University of KwaZulu-Natal

TEACHERS' VISUALISATION OF THE MATHEMATICS CURRICULUM

A research report submitted in partial fulfilment of the requirements for the degree of Master of Education at the University of KwaZulu-Natal

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DECLARATION

I declare that the research study titled, Teachers' Visualisation of the Mathematics curriculum, is my own work and has been completed under the guidance and supervision of Prof Nyna Amin. It has not been submitted before for any degree or examination at any other university.

Roshini Kowlesar

28 March 2022

Date of submission

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To my husband, I appreciate your patience and understanding when I was not available to give you the attention you deserve. To my children I cannot express my gratitude for your patience and support, especially continuously tutoring my IT skills. To my siblings, thank you for your motivation and encouragement when it was tough.

To my colleagues and friends, I appreciate your participation, co-operation, and dedication in ensuring the successful completion of this report. Your invaluable support is appreciated.

Abstract

This study explores how teachers in a suburb of Durban visualise the Mathematics curriculum. The inquiry is predicated on the assumption that teachers' visualisations make visible their foci on aspects of the Mathematics curriculum which is often not explicit. The study also aims to explain the different types of visualisations each participant held and the implications thereof for practice.

This was a qualitative study conducted at a private school in Durban. Six teachers participated in the study. The data was generated by asking teachers to produce an image of their visualisation and conducting semi structured interviews. An interpretivist paradigm framed the study.

Six visuals were generated by participants (tree, pizza, toolbox, jigsaw puzzle, germinating seed and 4-tiered cake). Based on its findings, the study identifies an understanding of the teachers' thoughts of the Mathematics curriculum. New teachers begin by following the curriculum at hand very closely. Over time, as they learn more about both learners and curriculum, they adapt and adjust their interpretation and implementation of the curriculum. Finally, the study shows that new and aspiring teachers need opportunities to analyse and critique curriculum, beginning during teacher education and continuing in the in-service period in the company of their more experienced colleagues and mentors.

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CHAPTER 1

1.1. Introduction

This study is about teachers' visualisation of the Mathematics curriculum. The way teachers think is closely related to the process of transforming curriculum ideals into appropriate tasks, lessons, and classroom activities (Kinchin, 2019). Visuals or images that teachers have of the curriculum presupposes the idea that it provides insights about how a Mathematics curriculum is activated in the classroom. Much research has been conducted on teaching students to visualise (Schubert, 2009; Calvo, Carroll & Ellis, 2007). In contrast, there are fewer but important studies on teachers' visualisation like focussing on becoming effective questioners (Stokhof, De Vries, Bastiaens & Martens, 2019), or developing reasoning abilities (Seah & Horne, 2021). Another study, like the one at hand, is sure to add value to the body of knowledge.

Although there is an emerging body of research on teachers' use of curriculum, all aspects have still not been covered because curriculum is dynamic and undergoes revisions all the time (Annala & Mäkinen, 2013). The developments in curriculum have placed great interest in the impact of the curriculum on teachers and teaching and learning because teaching and learning in Mathematics is studied, reviewed, measured, analysed, and publicly judged more than ever before (Meeran & Amin, 2021). Due to an accountability regime, there is increased pressure on teachers for learners to achieve better marks (Anane, 2015). The interpretation and implementation of the curriculum is a complex task (Doll, 2008; Knight, 2001). Various studies have revealed how teachers engage with the curriculum as, for example, developers (Martin-Kniep & Uhrmacher, 1992), modes of engagement (2011), thinking about the curriculum (Villegas & Lucas, 2002) and designing curriculum materials (Davis & Krajcik, 2005). Some studies draw attention to support (e.g., Harris & Graham, 2019; Hipkins & Hodgen, 2012) and some to challenges (Erstad & Voogt, 2018; Aydin, Ozfidan & Carothers, 2017). Therefore, understanding what teachers seek from curriculum is vital.

1.2. Background and rationale

The rationale for this study emanated from my desire to learn more about how to make optimum use of the curriculum and how the curriculum can assist teachers to create

and unpack a suitable and appropriate working document that is practical to use. Teachers are important sources as they are the one in whose hands the curriculum gets activated and it is equally important to know how teachers feel about the curriculum. Based on my experiences with colleagues I often hear staffroom chatter about the Mathematics curriculum. They would say that they do not have the competency, or that they do not know how to teach certain concepts. The conversations I overheard made me eager to understand what happens when they use the curriculum and what factors influence their choices. Furthermore, words are limited by the size of our vocabulary and the size of our knowledge (Zlatev & Blomberg, 2015). Consequently, words are not enough to capture the exact idea or meaning and may have certain limitations in what one wants to convey, in terms of what one thinks or what one feels. By contrast, visualisation offer an avenue to express one's creative ideas. Visuals may provide security and comfort around conversations and could prompt and facilitate the articulation of ideas (Dewan, 2015).

When using a visual, a person can express himself outside words. Readings about visualisation attracted me to the idea because it integrates non–verbal forms of communication (Scarles, 2010) and it offers interesting data.

The selection of the site of research was influenced by knowing that most research is done in state schools as it is thought that Mathematics is a problem only in state schools. Although the study by Aunio et.al. (2016) concluded that private education provided better outcomes for Mathematics learning, it is not optimal. Some of the teachers who teach in private schools received their qualifications in the same institutions as do public school teachers. Private school teachers also deal with curriculum issues in terms of interpreting and implementing a prescribed curriculum. Furthermore, private schools in South Africa are not researched widely and the kinds of problems associated with Mathematics in private schools are not known. So, this study contributes towards filling the gap. Ultimately, how teachers think about the curriculum is valuable knowledge – irrespective of the type of school they work in.

1.3. Research questions for the study

Guiding the production of data and analysis in this study are the research questions:

Question 1. How do teachers visualise the Mathematics curriculum?

Question 2: What aspects of the Mathematics curriculum are embedded in teachers' visualisations?

1.4. The Rationale and significance of the study

The focus on Mathematics stems from studies that continue to reveal perturbing trends in the Mathematics performance of South African learners which is a concern for teachers and parents alike (Spaull & Kotze, 2015). The studies by Reddy, Van Der Berg, Janse van Rensburg & Taylor, (2011) and Schollar,(2018) assert that despite the importance of Mathematics, 70% of the country's schools are underperforming in the subject. This places the focus on Mathematics teachers. Studies suggest that teachers, need sufficient content knowledge, relevant skills, professional values, positive attitudes, and motivation to instil a strong and effective foundation for learning in subsequent phases (Reddy, Van Der Berg, Janse van Rensburg & Taylor, 2011; Taylor, 2021).

I have focussed on teachers' visualisation as teachers are the executors of the curriculum. How will teachers' understanding, and execution of the Mathematics curriculum affect the implementation thereof? Teachers' insights and feelings need to be considered, confronted, acknowledged, addressed, and examined for meaningful curriculum enaction. Successful curriculum changes will be effective if teachers' voices are considered and if it assists teachers to develop a sense of value and purpose and empowers them to share this with others. In fact, collaboration, visualisation, and reflection among teachers are essential to the process of curriculum reform (Handelzalts, 2019).

Education in South Africa has experienced the following curriculum changes: Outcomes-Based Education (OBE), Curriculum 2005 (C2005), the National Curriculum Statement (NCS), the Revised National Curriculum Statement (RNCS), and currently the Curriculum Assessment Policy Statement (CAPS). These changes have presented an improvement in preparing learners for life, as well as for transformation, especially in its aims to undo the inequalities of the differentiated curriculum in the pre-1994 era (Gumede & Biyase, 2016). There are critiques, too of

the changes regarding its ironic effects, like worsening education inequalities (see e.g., Meeran & Amin, 2021; Nunalall, 2012).

Despite the undesired effects brought about by curriculum changes, it remains an important aspect of education provisioning as it contributes to the development of skills and the acquisition of relevant knowledge that learners need to apply in the context of their studies, their daily lives, and future careers. The curriculum encompasses content which is designed to develop the learners' understanding and skills of Mathematics (What to learn?). Guidance through sequencing and organising of content provide points of departure for learning to occur (How to promote learning?). The instructional design, teaching strategies and learning activities are supposed to facilitate the cognitive growth and development of children (learning interactions). Finally, assessment is specified to monitor the outcomes of learning (how to gauge learning?). The model of curriculum implementation used in medical education captures the elements described heretofore. See Fig 1.

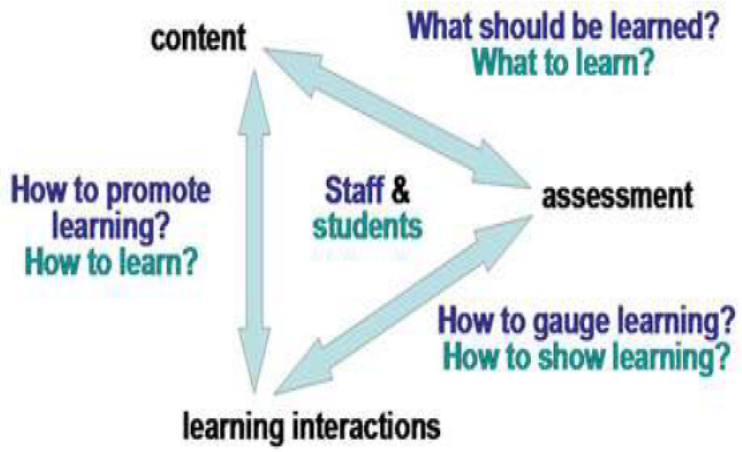


Fig. 1. Key elements and relationships in the curriculum (Source: Prideaux 2003)

Although the content of the Mathematics curriculum since 1997 has not changed substantially, the way it is taught (implementation) has changed. Table 1 is a representation of the current Mathematics curriculum for the foundation phase.

THE FOUNDATION PHASE MATHEMATICS CURRICULUM

<table>
<tr>
<td>CONTENT

• Number, operations, and relationships
• Patterns, Functions and Algebra
• Space and shape
• Measurement
• Data Handling

SKILLS
• Listening
• Communication
• Critical Thinking
• Reasoning
• Application
• Representation
• Investigation
• Problem solving
• Social
• Economical
• Measurement
• Estimation
• Connections
• Deductions</td>
<td>INSTRUCTION

• Written and practical activities/presentations
• Small group discussions
• Puzzles
• Games
• Worksheets
• Experiments

VALUES
• Sharing
• Caring
• Saving
• Discrimination
• Confidence
• Concern
• Consideration
• Co-operation
• Conservation</td>
<td>ASSESSMENT

• Observation
• Written and recorded activities
• Performance based activities
• Tests in grade 3
•

ATTITUDES
• Support
• Responsibility
• Commitment
• Empathy
• Consideration
• Tolerance
• Understanding
• Curiosity
• Judgment
• Perseverance
• Beliefs
• Interest</td>
</tr>
<tr>
<td colspan="3">OUTCOMES

• Recognise, describe, and represent numbers and their relationships, and to count, estimate, calculate and check with competence and confidence in solving problems.
• Investigate patterns and relationships. Develop an appreciation of the aesthetic and creative qualities of Mathematics.
• Acquire skills such as generalizing, explaining, describing, observing, inferring, specializing, creating, justifying, representing, refuting, and predicting.
• Recognise and describe objects and shapes in the environment that resembles mathematical objects and shapes. Handle objects and shapes, cut out and draw sketches, and describe them with appropriate and expanding vocabulary.
• Follow and give directions as well as to describe his or her own position and the positions of objects in space, using appropriate vocabulary.
• Make direct comparisons and using non-standardized measuring units (e.g., body parts, containers, pacing on foot). Develop appropriate vocabulary to describe comparisons (e.g., shorter than, longer than).
• Awareness of the passing of time should take place before he or she reads time.
• Manipulate data to represent or misrepresent trends and patterns. Develop a sense of how Mathematics can provide solutions that sustain or destroy the environment and promote or harm the health of others. Use Mathematics effectively and critically, showing responsibility towards the environment and health of others.</td>
</tr>
<tr>
<td colspan="3">ACTIVITIES
• Activities should begin with kinaesthetic activities.
• Activities should build on with hands on, concrete apparatus.
• Leading to abstract activities bringing in visual aids.
• Using critical and creative thinking.
• Co-operative strategies like group discussions and explorations.</td>
</tr>
</table>

Table 1. Current foundation phase curriculum

Curriculum developers normally design curriculum for widespread users and extensive environments. Thus, teachers are expected to use curriculum in flexible ways to meet the needs, interests, and experiences of their specific classrooms (Brown, 2009).

