.

Please feel free to get in touch with me at 076 381 8999 or at cslanguagesolutions@gmail.com regarding any queries or concerns.

Kind Regards,

Cindy Schoeman (MA Language Practice - UFS)

CS Language Solutions