Children in any class, as is well known, will show a mixed range of skill and learning styles (Pashler, McDaniel, Rohrer & Bjork, 2008). It is difficult to satisfy all their needs if a common curriculum is followed in an unquestioned manner. Children gain an understanding of mathematical ideas in different ways (Boaler, 2002). The problem of readiness is therefore important when planning, teaching, and assessing mathematics. Therefore, the teacher needs to know the importance of teaching and appropriate assessment methods to build on the child's previous knowledge. Periods of frequent revision are essential too and the way to access this may be achieved via Mathematics curriculum research.

Continuous assessment is useful for diagnosis and planning in Mathematics. It emphasises the identification of the child's existing knowledge, errors, and approaches. It gives information that supports teachers to cater for individual differences in talent, previous learning and learning style, and to prevent pressure to motivate the child to prematurely acquire mastery of facts and procedures. It is important that a learning environment is created to enable both boys and girls to learn all aspects of Mathematics successfully and to provide opportunities for extension work for the more talented children and support for the slow learners (Voigt et.al, 2020). All these important aspects of Mathematics teaching mean that researching teachers' knowledge of curriculum is vital too. Therefore, this study focuses on the visualisation of teachers of the Mathematics curriculum.

Many studies in Mathematics involve issues around teacher attitudes (Crisan, Lerman & Winbourn, 2007), societal influences (Adler 1997, Apple 2012), school mathematics curricula (Tikly, 2011), classroom processes (Blignaut & Remillard, 2015), mathematics anxiety (Lyons & Beilock, 2012), curriculum restructuring and curriculum evaluation, (Msibi & Mchunu, 2013). In contrast, the aim of this study is to contribute to the knowledge of foundation phase teachers' curriculum understanding by gaining insights from their visualisation of the curriculum. Furthermore, understanding the teachers' visualisations may be a way to rethink strategies to improve the learning outcomes of the Mathematics curriculum in the foundation phase.

1.5. The research approach

This is a qualitative study drawing its participants from a private school situated in the city of Durban, in KwaZulu-Natal, a province of South Africa. The participants are foundation phase teachers, both experienced and novices. The paradigm that frames this study is interpretivism because the intention is to understand curriculum visualisation from the teachers' perspectives. The aim is depth of understanding as it pertains to a particular context. Participants were interviewed and asked to draw a picture that captures their visualisation of the curriculum. Each visual was analysed and inferences were made in terms of its connection to the curriculum.

1.6 Conclusion

This chapter introduced the focus of the study, which is the visualisation of the curriculum by six foundation phase teachers who work in a private school in KwaZulu-Natal. The intention of the study is identifying the teachers' visualisation have of the foundation phase Mathematics curriculum and to infer the suppositions they make regarding teaching and learning. In the next chapter, the literature review and theoretical framework are offered.

CHAPTER 2

Literature Review: Teachers' Visualisation of the Mathematics curriculum

2.1. Introduction

This chapter shows how research relates to the field of study and links to the contributions of scholars, philosophers, and theorists. The emphasis of this study is to look for numerous considerations and insights of what the Mathematics curriculum is and how teachers relate to it.

The review depicts a range of assumptions about the role of teachers and their engagement with Mathematics curriculum. These components provide a background to frame the study findings. Thus, this chapter reviews four areas of research that are significant to the study namely: The Mathematics curriculum, Teachers' beliefs of the Mathematics curriculum, Mathematics teachers' curriculum practices and visualisation.

2.2. The Mathematics Curriculum

Mathematics is important in our everyday life (Kember, Ho & Hong, 2008). It equips learners with the skills, knowledge, and values that they need to interpret and analyse information, to simplify and solve problems, to assess risk and to make informed decisions (Greiffenhagen & Sharrock, 2008). Every day, people are presented with different types of facts that must be handled and engaged with to make decisions. Daily activities such as travelling, making purchases, phoning, playing (jump left, right), cooking, cleaning, and calculating expenses require math skills.

Curriculum is a plan for teaching and learning (He, Schultz & Schubert, 2015). The Mathematics curriculum connects history, the environment, society, and the workplace. The Mathematics curriculum enables teachers to make meaning of the proposed guidelines in the environment in relation to society, culture, politics, history, and economics (English & Gainsburg, 2015). The major role of the Mathematics curriculum is to ensure all learners achieve a level of mastery that will serve them well in life and it is the teachers who give tone and colour to the curriculum teaching, gives rise to learning (Alismail & McGuire, 2015). Learning is what teachers want to achieve

at the end of educational processes and it takes place through several related elements.

The curriculum represents the presentation of educational concepts in practice. The word curriculum has its roots in the Latin word 'currere' for track or racecourse (Doll, 2016). From there it came to mean course of study or syllabus. Today the definition is more extensive and includes all the planned learning experiences of a school or educational institution (Prideaux, 2009). The intended Mathematics curriculum focuses on developing mathematical understanding, fluency, logical reasoning, analytical thought, and problem-solving skills.

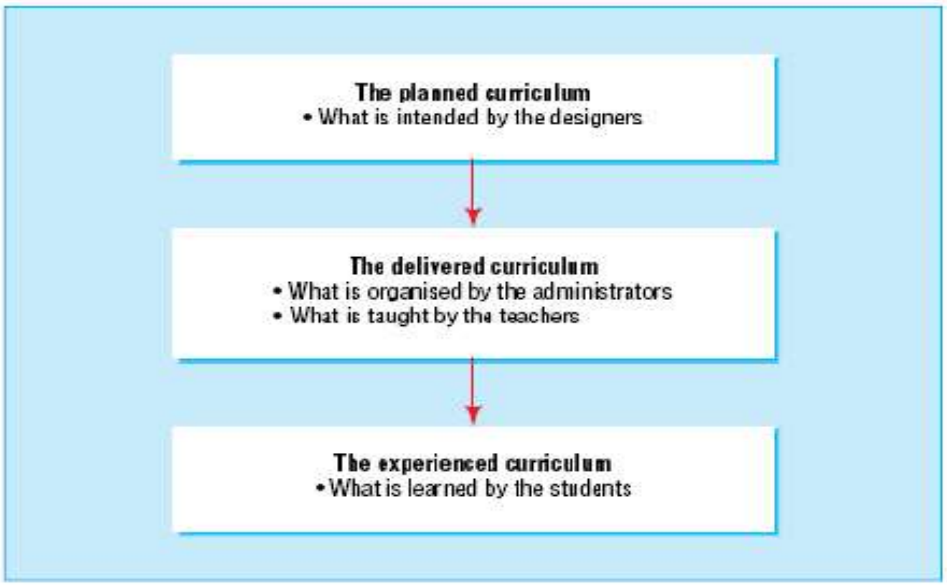


Figure 2. The three levels of the curriculum (Source: Prideaux, 2009)

The curriculum, it transpires is organised in a way so that it can be transferred to learners, is open to analysis, and is able to be readily transformed into practice. The curriculum exists at three levels: what is planned for the society, what is delivered to the learners, and what the learners' experience (Prideaux, 2009).

Curriculum can be represented in three different ways: the intended, implemented and attained curriculum (Van den Akker, Gravemeijer, McKenney & Nieveen, 2006). The intended, implemented and attained curriculum refer to different curriculum representations. The intended curriculum refers to the formal documents that set levels of expectations for learning of Mathematics. The intended curriculum is the justification and goals for learning as intended by policy makers, as written down in

policy documents and curriculum documents. These competencies are needed of citizens today. The intended level is concerned with the system level. Thus, the making of a curriculum, from the design to the enactment, is a process of "narrowing down from the universe of possible activities to those considered desirable for use in the classroom" (Bishop, 1988). Bishop argues that the first stages of this process are established not by teachers but by education authorities. Schools and teachers do not make the decisions.

The implemented curriculum refers to the way teachers understands and interacts in the classroom. The attained curriculum describes the results of what transpires in the classroom. Bertram, Mthiyane, & Naidoo (2021) indicate that it has been noted that learners' poor achievement in Mathematics is due to teachers not always covering the official curriculum within a specific year. The curriculum requires a fast pace of coverage and learners often cannot cope with the pace. This hampers the quality of learning. It is the subsequent skills and results of the learners. One of the primary concerns is to create balance and stability amongst these curriculum representations. Figure 3. provides a succinct description of the differences.

Figure 3. Intended, implemented, and attained curricula

Intended / Planned	Official	Vision (rationale or basic philosophy underlying a curriculum.)
	Formal / written	Intentions as specified in curriculum documents/materials. Policy.
Implemented / Enacted	Perceived	Curriculum as interpreted by its users. (teachers)
	Operative	Actual process of teaching and learning. (class)
Attained / Realised / Achieved	Experiential	Learning experiences as perceived by learners.
	Practical / Scholarly	Resulting learning learners' outcomes. (assessment

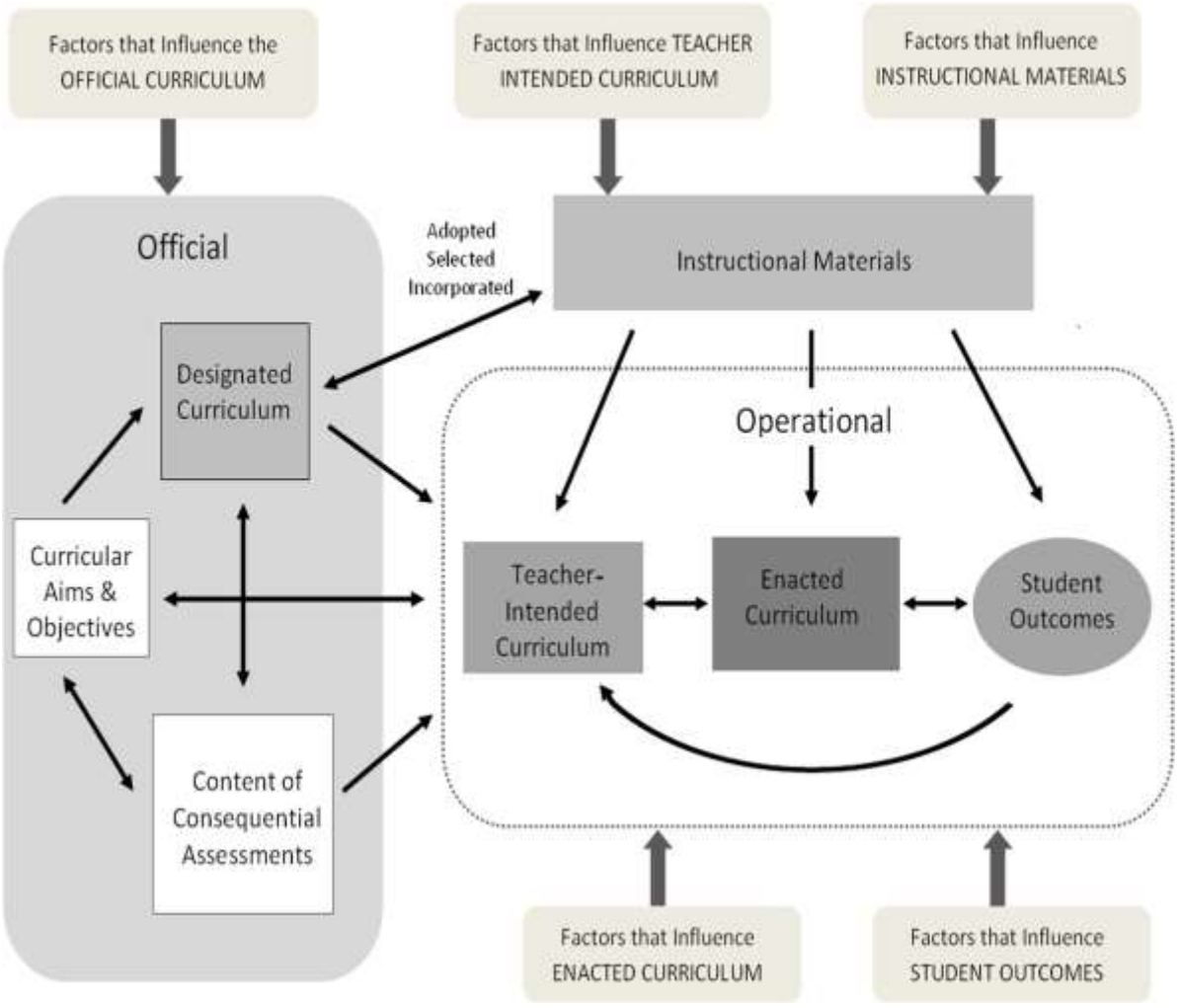


Figure.4. Visual model of the curriculum policy, design, and enactment system (source: Remillard and Heck,2014)

The basic elements of the intended curriculum are the aims and objectives of the curriculum. It contains guidelines to shape the content, pacing and resources of mathematics instruction. Khoza (2012) declares that any person or thing that connects teaching and learning becomes a resource, making curriculum materials a resource for teachers and learners. Teachers are energetic activators who work together with curriculum to develop the planned curriculum and construct the enacted curriculum. The enacted curriculum in essence is the teacher and learner interaction in the Mathematics classroom. It necessitates teachers to respond in an instant to events in the lesson (Remillard & Taton, 2013). The relationship between curriculum and what happens in the classroom, reflects situations, and shapes the best way to act on it. Neither the curriculum policy nor the teacher can fully foresee the complicated and extraordinary nature of the mathematical analysis that might go on among the several

learners in a classroom Miller (2004). The teacher and curriculum contribute to an array of knowledge about learner thinking that leads to better mathematics teaching and learning. It is a partnership rather than a guide for sequencing learners' work.

Teachers' interpretation may change with the ambit of time, as their experience with using the curriculum increases. However, as the teachers' expertise develops, their interpretations of materials representing the curriculum system may change as well (Mokros, 2003). The achieved curriculum is shaped by the assessment of content of that is significant for schools, teachers, and learners (Ruthven, 1994).

The Mathematics curriculum has led to a greater cognizance of the difficulties of the Mathematics classroom and of the important role of the teacher (Ponte, Matos, Guimarães, Leal, & Canavarro, 1994). The Ponte et. al. (1994) case study was undertaken amidst a period of reform in Portugal. Data was collected via interviews, observations, and document analysis. The study was directed by the teachers' views and attitudes. A limitation that arose was that little was known about the relationship between teachers' views and learners' views. I have cited this study as it is like some school settings in South Africa.

Remillard (2000) argues that it would be better to speak to teachers rather than through them. Teachers are responsible for the appropriate instruction, activities, and evaluation. As curriculum materials are modified, it is vital to know how teachers use them or the degree to which curriculum materials support teachers' learning. Teachers help learners become enthusiastic, positive learners through inquiry and active participation in difficult and demanding experiences (Sherin & Drake, 2009). Some attempt has been made to understand the reasons that teachers have for their actions as identified by Sherin & Drake (2009, p. 468):

> "What are teachers looking for as they read the teachers' guide? Do teachers focus on examples or on explanations? What are the main issues that teachers consider as they adapt a given lesson?"

The study reflects that the teachers interpret the curriculum according to personal characteristics. Sherin & Drake (2009) undertook a study to describe 10 elementary teachers' interactions with Mathematics curriculum at four public schools in Western United States. Data was collected via observations, interviews, and video. The results

back the notion that teachers interact with curriculum in a variety of ways. Since most of the studies like this one, are at public schools; this is a gap I would like to cover in my study by focussing on a private school.

Banilower, Pasley, & Weiss (2006) argue that giving teachers the opportunity to increase their expertise with support of professional development materials will give rise to greater teachers. The study claims that these teachers, with constant support and guidance, will be more likely to make effective instructional choices and will have more capability to build on their experiences. Improved instruction will in turn lead to higher learner outcomes. Data was collected via observations of professional development activities, classroom observations, teacher questionnaires, principal questionnaires, and teacher interviews. This study also states that teachers tend to reduce the curious nature and tend to become less conversant, decreasing the extent of their reporting. I referred to this study to alert me of the choice of the research strategy, my choice should assist me to make the participants comfortable to answer reliably and honestly.

Viholainen, Asikainen, & Hirvonen, (2017) study examines Finnish mathematics student teachers' scholarly beliefs concerning the nature of mathematics and the goals of mathematics teaching and learning. Data was collected by 18 student teachers via a short questionnaire and interviews.

These reviews sought to highlight the importance of the Mathematics curriculum, what it constitutes, the methods of implementation, and encounters with its implementation.

2.3. Teachers' beliefs and the Mathematics curriculum

It is recognized in literature that personal factors like beliefs, experience and understanding of mathematics influences teachers' decisions when relating with Mathematics curriculum materials (Lloyd, 1999; Manouchehri & Goodman, 2000). Teachers' beliefs about the nature of mathematics (i.e., epistemological beliefs) and the teaching and learning of mathematics (i.e., pedagogical beliefs) form key factors in research on teachers and their teaching practices, especially after the publication of Alba Thompson's (1992) handbook on mathematics teaching and learning.

Beliefs may arise from personal experiences such as family traditions and values, social encounters, community involvement, cultural organisations, teacher preparation, observing mentor teachers, professional development, and scholarly literature. Researchers have theorised beliefs in many ways. However, beliefs can be concealed or shaped by opinions, ideals, decisions, ideas, and perceptions (Pajares, 1992).

When teachers select tasks, they make decisions based on chosen results. They are limited by constraints particular to their individual circumstances and influenced by their beliefs about mathematics and about mathematics teaching (Sullivan & Mousley, 2001). As the teachers teach mathematics, they express their vision of mathematics and their views on teaching mathematics. The idea of teacher beliefs, or teacher conceptions, reveal these ideas and aspirations, which are usually not expressed by the teacher in a noticeable manner.

Early research on teachers' beliefs has been inspired by the assumption that teachers' beliefs generally control the classroom. Some researchers claim that teachers' beliefs correlate with their classroom practices, teaching activities and the decisions they make (Ashton, 1990; Ashton & Webb, 1986; Brookhart & Freeman, 1992; Buchmann, 1984; Clark, 1988; Dinham & Stritter, 1986; Feiman-Nemser & Floden, 1986; Fenstermacher, 1979, 1986; Goodman, 1988; Munby, 1982, 1984; Nespor, 1987; Tabachnick, Weinstein, 1988, 1989; Wilson, 1990).

Teachers do not join the profession believing that they know nothing about teaching as suggested by Ball (1988, p. 40):

> Long before they enrol in their first education course, they have developed a web of interconnected ideas in Mathematics, about teaching and learning Mathematics, and about schools.

The pioneering work of many researchers assumes that what teachers do in the classroom mostly depends on their content knowledge and beliefs about mathematics and mathematical teaching that comes from their academic experiences. A teacher interprets the curriculum, and this interpretation depends greatly on what the teacher

knows, including his or her knowledge of the subject matter, and the teacher's beliefs about instruction.

Teachers acquire these beliefs from their previous mathematics teachers (Thompson, 1984). The Thompson (1984) study was a purposive case study of three teachers from a pilot study of thirteen. Data was produced by observing, audio taping lessons and interviews. An important finding was that there was an inconsistency with one teacher's expressed beliefs and the way she taught, suggesting that such inconsistencies might be more prevalent. The Thompson finding is a reminder about the dangers of research presumption. Sometimes participants may say what they think the researcher wants to hear.

Studies have also shown that various factors like the classroom environment, social and educational factors also form teachers' beliefs (Thompson, 1994). Teacher's beliefs shape their instructional practice. Their beliefs, knowledge and experience may be considered as internal factors. These beliefs act as a filter through which they make their decisions rather than relying on their pedagogic knowledge or curriculum guidelines (Clark & Peterson, 1986). Clark & Peterson (1994) declare that teacher beliefs affect the way teachers teach, the judgements they make and how they manage classroom discipline. The Clark & Peterson study adopted a survey method. Data was collected via questionnaires. 820 Chinese primary school teachers participated in the survey to explore the nature of teachers' beliefs. The limitation was that the conclusions were derived from self-reports. The study could have other research methods like video reporting or observations to substantiate the conclusions. I have used this article as a learning curve to eliminate this limitation. I used visualisation in combination with semi-structured interviews.

The Zhu et. al, (2021) study explored Chinese teachers' beliefs about Primary Mathematics teaching and learning. Data was collected from 391 early childhood teachers who participated in this study. A questionnaire-based survey indicated that teachers' beliefs about Mathematics teaching and learning and Mathematics teaching efficacy were significant predictors of their Mathematics teaching practices. The results suggest that Mathematics teaching success enables a positive relationship between beliefs and practices.

Teachers continue to face challenges finding the balance of attaining high expectations and constructing a suitable environment to implement the curriculum. Teachers' beliefs can be altered, even though educational beliefs are often considered permanent and difficult to modify despite the teachers' schooling and experience (Pajares, 1992). Beliefs may be a consequence of or an explanation for practice e.g., environmental, or social factors may force a teacher to teach in a particular way (Mayer, 1985). When teachers enter the profession, they hold a Platonic view about mathematics.

> Plato believed that there was a perfected representation of everything in the world of the forms. In Plato's view, the things that people experience in the ordinary world are like shadows reflected on a dark cave wall by flickering flames. Humans are unable to turn and see the reality. Instead, they must deduce reality from the shadows before them (Mayer 1985).

In real life, this means that people must look at many things to get an idea of the shape of something. For instance, there have been many different types of curriculums. However, they all have certain things in common. The outline of "curriculum" would therefore be the perfected example of all curricula. Plato (in Mayer, 1985) argues that the shape is upon which all thoughts may be patterned, meaning that the main task of these teachers is to learn from policy documents, refer to it and communicate it through the language offered.

Spillane, Reiser, & Reimer (2002) have established an outline to illustrate how teachers make sense of and implement the curriculum. This study focuses on the teachers' knowledge, beliefs, their understanding of the curriculum, their situation, and the policy signals. Data was collected from field notes and videotapes. The study reports that teachers may focus on surface features (familiar and concrete examples) and don't delve deeper into relationships (make connections with real life situations) and that people are inclined toward interpretations that are in line with their prior beliefs and value that when policies are not implemented or inconsistent. It is not because teachers ignore direction, but rather that it is because they do not understand them as policymakers intended them to.

Sherin & Drake (2009) assert that the way in which a teacher utilises the curriculum depends on many aspects (the nature of the materials, the teacher's own knowledge and beliefs, time, administrative expectations, scope, and sequence). Data was drawn from video observations and interviews with 10 elementary-school teachers who were using the Mathematics curriculum. The teachers described in this study could not understand ideas and recommendations in the curriculum but continued using them and clutched to the idea that they could use the ideas to their advantage by altering them. Modifications and choices are made by the teachers to fit the curriculum within the constraints of the classroom. Even though it is understood that what teachers do in the classroom generally depends on their beliefs about Mathematics and Mathematics teaching, these findings show that curriculum use is unbalanced, instead, it is strong and developing.

Some challenges in enacting the mathematics curriculum are teachers' attitudes, lack of motivation, and inadequate resources, (Mata, Monteiro, & Peixoto, 2012). Poverty, which contributes to children not obtaining the most fundamental Mathematics skills in the foundational years of schooling, is a social factor that affects the mathematics curriculum (Sabates, Westbrook, & Fernandez, 2012). The Sabates et. al. study took place in Tanzania. Data came from four age groups of women via surveys. The findings study was made on a dream of continued educational access for those who faced problems like child headed household responsibilities, lack of parental support, financial difficulties, which cause irregular school attendance, highlighting some poverty issues that impacts on Mathematics curriculum.

The study by Akim, (2018) was conducted by 133 participants. Data collection was obtained through semi-structured interview, questionnaire, and document analysis. The results that exposed several challenges, including school and home related challenges. The findings relate to poverty challenges like lack of school materials, lack of home basic needs, engaging in petty business and domestic activities that impact negatively on academic achievement.

A study by Stylianides & Stylianides (2013), addresses problems that can be supported by curriculum when teachers interact with resources and the implications for professional learning. They report changes in teachers' beliefs as they interact with curriculum.

“Tasks are recognized as an arbitrator to link teaching and learning” (Lee, Lee, & Park, 2019, p. 966). Leavy and Hourigan, (2020) study engaged 415 prospective primary school teachers. Data was collected via a questionnaire on the ability to pose problems. The findings reveal that the action of selecting and adapting a new task, is difficult for prospective teachers.

When encountering new knowledge, teachers rely on their previous experience and patterns to make sense of it. Teachers’ beliefs are the starting point that helps them develop more in–depth understanding of the mathematics curriculum.

Beliefs, and their influence, are implied, unspoken, or unconscious. By not examining beliefs can have a negative impact as they guide practice and fears, determine what is overlooked, influence decision making, and shape types of interactions. Teachers shape their own progress as they recognize and amend beliefs.

Similarly, studies perceive those beliefs influence teachers' understandings of what it involves teaching and how best, teaching is to be accomplished. For example, teachers who believe authority figures (e.g., principals, academic, scientists) are the only sources of knowledge, may adopt a more observable conduct about learning. They are also likely to deliver traditional (transmission) instructional techniques, such as direct instruction, founded on the perception that teachers know, and learners learn when teachers transmit knowledge to them.

On the other hand, teachers can build their classrooms in ways that emphasize learners' impact to education. Teachers may be inclined to believe that teachers and learners know and learn simultaneously, and that learning happens best through dialogue and shared interaction. Conversation and exploration were founded in the belief that individuals and groups can acquire meaningful understandings.

Teachers tend to be resistant when information contests their beliefs, such as policy for change, to adjust or include new populations of learners, or to modernize with new technologies. Teachers are likely to feel vulnerable when they need to deal with that which they do not know.

2.4. Mathematics teachers' curriculum practice

Practice advocates when interpretations are not coherent; rather, they are examples of activity usually learnt by teachers' own knowledge. The Lampert (2001) study suggests that teachers participate in a multitude of practices even while teaching a single lesson, all of which influence what arises in the classroom, ultimately leads to learner results. Getting learners to participate in mathematically powerful and intellectually demanding learning environments creates a demanding task, and task that comprises of numerous challenges and imposes important demands on teachers. Teachers require to balance the difficulty of tasks and maintain learners' interest. Teachers also need to gauge the amount of information and of what type of information should they make impart to learners and when. They need to support and encourage learners to explore critically rich and intellectually demanding mathematical tasks without reducing the reasoning. Teachers themselves need the knowledge to understand the content comprehensively so that they can transmit it to their learners.

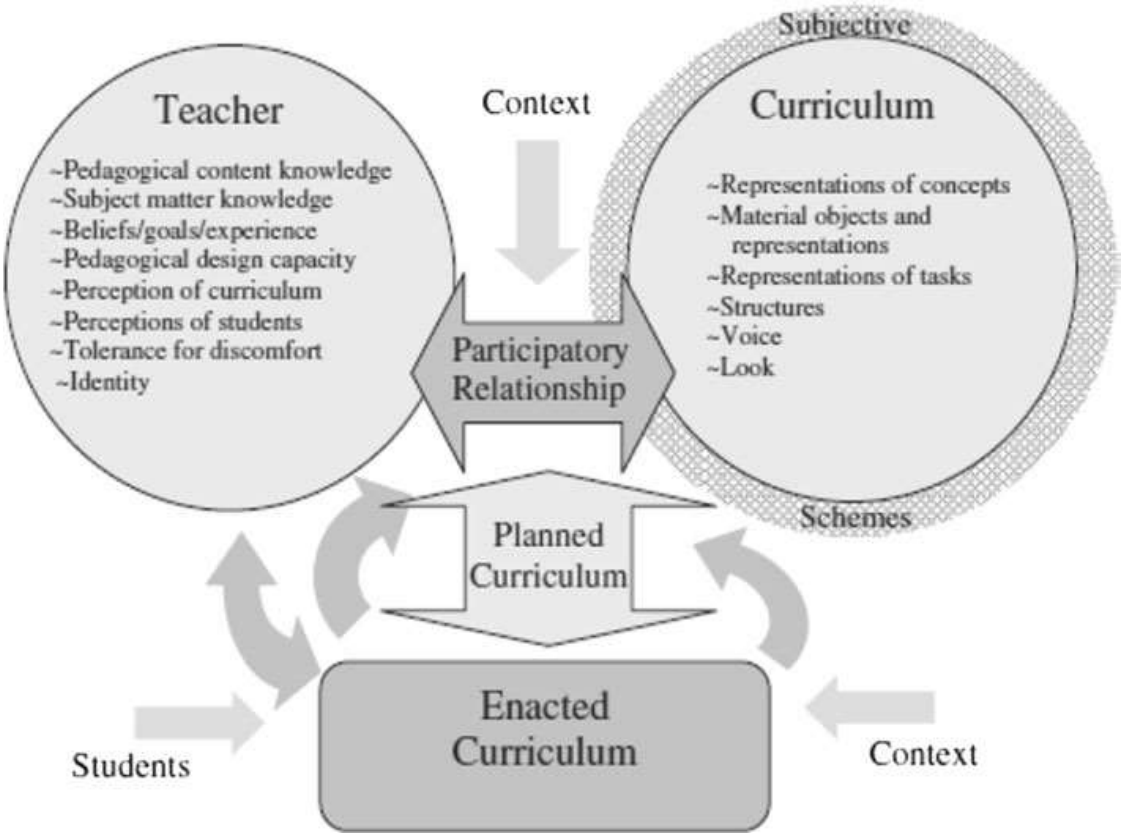


Figure 5. Remillard's (2005) framework of components of the teacher/curriculum relationship

Remillard (2005) study examines the way teachers interact with curriculum resources. It is understood that there are numerous ways teachers may rely on their personal understanding, how they assess resources, and subsequently select (or not) them, They make sense of curriculum according to their understanding and perhaps modify them. Therefore, curriculum resources have become an important part of developing a greater understanding of their use, and teachers' participation with curriculum resources may depict significant transformations in how they relate to them.

Jacobs et al (2010), declares that,

> curriculum materials are designed to be used on a large scale and thus cannot anticipate or respond to the thinking of individual learners. That is the job of the teacher. We acknowledge that responding to individual learners in this way is an area where curriculum materials, by design, fall short.

Teachers' beliefs, knowledge and experience may be considered as internal factors. Classroom practice is influenced by many factors. Mathematics teachers' practices are influenced or constrained by various contextual factors. Other factors such as learners' characteristics, curriculum, assessment, and peer pressure are isolated from the teacher. These external factors may be limitations to the teachers' internal factors that shape classroom practice (Grouwes, Koehler, 1992). Studies (Brown & Borko, 1992; Cooney et al., 1998; Raymond, 1997) similarly show that teachers' beliefs about Mathematics and the way they teach Mathematics are inspired in substantially by their involvements with Mathematics and preparation long before they enter the specified tertiary Mathematics education. To appreciate how teacher knowledge contributes to producing mathematically rich and logically demanding learning environments, one needs to focus on the practices of teaching, the choice of and the amendment of activities. According to scholars who have discussed the importance of studying instructional practices it is important to recognise the work entailed in teaching (e.g., Shavelson, 1983) asserts:

> To be effective, teachers must know and understand the mathematics that they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks. Teachers' actions are what encourage learners to think, question, solve problems, and discuss their ideas, strategies, and solutions. The teacher is responsible for creating an intellectual environment where serious mathematical thinking is the norm. If learners are to learn to make assumptions, experiment with various approaches to solving problems,

> construct mathematical arguments and respond, then creating an environment that fosters these kinds of activities is essential. A collection of factors informs such decisions and actions, and teacher knowledge is only one of them.

The Mathematics curriculum necessitates teachers to transform the way they teach and acquire new teaching methods, overseeing the variations in teacher capabilities and ideas of competence, (Drake, Land & Tyminski, 2013). This leads to challenges that teachers experience in understanding and enacting the mathematics curriculum. Teachers who are struggling with pedagogic knowledge may find it challenging to incorporate teaching strategies that require additional time and resources to implement. Teachers are likely to behave in an opposing way when there are complications that affect their beliefs, such as policies for reform, to adjust or include new populations of learners, or to experiment with new technologies.

Recent studies by Askew, Venkat & Matthews (2012), reveal poor, incoherent and inconsistent mathematics lessons highlighting teachers' pedagogical content knowledge. 41 teachers participated in this study. The data emerged from observations and videos of one mathematics lesson from primary school learners in the ten project schools. This paper shows evidence of one of many teachers who cannot transfer competence to tasks displaying poor content knowledge.

The Taylor (2011) study indicates that majority of the teachers have the bare minimum knowledge of the subjects they teach, especially Mathematics. Data was collected, between 2007 and 2009, from 266 schools from eight provinces of South Africa. Information was collected via learner questionnaires, teacher questionnaires and school principal questionnaires. The study also used document analysis. The study was carried out in predominantly white and coloured schools. Content coverage was also inspected using the number of topics as an indicator of curriculum coverage. The study concluded that programmes should also ensure that textbooks and workbooks are suitably designed to support the coverage of curriculum and activities, making this simpler for both teachers and learners to utilise. I chose to cite this study since it highlights the numerous issues undertaken in this study concerning timing, materials, procedures, techniques, and its extensive significant investigations.

Teachers choose to read different portions of the curriculum and they make use of several resources to comprehend what they had read (Remillard, 2000). A teacher

may modify simply by ignoring parts of a lesson or be creative and make major and resourceful modifications to the curriculum. Teachers prepare lessons by making comments in the teachers' guide, by planning new materials, or by reading other materials that they may possibly use during instruction. Remillard (2000) studied three elementary school teachers to find out what teachers know about the mathematics curriculum and mathematics education. Data was collected through observations; follow up interviews and audio taped transcriptions. Observations revealed that all three teachers grappled with whether and how to react to certain questions. Based on challenges of understanding questions in the Remillard (2000) study, I have decided to use visualisation as a method of data collection in my study.

Teachers with the skills and competence to organise and construct classroom activities that enable children to achieve expected levels of basic education remains vital (Tikly, 2011). Teachers' domain-specific knowledge is an important component for instruction, especially in the mathematics classroom, (Lindemann, Toni & Bekkering, 2014). Smith & Barret (2011) also suggest that teacher education and practice have a significant impact on learner achievement. Parents, policy makers and teachers participating in Mathematics education agree that teachers need excellent content knowledge to be good teachers of Mathematics (Ma, 1999). Many reports suggest a move towards governmental forms of accountability instead of professional accountability. This masks the problem instead of attempting to attend to it, (Msibi & Mchunu, 2013). Granting that the present educational sector is swamped with complaints of unprofessional teacher behaviour (Msibi & Mchunu, 2013:25-28), the focus of this article is on personal transformation as a professional expert. Ma (1999) introduces evidence that American primary school teachers, for the most part, are not well equipped to teach mathematics with understanding, suggesting that teachers simply lack the Mathematics capability required to adapt and modify it, to teach it. Ma points out that,

> a good vehicle, however, does not guarantee the right destination. The direction that students go with manipulatives depends largely on the steering of their teacher" (p. 5).

Research studies on 'teacher information behaviour' (Diekema & Whitney, 2012) claim,

> that the main reason for the choice of a particular teaching resource is its recommendation by colleagues, that is, drawing on shared experience and

> information from colleagues. This very important collective way holds true for both textbooks and internet resources). Educators use material to support their teaching, which is largely concerned with the transfer of information. Decisions on when to go out and seek additional information, what information to incorporate, and what information to dispose of are all based on ideas of relevance. This exploratory study found that ideas of relevance are largely determined by the educational context and are therefore distinct to a particular user group. Relevance is often rigid for teachers, that is, information needs are driven by curriculum and school policy. Teachers also appear to hoard when looking for relevant resources, increasing their chances for finding a good resource fit by drawing on shared experience and information from close colleagues. Resource selection is again curriculum based.

Hill and colleagues (Hill et al., 2005, p.19) assert:

> Effectiveness in teaching resides not simply in the knowledge a teacher has accrued but how this knowledge is used in the classroom. Teachers highly proficient in mathematics … will help others learn mathematics … only if they are able to use their own knowledge to perform the tasks they must enact as teachers. Tasks alone are not sufficient for effective teaching. Teachers must also decide what aspects of a task to highlight, how to organize and orchestrate the work of the students, what questions to ask to challenge those with varied levels of expertise, and how to support learners without taking over the process of thinking for them, and thus, eliminating the challenge.

These studies indicate that Mathematics teachers are required to understand the content intensely, in ways that assist them to see relationships among and between ideas and to produce it in an approach that supports learning.

Resources significantly impact on the enaction of the mathematics curriculum, Price & Ball (1997). Teachers' methods of constructing the enacted curriculum with the use of textbooks are considered important in the teaching and learning of mathematics Remillard, Eisenmann, & Lloyd (2011) Taylor (2013). The Taylor case study was undertaken to understand how teachers use curriculum and how, when, and why teachers make changes to textbook materials. The curriculum use of four teachers in the western US was studied by using document analysis, observations, and focus group discussions.

The ways in which teachers adapt their teaching skills and practice to accommodate the introduction of ICT (visuals) was described by Ruthven & Hennessy (2002). These changes affect all aspects of the Mathematics curriculum: teaching approaches, assessment of learning, student tracking, communication, and evaluation. With the rapid advancement in technology today teachers are expected to include ICT into their practices. Computers are often not used for teaching and learning purposes Sutherland (2009). Teachers do not have a real understanding of the benefits of using computers as they do have not have the necessary experience themselves. These initiatives were found to be ineffective in helping mathematics teachers in classrooms Crisan, Lerman & Winbourne (2007). These studies describe how the teachers adopt a given technology, according to his/her activity, or knowledge. This means that two different teachers are likely to develop two different tools from the same artefact.

There is implication from research Gueudetet al. (2013) that Mathematics teachers do not precisely adhere to the textbook. They adhere to curriculum materials and include other resources into their lesson preparations and teaching for example, e-textbooks Pepin et al. (2015).

To teach differently, teachers collect, share, select, revise, and implement resources to tailor them for curriculum enaction. In South Africa, teachers are not prepared to cope the Mathematics curriculum; there is also a lack of support from the Department of Education to empower teachers to implement the Mathematics curriculum Tshirangwana (2013). The Tshirangwana (2013) case study was undertaken to investigate the management of Grade 3 Mathematics curriculum at three schools in Johannesburg East. Data was collected via observation, document analysis and interviews. Three heads of department (HODs) and eight teachers were chosen for observations. Subsequently two of the eight teachers were interviewed. Findings indicate that there is lack of support from department of education in empowering teachers to manage the Mathematics curriculum. It was also found that teachers are not prepared or not trained to manage the Mathematics curriculum.

Teachers use diverse approaches, variation, and adaptation of curriculum to produce quality teaching, Keth (2011). The Keth (2011) case study highlighted the impact of teaching strategies in delivering of the Singapore Mathematics curriculum in East

London. Data was collected from semi-structured interviews, individual questionnaires, focus group interviews, journals, and presentations. Six teachers participated in the study. The findings reported that teachers understood the importance of mathematical expertise. Their Mathematics knowledge was enhanced, and teachers enjoyed the encountering of Mathematics using a variety of manipulatives as required by the Singapore Mathematics curriculum.

Local research indicates that time management is an important challenge in most South African schools Taylor (2011),Van der Berg & Louw(2007), Taylor & Vinjevold (1999). This study illustrates that the amount of contact time that teachers spend on a lesson is alarmingly low. Late coming and transport difficulties are the main causes for condensed classroom time. Administrative tasks and disruptive behaviour similarly result in less teaching time. There is indication that classroom management also affects teachers' practices Kaplan & Ryan (2011), Brown et al (2010). Another factor influencing Mathematics teachers practice is examinations. Our education system is examination motivated and this has influenced teaching and learning in the classroom. Since there seems to be a race to complete the curriculum, less time is spent on concepts.

The Dempsey & O"Shea, (2020), was a case study that employed 9 preservice student teachers to develop tasks. They were asked how it influenced their practice. Data was collected from interviews. The findings of the study indicate that the preparation of tasks and activities is central to what you do in class. Lesson preparation influences teaching and learning.

Teachers are crucial to the classroom therefore professional development is important to assist teachers expand their practise. Professional developments are those courses and endeavours aimed to boost the professional knowledge, skills, and attitudes of teachers as they in turn promote learners' outcomes Guskey (2007).

Frank et al. (2020) state that teachers have this understanding based on their own experience as well as from interactions with other experienced teachers. Data was collected from 119 teachers over 3 years via observations and surveys. They concluded that novice teachers imbibe ideas and experience from older mentor teachers who provide support that is more tailored to the needs, challenges, resources and demands of the institution.

It is essential to detect teachers' learning needs and help address them. The insights about teachers' practices that emerge from these studies show that one must never to overlook the goal which is the enhancement of outcomes. Therefore, it is important to reflect, interpret and report curriculum practices.

2.5. Visualisation

Visualisation can be considered as both a product (an image) and a process (the act of visualising). Arcavi (2003, p.217) suggests that:

> Visualisation is the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about, and developing previously unknown ideas and advancing understandings.

Visualisation also includes imagery that depicts pictures in the mind, a thought process. It is also a teaching method which involves construction of visual connections and visual imagery. Visualisation is a type of method used in research, e.g., an artefact or picture.

An alternative to verbal reporting is visual reporting (the use of pictures, diagrams, and computer graphics (Meyer, 1991). Meyer notes that researchers have practically ignored visual approaches to collecting data. There seems to be slight enthusiasm for visual data. The article also highlights a limitation of visual research. One cannot solely depend on visual data. It needs to be accompanied by verbal methods. Visuals offer the prospect to investigate participants' social and personal meanings and values by their reaction to images, (Bignante, 2009). Benefit, therefore, lies not only in the visual as object or artefact, but in the dynamic, practices and performances that are demonstrated. It strengthens the importance of the visual and creates the need for its presence. Dahmen et.al, (2021) study suggest that visual reporting is more engaging. Visualisation includes teachers' opinions, principles, decisions, beliefs, philosophy, insights, notions, presumptions, personalities, and social strategies.

There is a gap in literature of visualisation of the curriculum but more of teachers visualisations in implementing the content of the curriculum.

Recently there is a growing interest in visual methods (Frith, Riley, Archer & Gleeson, 2005). Visualisations provide views for investigation, examination and direct and change the path of reasoning and understanding, highlighting the use of visuals, (Sedig, 2009). Some sensitive and emotional experiences are not well expressed (e.g., pain) by words and some participants prefer visual expression providing them with an opportunity to reflect in a different way (Guillemin, 2004).

The use of pictures is not a new methodology but is rooted in disciplines such as anthropology and sociology (Harper, 2002). This has guided and steered a growing acknowledgement of visual methods can offer beneficial and rational data about challenges in the social sciences and there have been requests for further reports of these methods to psychological questions (Frith et al., 2005). The communication or construction of images can facilitate the interview process by breaking the ice, prompting memory, improving the cascade of content of the interview. By assisting to create connection and collective understanding (Harper, 2002; Bagnoli, 2009). The method of producing a visual image grants participants time to consider the topic being studied, which may not only generate rich and perceptive images but enlighten a more comprehensive interview.

A researcher can collect visual data in various ways and the choice of the method depends on the aims and theoretical perspective of the study. This may incorporate the following categories of visual data: maps, diagrams, and matrices (e.g., Copeland & Agosto, 2012), photographs and video footage (e.g., Radley, Hodgetts & Cullen, 2005; Ross, Renold, Holland & Hillman, 2009), and collage and drawings (e.g., Bagnoli, 2004; Guillemin, 2004).

Scarles (2010), study states that visuals are often linked with other techniques such as interviewing, focus groups, researcher, or respondent diaries and so forth, as a means of promoting communication and expectations for participants to convey and encounter experiences of research phenomenon. Visuals (photographs) become crucial to retrieving personal confrontations as they not only offer participants protection and reassurance but facilitate the 'connection' between researcher and participant as knowledge is communicated and shared (Scarles, 2010**)**. Thus, visuals create areas of understanding as the opportunity arises to exceed the limitations of vocal address and open areas for creativity, reflection, and comprehension. "Where

words fail, visuals ignite and open the possibility of sounds of silence*", (*Scarles, 2010, p. 923).

Visualisation emphasises variables such as colour, size, texture movement and emotions via an artefact (Manovich, 2011). He also suggests that "the visualisation helps the researcher to understand meaning or cause behind patterns as well as discover new patterns." The focus of this article is to feature the strengths of visual data. The author suggests that visualisation methods are important for humanities studies tweaking my interest to implement it as an instrument for research. The use of multi-sensory approaches contributes to a rich understanding of people and their world (Taylor & Coffey, 2009).

The Bates et al, 2020 study investigated how visualisations are related to mathematics in the 5 classrooms with 92 primary school children. Each participant completed three 30-minute sessions. Evidence shows that early visual areas support depiction of visual representations and visual perception. The ability to mentally manipulate images is particularly important for mathematics.

Some limitations concerning visual methods that have been reported are that a marginal number of participants are uneasy with using visual methods and may seldom refuse to participate in activities such as drawing (Bagnoli, 2009). There may also be challenges of inclusivity. Bagnoli (2009) found that people with intellectual disability were incapable of taking part in creating timelines due to complexity with the concept of time. Other sensible issues include confirming those included, know how to handle technology such as cameras and the risk of losing data through accidents (Gibson & Riley, 2010).

The indication from these readings suggests that via visualisation, the groundwork of delivering descriptions also includes the use of illustrations and parallels, since it is possible that teachers use these "tools" that is the sketches to structure their explanations of what Mathematics curriculum signifies to them. In this section visualisation is the phenomenon imagining the curriculum and dramatically increasing its comprehension.

2.6. Theoretical framework

Theoretical framework is significant to a form of research as it surrounds the questions queried and the way they are queried. Thompson (1994, p. 229) asserts that “theory is the paraphernalia by which we formulate problems and plan solutions”. It permits us to see both what we know and what we still need to understand.

Over the years researchers have looked to cognitive, social, and socio-cultural theories to exemplify teaching as work driven by knowledge, beliefs, and practise. The theory contributed immensely to the relationship between the written and enacted curricula. How do these theories explain the way in which teachers visualise, follow, or practise the mathematics curriculum?

This study is steered by a sociocultural theory Cole (1996), Wertsch (1981) for question. The understanding of sociocultural theory perceives learning as involving tool-facilitated action; and the curriculum that the teachers utilize, represent important tools for learning to teach. Enclosed within the curriculum are views of what it involves teaching mathematics, as well as practical tools that are utilised in classrooms. Teachers’ use of these tools will vary, depending upon their own beliefs and practice, values, their knowledge of the subject, and the circumstances in which they teach, how they utilise the materials and aspects that impact on how teachers comprehend the Mathematics curriculum. These features are mindful of the theoretical framework of the study. These aspects were beneficial in interpreting Mathematics teachers’ visions.

As teaching is such a complex endeavour, it is interesting to know ways the curriculum might help teachers learn and grasp the countless tasks involved in teaching, including planning, enacting pedagogies, and assessing student learning, to guide question 2: What aspects of the Mathematics curriculum are embedded in the way teachers visualise?

“The qualities of thinking and learning are actually produced by the structural features of the social interaction” (van Oers, 1996, p.93). Primarily pertinent to Mathematics education is the observation that “learning is the beginning into a social tradition of mathematical inquiry, mathematical discovery, mathematical argument, and so on” (Solomon, 1989, p.150). With progress as the importance, a teacher who engages in the sociocultural approach to teach mathematics would create a learning task through

which learners can cooperate with teachers. It is a process of directed involvement and collaboration of learning by solving problems just beyond a learner's existing ability with the assistance of a proficient person through support. Experts do not necessarily imply mathematicians. Teachers are most frequently the specialists in real classrooms, and professional development supports their expertise in mathematics.

Monitoring learners closely, teachers would rectify the learners' wrong moves, indicate the reasons for the wrong moves, and confirm appropriate moves continuously. This relationship between teacher and learners, is regarded as apprenticeship in nature, is the very foundation of the sociocultural approach that requires social engagement and collaboration of the whole classroom community.

Curriculum can be considered as a range, of prescriptive material, indicating precisely what should be taught, offering guidance and ideas about what and how to teach, but leaving many of the necessary choices up to the teacher. The interest in this study is in how teachers visualise the Mathematics curriculum and grow and develop over time during their teaching practice. These varying concerns directed the formulation of these research questions that will guide the study:

Question 1: How do teachers visualise the Mathematics curriculum?

Question 2: What aspects of the Mathematics curriculum are embedded in the way teachers visualise?

2.7. Conclusion

With the literature review as the background for this study, a deeper understanding of how teachers have visualised the Mathematics curriculum will be obtained. The following chapter provides a detailed discussion of the research methodology employed for this study.

CHAPTER 3

METHODOLOGY

3.1. Introduction

This chapter provides the details of the methodology used in this study. The paradigm informing this study is constructivism. A constructivist worldview is a coherent perspective that requires researchers to spend an extensive amount of time in the field, pay attention to the multiple worldviews people hold, try to understand, and present these worldviews with restraint and to provide pertinent details that make visible the rationality of the interpretation for a reader (Creswell, 2013; Lincoln, Lynham & Guba, 2011; Neuman, 2011). It explains the worldview that guides the study, the research design, selection of participants and site, data generation methods and tools and the procedures used in analysing the data. It also discusses ethical issues and trustworthiness of research procedures relevant to the study.

3.2. The paradigms underpinning the study

Hennink, Hutter & Bailey (2011) define paradigms as ways of looking at reality and frames of reference used to organize observations and reasoning. Paradigms therefore provide researchers with contextual grounds on which to place their views. According to Christiansen, Bertram, & Land (2013), a research paradigm represents a particular worldview that defines for the researcher who supports that view, what is acceptable to research and how it should be done. Research paradigms are described by the way it generates data and interprets the findings. A research paradigm can consequently be considered as an expression of individual beliefs, about the types of people, what can be known about their relationships and how to appreciate and understand them well. Christiansen et al (2013) deems that the way we see the world impacts on the way we research the world. Therefore, it is essential for each study to describe which paradigm it uses for its research.

Positivism works with recognised as the ‘scientific method’ in both the social and the natural sciences. Researchers working within a positivist approach consider turning to the study of evidence and data to get knowledge rather than only from the teaching. There are short, strong, succinct patterns that we can discover. Researchers believe that a world exists ‘out there’ and thus the associations between things can be

determined. The objectives of the post-positivist researcher are to pursue to define, manage and anticipate how the world works. They claim that humans can only estimate the truth or get 'close enough'. In other words, knowledge is not created on facts rather on assumptions about the world. In interpretivism the subjects of the research in the social sciences are people (as individuals or groups), People often behave and respond in composite ways except plants or chemicals. The mode in which a person behaves in each situation depends largely on their past experiences and circumstances. Therefore, their context is very important.

The necessity for educational research is to understand the implication that communicates human behaviour. Researchers make explanations with the intention of realizing human agency, behaviour, attitudes, beliefs, and perceptions. This influences the methods that they choose. It is plausible that meaning can only be realised in the communication between researcher and participants. Thus, the criterion for quality post-positivist research which is objectivity between the researcher and the researched does not hold in this paradigm. This study constitutes the interpretivist paradigm because it is looking for the cognisance of human actions, individual perspectives, and personal assumptions. In Christiansen, Bertram, & Land (2010) interpretivism is described as a paradigm in which researchers do not aspire to foresee what the people will do, but rather to describe how people make sense of their worlds, and how they construct meaning of their behaviours. The visualisations of Mathematics educators will therefore be explored to see how they comprehend the prescribed Mathematics curriculum. This paradigm accepts that community is created by interactions of individuals and, therefore, there is an adaptable society.

It is recognised that experience and context impact not only on participants' belief system but the researchers' interpretation of the outcomes as well (Creswell, 2013; Lincoln et al., 2011).

3.3. Research Approach

This study is guided by constructivism. “Other researchers embrace the supposition of social reality is subjective” (Creswell, 2012, p. 22). It respects the world as a basis of the human mind through experience and presumes that the social world comprises of multiple realities (Denscombe, 2014). Constructivism acknowledges that social realities are based on culture, society, and individuals. People foster meanings of the social world as they participate in the world (Corbin & Strauss, 2014). The study assumes that through interpreting, the researcher would understand teachers' visualisation of the Mathematics curriculum materials. Guba & Lincoln (1994) assert that understanding a social occurrence mainly comprises of interpreting activities of individuals and the social context of the experience.

Scotland (2012, p.9) explained that “epistemological assumptions are concerned with how knowledge can be created, acquired and communicated, in other words, what it means to know.” The epistemological (the nature of knowledge and how it can be acquired) stance taken in this study acknowledges the collaboration between the researcher and the participants, seeking to explain and predict what happens during the visualisation of the Mathematics curriculum by searching for regularities and causal relationships among the selected teachers. The researcher is the primary instrument of the data collection and analysis (Merriam, 1998) and consequently the researchers' own bias in conducting and interpreting the data may be apparent. It also acknowledges the participants may become aware of the research purpose and act differently from normal (Denscombe, 2014). Rather than trying to eliminate the researcher's influence and participant's response to the study, efforts are made to understand and explore it and use it effectively (Merriam, 1998).

The ontological assumption of this study is a qualitative approach. This study rests upon an ontological belief that humans can create meaning and make sense of their individual worlds. Qualitative research is based on constructive ontology (the nature of the world) and is based on the notion that the relationship between the knower and the known is subjective (Glesne, 2006).

Denzin & Lincoln (2011) suggest that despite the diversity within qualitative research it can be described as:

> a set of interpretive, materials practices that make the world visible. These practices transform the world. They turn the world into a series of representations interviews, conversations, photographs, recordings, and memos. Qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them (2011, p. 3).

Denzin & Lincoln (2011) describe qualitative research as being associated with words or images rather than numbers. This study undertakes qualitative methods in natural settings via artefacts (visual representation) and interviews, to acquire meaning from the way teachers visualise the Mathematics curriculum materials.

3.4. Research Design

Research methods are all those data generation techniques which are used by the researcher during studying the research problem (Kothari, 2004). They include methods that are concerned with the collection, analysis, and interpretation of data. There are many research methods, and each research paradigm has methods that are most suitable for them to achieve their intended objectives.

A study within the interpretive paradigm can be an ethnography study, naturalistic or a case study as mentioned by (Bertram & Christiansen, 2013). This study will employ a case study because it will help "the researcher to produce rich descriptions" (Bertram & Christiansen 2013, pp.36-37). Kumar (2011, p.127) proclaims that a case study is appropriate "when exploring an area where little is known". Cohen, et al. (2011) described the main belief of interpretivism is to "understand, explain, and clarify social reality through the eyes of the participants" (Cohen, et al., 2011, p.17). The interpretive paradigm is therefore designed to understanding rather than explaining (Scotland, 2012). This form of research concentrates on understanding through the eyes of the participants. In this regard, the case study was a private school, which offered me the opportunity to interact with mathematics teachers and explore their experiences, interactions, and perceptions of implementing the Mathematics curriculum. Thus, a qualitative case study was employed in this study with 6 foundation phase teachers to illuminate their conceptions and responses to Mathematics curriculum.

3.5. Site selection

The site was selected based on characteristics such as location, time, and cost. The suburb is close to the researcher to moderate transport cost and time. This study

focuses on a private school in a suburb in Durban. The school has grades from Grade R to Grade 12. The selection was convenient because it depended on accessibility and availability (Ormrod & Leedy, 2010) and more importantly, because of the availability of appropriate participants in a dynamic context reflective of characteristics of some types of school contexts in South Africa. Initially the school was created for students and teachers of Indian origins. Now it is a multiracial school comprising mainly of African and Indian learners with a predominance of Indian learners. It is a multi-lingual school. Whereas the language of instruction was English only, instruction is now offered in English, Afrikaans and IsiZulu. The learners emanate from average and above average socio-economic communities. The learners and teachers can afford the latest technologies, tuition, and tutorial materials.

3.6. Selection of participants

Cohen, Manion & Morrison (2011) describe research participation as defining the population on which the research will focus while the selection of participants is described by Christiansen et. al, (2010) as determining which people, setting, events or behaviours to observe or study. I used purposive sampling for the selection of participants. Cohen, et al. (2011, p.156). The inclusion of participants is determined by the researcher bearing in mind, the data generation methods, and the style of the study. This means the number of participants will vary depending on the research style. Variables such as expense, time and accessibility often prevent researchers from using all existing participants to gain information needed; therefore, a small group or a selected segment is used in such a way that it will offer deep understanding. Methods of participant selection used in educational research are either arbitrary or goal directed.

Purposive and convenience selection was used for the study. According to Christiansen et al. (2010), convenience sampling is a method used when the researcher selects participants who will provide a great deal of information, based on the purpose of the study; in this instance the criteria being the six most accessible Mathematics teachers. Informed consent and ethical considerations were attained in

terms of confidentiality, voluntary participation, and anonymity. Participants were given pseudonyms to protect their identities in the study.

3.7. Research questions guiding the study

The research questions in a study are vital in understanding the data generation methods selected. They determine the choice and direction of the study. They also are important in determining the type of data needed in the study. These questions aim to reveal teachers' visualisations of the Mathematics curriculum, their interaction and application of the Mathematics curriculum. By focussing on method or strategies teachers use to visualise the Mathematics curriculum, the researcher explores insight and understanding of what teachers require from the Mathematics curriculum.

This study addresses 2 questions:

1. How do teachers visualise the Mathematics curriculum?

2. What aspects of the Mathematics curriculum are embedded in teachers' visualisations?

3.8. Data Generation Methods

A case study's data can be generated using a variety of methods like direct observation, document analysis, archival records, interviews, participant observation and physical artefacts (Cohen et al 2011). Case studies also allow for the use of a combination of these methods depending on the case studied and its fitness for purpose. This study adopted two techniques in data generation, namely, semi-structured interviews, and artefacts (visual representations).

According to Denzin & Lincoln (2008, p.118), interviewing is "one of the most common and powerful ways in which we try to understand fellow humans." The semi-structured interviews were conducted once with each teacher. In semi-structured interviewing, a guide is used, with questions and topics that must be covered. There is a need to have some idea about the order in which questions are to be asked. This kind of interview collects detailed information in a style that is somewhat conversational Riessman (1993). Semi-structured interviews are often used when there is a need to delve deeply into a topic and to understand thoroughly the answers provided. Some limitations and

weaknesses using interviews are when the participants are uncomfortable sharing all that is hoped to be explored.

When working with artefacts the same sorts of questions should be asked as when operating with other types of primary sources, such as who produced the object, did s/he have a particular perception or objective. An artefact offers awareness into the customs, preferences, styles, special occasions, work, and play, of the culture in which it was produced. In many cases, a valid judgment is made about practices based on artefacts. However, there are also limitations to the use of artifacts. It sometimes may communicate only one aspect of the phenomenon. Teachers used the artefacts to clarify their understanding of the Mathematics curriculum.

Inferences are supported by the data to reinforce the quality of the findings.

3.9. Validity issues

"Validity is "a measure of how accurate the research is. Are the findings an accurate reflection of what was researched?" (Bertram & Christiansen, 2013, p. 46). I had to ensure construct validity which means that concepts used were understood in the same way by the participants and me. I also used participant validation, where the report was sent to the participant to verify the findings before submission for examination. The credibility of the research is also enhanced using observation notes and audio recordings of the interviews with the participants. The notes were also compared with the recordings to increase accuracy. The use of multi-methods increased the measures of trustworthiness (Krefting, 1991).

Credibility

In qualitative research, credibility is demarcated as the extent to which the data and data analysis are believable (Llincoln & Guba, 1985). Credibility is defined as the confidence that can be placed in the truth of the research findings (Holloway & Wheeler, 2002; Macnee & McCabe, 2008). Credibility establishes whether the research findings represent believable information drawn from the participants' original data and is a correct interpretation of the participants' original views (Graneheim & Lundman, 2004; Lincoln & Guba, 1985).

Sometimes, in qualitative research it is only the participants of the research who can rightfully judge the credibility of results. Therefore, it is important to try to give evidence and to show the reader that the research is credible. In showing the credibility of the research to the reader it makes the reader trust the research. This gives the research trustworthiness. Credibility is interpreted by the reader as only the reader can judge whether the study and the claims it makes are believable.

Transferability

Research findings are transferable or generalizable only if they fit into new contexts outside the actual study context. Transferability is like external validity, that is, the extent to which findings can be generalised (Lincoln & Guba, 1985). Generalizability refers to the extent to which one can extend the account of a particular situation or population to other people, times or setting than those directly studied (Maxwell, 2002). Transferability is considered a major challenge in qualitative research due to the bias from the researcher as the key instrument and is a threat to valid interpretations in its old-style thinking about research data. However, a qualitative researcher can enhance transferability by detailing the research methods, contexts, and assumptions underlying the study. Seale (1999) indicates that transferability is achieved by providing a detailed, rich description of the settings studied to provide the reader with sufficient information to be able to judge the applicability of the findings to other settings that they know (p. 45).

Since this study adopts a single case study approach, the process of generalisation that aptly matches it is “inferential generalisation” which is best explained as generalising from the context of the research study itself to other settings or contexts,” (Ritchie & Lewis, 2003). Therefore, it is a requirement that the researcher documents and justifies the methodological approach, and describes, in detail, the critical processes and procedures that have helped him to construct, shape and connect meanings associated with those phenomena. Further, throughout the process of this study, the researcher was sensitive to possible biases by being conscious of the possibilities for multiple interpretations of reality. However, the researcher has provided descriptions of the study such that data and description speak for themselves to enable readers to appraise the significance of the meanings attached to the findings and make their own judgment regarding the transferability of the research outcomes.

The study provides a detailed description of organisational context to assist readers interested in making use of the study outcome in other situations.

Transferability refers to the degree in which the research can be transferred to other contexts; this section is defined by readers of the research. The reader records the specific details of the research situation and methods and compares them to a similar situation that they are more familiar with. If the specifics are comparable, the original research would be deemed more credible. It is essential that the researcher supplies an extremely detailed description of their situation and methods.

Trustworthiness

For issues of trustworthiness in qualitative approaches Bertram and Christiansen (2013) both agree that the concepts of credibility, transferability, dependability, and conformability should be used to ensure the quality of the study. This is so because qualitative research is more concerned with meanings and personal experiences of individuals. It aims to describe and not to measure. Issues of trustworthiness was considered at the data generation stage, data analysis stage and data interpretation stage. This ensured that the findings of the study reflected what happened on the ground and readers. Cohen et al. (2011) state that validity in qualitative research can be ensured by intensive long-term involvement, rich data, participant validation, intervention, triangulation, and other techniques.

3.10. Ethical Issues

Research involves humans; therefore, it is vital for the rights of these individuals to be protected from any harm that might be caused by the research. Participants received clear explanations of what the research envisions of them because this will allow them to make informed decisions to voluntarily participate or not. Permission to conduct this study was sought from the university's Humanities and Social Sciences Research Committee. After ethical clearance was obtained, I began the process of contacting each participant to confirm their participation and seek permission to partake in my study. Permission was sought from the principal of the school used in the study to conduct the study. Consent from participants was obtained by having them sign a consent form after receiving a letter. The letter included the following as outlined by

Cohen et al, (2011), an explanation of the procedures. The participant is free to leave the study at any stage if there was any feeling of discomfort. The participants may not receive any benefits or any advantages. The researcher offered to answer any queries concerning the procedure. Participants responded to each question in a manner that will reflect their own opinion. There were no right or wrong answers. The participant is free to withdraw consent and to discontinue participation at any time. Participants were given the chance to remain anonymous and promised the copy of the report once the study is finished. Audio or video recording was only done with the consent of the participants. Burton & Bartlett (2005) agree that these ethical issues should be taken into consideration before embarking on a research project and considered whilst the research is on-going. Audio recording was done with the consent of the participants. Burton & Bartlett (2005) agree that these ethical issues should be taken into consideration before embarking on a research project and considered whilst the research is on-going. I acknowledged the presence of recording equipment and assured participants that the recording will remain confidential, and its circulation will be limited. Participants who are uncomfortable with being recorded will be given the opportunity to leave the session without embarrassment.

3.11. Conclusion

I have provided a thorough description of the research methodology utilised to produce the data for this study. These comprise of the paradigm of the study, the research site, the research questions, selection of participants, issues of validity and ethics. In the next chapter I analyse the data.

CHAPTER 4: DATA ANALYSIS

Teachers' Visualisation of the Mathematics Curriculum

4.1. Introduction

In the previous chapter I provided a detailed description of the research methodology utilised to produce the data for this study.

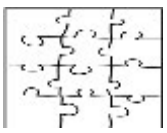
In this chapter I present the visuals which were derived from semi structured interviews. Data generated from the creation of visuals (sketches) by each participant which are interpreted and analysed address the research questions of this study. Six teachers were asked to sketch their ideas of the Mathematics curriculum. Each visual gives a different idea of the Mathematics curriculum. This was then followed by semi-structured interviews. Teachers were asked about the mathematics curriculum materials they used and why they visualised the curriculum in the ways they do. Similarities and differences amongst the teachers' visualisation were looked at. The analysis comprises a contextualisation of the visualisation of the curriculum by linking it to the participant's teaching experience and interview data (about the visual). The analysis is offered in two sections. The first describes the visuals and the second part provides explanations for each visual in the way it relates to the Mathematics curriculum.

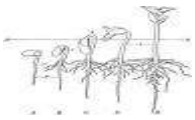
4.2. Analysis of sketches

SECTION A – Data Construction

Participants' visualisation of the mathematics curriculum

Fig. 6. *Teachers' visualisations of the mathematics curriculum*

TIA *Jigsaw Puzzle*		**JENNY** *4-Tiered cake*	
KATE *Pizza*		**ANN** *An apple tree*	

RAE *Germinating* *Seed*		**PAM** *A toolbox*	

The sketches depicted in Figure 6 are teachers' visualisations of the mathematics curriculum. Each of the six participants sketched their vision of the curriculum. The sketch was then used to stimulate discussion about the Mathematics curriculum. The study by (Westecotte,2020) describes drawing as a method to stimulate discussion. Figure 6 comprises the sketches the teachers drew. Each visual is an exact reproduction of the actual diagrammatic representation provided by each participant. These sketches were used to guide me to answer the first question: How do teachers visualise the Mathematics curriculum?

Data Analysis

Curriculum as a puzzle

Tia is a 39-year-old female who is teaching Grade R. Most of her experience has been in the Grade RR class. Grade RR is the grade that precedes grade R. In Grade RR there is more flexibility and less structure. Tia describes herself as an all-rounder, incorporating all the three learning areas. Tia was accepted into Grade RR with a Montessori diploma. She says that she did not specialise in Mathematics, but she says that she inherited her mum's excellent mathematics acumen, and this she feels qualifies her to teach Mathematics. She believes in allowing the children to learn by doing with the aid of concrete objects, which is like the findings of (Koparan, 2017) study which advocates those concrete materials in Mathematics help with permanent learning. The study reports that learners personally do and express what they have learnt.

This is Tia's second year in the Grade R class. She says,

> I have related my sketch to the resources and concrete apparatus that I used to work with, so I have sketched a puzzle. Then I was free to be creative but now there is more structure.

Tia mentions that there are so many pieces, and it is difficult to figure out where to start. She says,

> Some start from the outside while some sort colours and shapes but if one has a starting point, one creates a journey to complete the puzzle.

She mentions that there are different approaches to the puzzle and that one must keep chopping and changing until one gets the desired result, which corresponds with the Ferguson, (2017) study. The study states that new pedagogies enhance skills and contribute to personal growth.

Tia acknowledges support from the out- going teacher. She had to alter and adjust her methods and resources to find her own direction. Tia feels that the puzzle refers to all aspects of the Mathematics curriculum. She says that she uses the Mathematics curriculum daily to guide her in her forecast in daily teaching, actual teaching, setting of exam papers and to align teaching to the prescribed curriculum. She says she also uses other resources like the internet and other books. She described her Montessori education as “basic knowledge” and that “she had to look elsewhere for her own enrichment.”

This is consistent with the (Garcia & Tadeu, 2018) study which reveals that the construction of professional identity through the self-knowledge and professional development leads teachers to continue learning and training. The empowerment of teachers is a way of leading to school improvement.

According to Tia, the strength is that she refers to it daily and the weakness is, that it is not straight forward to implement.

> I have learnt that are no short cuts. I know what the outcome looks like, but it takes time and effort to put the pieces together. In the beginning it is a lot of hard work and planning but when I accomplish the picture it is satisfying. It takes time and effort, along with trial and error to put together. Time and experience will help me be more efficient the next time round. Therefore, I chose the puzzle.

Tia said she enjoyed problem solving at school. She said she enjoyed it when everything worked out just like the puzzle. The one word she used to describe the Mathematics curriculum was 'radical', like the views of Freire (1970), who proposes a radical shift (moving from knowing to explain) denoting that it is fundamental to teaching with far-reaching consequences. The visual by Tia resembles a jigsaw puzzle. Tia's sketch gives one the idea of curriculum as pieces of a puzzle that fit together. Each piece has a precise location as it cannot fit just anywhere. What makes curriculum complicated for Tia is that the pieces (e.g., aims, objectives, method, and content) must fit in a specific order, keeping in mind their edges (the scope of the mathematics curriculum for the grade), their centres (e.g., concepts and methods), and their interlocking pieces (e.g., assessment, practical application). Curriculum is also structured in that way for Tia, but she knows that how the pieces fit together are not always explicit, so by trial and error she must complete the curriculum. Because the curriculum is a puzzle, she cannot picture the final (whole) version. However, it does all come together at the end. The main idea emerging is of the Mathematics curriculum as a puzzle. It has fixed ways of being put together and the idea is to discover the fixed ways to make sure all of it matches and fits the designer's intentions.

The Pepin et al study indicates there seems to be a differentiation between the designer and the user, whereas an understanding about design continues due to the different nature and consequences.

Curriculum as a pizza

Kate is a 40-year-old female teaching Grade R. She has eighteen years of teaching experience and has taught all grades in the foundation phase. She chose to sketch a pizza. She says that "everyone likes different toppings on their pizza, just as everyone likes different aspects of the Mathematics curriculum." She says that each piece represents a different aspect of Mathematics (e.g., geometry, trigonometry, algebra). She says that she has learnt that all aspects come together to make a whole. Kate uses the Mathematics curriculum daily to guide the planning of forecast and scope of the lessons for the week. She also uses other resources to enhance teaching and learning. According to Kate,

> The strength is that it provides guidelines, and the weakness is that it is inadequate because I must go elsewhere for more inspiring resources.

Kate said that she enjoyed solving equations when she was at school. She accredits her good maths knowledge to her primary school teacher Mrs Green who made everything interesting. The one word she used to describe the Mathematics curriculum was 'stimulating'; in other words, she felt that the curriculum energised her teaching and that it provided refreshing perspectives of Mathematics and its goals. Nutov et al., (2021) study indicates that the curriculum contributes to enthusiasm and stimulates optimistic feelings amongst teachers with well-developed basic skills and competencies, teamwork and leadership and communication for them to lead their learners into society.

Kate's sketch depicts a radial shape, starting from the middle with a limited number of slices. This gives one the idea of curriculum being pieces of knowledge that need to be put together for learning. It is the teacher who brings in the variation of toppings (methods and examples) according to the needs of her learners. The pizza has an organic shape, but the puzzle is more structured like Mathematics with lines and edges. Another way is to describe the Mathematics curriculum as a planned design and structure. The pizza shape is non-hierarchical and suggests that any slice (of the curriculum) can be the starting point, and that each slice is of equal importance. By implication it promotes the idea that aims are as important as, for example, content, methods, and assessment.

The pizza conception of curriculum suggests that each aspect of the Mathematics curriculum is vital and coheres with Chappell's (2020) opinion that suggests that no one aspect of the curriculum is superior to another. Curriculum is practiced via creativity embracing risks and unknowns.

Curriculum as a germinating seed

Rae is a 26-year-old female teacher teaching Grade 3 with five years of experience. Still a novice teacher, Rae chose a seed to show how the curriculum guides educational growth from the foundation phase to the higher grades. She says that a seed represents the potential for the growth and building of knowledge and that the seed represents progression. Rae says that she does not see any weaknesses

because she relies on the curriculum to guide her. When she needs a bit of clarification or more activities than she goes online. She says that its strength is that it gives her direction and shows her the right way. Rae says that she only enjoyed problem solving at school. She says she never really worried about Mathematics as she passed her tests and never thought she would use maths as girls were never really allowed to study in her family. When she did study, she did not consider Mathematics as a specialist subject. The one word she used to describe the Mathematics curriculum was 'signpost', meaning that it serves as a guide that shapes her conduct as a teacher. The one word she used to describe the Mathematics curriculum was 'signpost', meaning that it serves as a guide that shapes her conduct as a teacher. The da Silva et al., (2021). study reveals that the curriculum supports educators in delivering the new curriculum. The examples assist educators to be able to develop and deliver the curriculum.

Rae's sketch of the Mathematics curriculum is likened to a germinating seedling. A seedling symbolizes potential, growth and development, turning into something much larger than its original self. Similarly, with teachers' intervention it seems like the curriculum grows bigger, depicting the growth of knowledge. It shows that when content is learnt. A learner's potential is boosted and through learning, there is intellectual growth and cognitive development. The content of the Mathematics curriculum represents the growth of knowledge. At each stage of development, knowledge reaches a different range. Knowledge is not given in the ways reflected on by participants of the previous two sketches, here knowledge is given to learners, and they nurture and grow it. An alternative way to define the Mathematics curriculum is that it becomes progressively more complex.

Curriculum as a tiered cake

Jenny is a 26-year-old female teacher teaching Grade 3 with four years of experience. Jenny is also one of the recent appointees at the school. Jenny sketched a four-layered cake. She says that her love for food and desserts made her choose this representation. She says that she chose this image because learning takes place at all levels of schooling. She says that decorating the cake with her creative ideas resembles the way she executes lessons. For Jenny the cake refers to the layout, and how each term unravels into new and more complex ideas. She refers to it daily for

her lessons and activities. She says, “It gives me greater understanding in order to teach my learners.” She says that she also uses other resources like the internet, books, radio, and television. She says that the strength of the curriculum is that as each term progresses, she gains more understanding. Kate says it helped her to plan lessons and activities that cater for all her learners.

> It is creative. It has layers of work that I can use to unpack and teach. This image has made me realise that the Mathematics curriculum is a basic recipe.” The cake depends on me, my creativity, and adaptations. It is like a recipe that gives me the ingredients. The variation and method depend on me.

Jenny says that she enjoyed geometry at school. The one word she used to describe the Mathematics curriculum was ‘map’, implying its usefulness to guide teaching and learning just like the (Kennedy, 2018) study which reveals that the curriculum opens a range of interpretations that provide bridges and connections.

In essence, the image of the Mathematics curriculum as a four-tiered cake means that it has a broad tier with progressively smaller tiers placed one on top of each other. As a visual representation of a curriculum, it communicates the idea that a curriculum is hierarchically structured with a base made up of a wide range of content, skills, values, aims and objectives. The base is very important because it is on which others get built on. It helps connect ideas, concepts, and skills. The basics need to be mastered before more tiers (knowledge, skills, and values) can be extended and built on. Any slice of the cake (the curriculum) will comprise of basics and extensions and additions. Thus, curriculum can be seen to be one with a broad, basic core with smaller layers of specialised content.

Curriculum as a tree

Ann is a 44-year-old female teaching Grade 1 with sixteen years of experience. Ann says that she chose to sketch a tree because of “my personal experience with Mathematics as a specialist subject during my studies”. She says that a tree has lots of branches and if is not nurtured at the right time it is difficult to get a healthy upright tree. She says that to reap the best fruits one needs constant support from subject advisors and professional development workshops. Ann says that what she has learnt from this sketch,

> is that besides planting a tree one must have knowledge about the soil and weather conditions. Besides knowing the Mathematics curriculum framework, one needs to know more than just the basic Mathematics." Ann adds that, "The Mathematics curriculum is a support structure that informs one about the goals, content, methodology and assessments.

She refers to it daily because, "It is different from our schooling and to plan age-appropriate lessons". Ann says that her schooling experience with Mathematics was emphasis on the importance of bonds and timetables. The strength is that it provides guidelines. The weakness is that too many learner-centred resources are required, and they are not available. Ann found Mathematics very challenging at school. The one word she used to describe the Mathematics curriculum is 'complex'. A complex curriculum means that she sees it as challenging and requiring her to engage with it constantly to decode it for implementation.

Ann portrays the Mathematics curriculum as a tree with a strong trunk, branches, foliage, and fruit. The trunk represents a core which thickens over time, whilst the branches, foliage and fruit show growth and development. Similarly, a curriculum has a trunk (an irreducible core) which ground and provides the support for teaching and learning. When a tree is planted it is quite easy to predict what it would look like but the exact way in which the branches will grow is unpredictable. In the same way, we know the intentions of a curriculum but how it is interpreted or received by learners is unpredictable. Teachers know the core curriculum that should be taught and what outcomes (fruit) they are wanting. Thus, a curriculum can be seen as providing a solid, sturdy grounding for teaching and learning. The Jenset et al., (2017) study reveals how new teachers learn to decompose and enact actual classroom practices.

Curriculum as a toolbox

Pam is a 40-year-old female teaching Grade 2 with fourteen years of experience. Pam sketched a toolbox. In her words,

> My family is in the carpentry business, so the inspiration came from there. As you become a more experienced carpenter, your knowledge and proficiency of your tools will grow. What I have learned is that you will make better decisions, you will know more about what tools to use

> and how each tool is used to perform its specific task just like when you acquaint yourself to the Mathematics curriculum, it becomes the toolbox to teaching.

She uses the curriculum daily in planning lessons to check if she has covered everything. Pam uses other teacher guides and the internet as well. The strength of the curriculum is that it is helpful. The weakness is that the curriculum requires experimentation, and it needs constant revision. Her interpretation via the toolbox is that "I have my tools. I choose my design and build my lessons according to my needs". Pam says she understands Mathematics, but she would like fresh ideas, so she uses the internet for that. Pam did not like square roots and timetables at school, but she does not have to teach that. The one word she used to describe the Mathematics curriculum was 'explanatory', meaning that the curriculum contained a series of explanations of what and how to teach.

Pam illustrates the Mathematics curriculum as a toolbox because it is filled with all kinds of instruments, implements and useful tools. When something needs to be fixed, the repairer looks through the toolbox and picks the most appropriate device to sort out the problem. Thus, a curriculum can be viewed as a box of tools for teaching and learning. A teacher picks and chooses the most appropriate content, methods, resources, and applications for the required purposes like the study by Singh et al., which expresses the using the right tool, in the right context, at the right juncture, supplemented by other tools.

The visual implies that the curriculum is available; a teacher can do whatever she wants with it. The more a curriculum is used, the more adept teachers become at implementing the curriculum. Thus, the Mathematics curriculum can be viewed as a toolbox.

4.3. Conclusions drawn regarding the analysis of the visual sketches

It is clear from the analysis that each teacher visualises the curriculum differently. The data indicates that five of these sketches (puzzle, pizza, germinating seed, tiered cake, and tree) depict the curriculum as the means for building, understanding, and acquiring knowledge, while the toolbox depicts application of knowledge. One can infer, therefore, that the way a teacher sees a curriculum can influence the way they

respond, understand, and implement it. In turn, it may also be an indication that a curriculum is understood differently by different teachers and could explain why each mathematics lesson is different when taught by different individuals. One can conclude that a common curriculum is not a guarantee for a common approach or understanding thereof.

CHAPTER 5

Inferred aspects from teachers' visualisations as embedded in the Mathematics curriculum

5.1. Introduction

In this section, I provide explanations for the teachers' visualisations of the curriculum.

Section B

5.2. Tia: Visualising the structure of the mathematics curriculum

Tia's visualisation of curriculum as a jigsaw puzzle could be associated to the structure of the contents of the mathematics curriculum. In other words, the mathematics curriculum comprises of a multiplicity of pieces that constitute it. Each piece provides an understanding of the whole. Every piece, be it numbers, fractions, graphs, ratio, and proportion are necessary to develop mathematical competencies. Furthermore, each piece is connected to another. For example, knowledge of whole numbers and factorisation is a prerequisite for working with multiplication and division of fractions. The visual also implies that there are multiple ways to engage in problem solving. It requires persistence, multiple perspectival approaches, and constant change to assemble it. More importantly, it alludes to the idea that the mathematics curriculum is not linear or hierarchical. A teacher could perhaps begin anywhere. However, the CAPS document for the mathematics curriculum denies teachers the option of choosing anywhere as it is highly structured and prescriptive. The visualisation indicates a personal conception of the mathematics curriculum that is at odds with the official policy relating to the study by (Clift & Liaupsin, 2019) expressing the effects of curriculum which was inconsistent amongst teachers.

The sketch could also draw attention to sequencing (progression). Children usually begin with simple puzzles that are outlines of simple shapes that fit into corresponding cut – outs. From there they progress to more complex shapes of real-world objects that require more thought. Younger children require fewer pieces and more complex

puzzles are required for older children. This varying complexity serves as a guide for activities and lessons to be age appropriate.

This image of a puzzle could be connected to assessment. It builds three basic skills. Physical skills when one is handling the puzzle, cognitive skills to solve the puzzle and emotional skills, to instill patience and are reward when the puzzle is completed Different strategies and opportunities are required to cater for differentiated learning. Tia says that a child may use colour to solve the puzzle, while another may use shape and yet another may use the edges as a starting point but ultimately all solve the puzzle with differing needs and skills.

In addition to this the puzzles allows for growth of social skills as people (teachers and learners) work together and communicate about what fits where.

The puzzle can also relate to problem solving where one may look for clues such as shapes and colours which fit together for later use when dealing with more complex and abstract puzzles. There is no better pleasing way to gain an understanding of the world by manipulating the world. The use of critical skills is required when fitting the pieces together. It either fits or does not, but most important trial and error methods are used to make these decisions. Tia says that the critical thinking skills assists to assess outcomes, compare ideas, and draw conclusion from a given piece of knowledge.

This can be associated to goal setting. First goal is to solve the puzzle. Second goal is the use of multiple strategies to solve the puzzle. Tia says that one must develop patience and practice and follow rules to achieve the outcomes.

For Tia, her pedagogical outlook is how to teach so that the learners do not get confused. Symbols and notations are not clear, how do she make them fit like a puzzle? How do she assist and guide learners to reason, justify and explain one's mathematical ideas, and communicate them using mathematical language and symbols? She says that she thinks using puzzles, it seems would make teaching dynamic and creative instead of automated and procedural. In addition to this, the puzzle it can be surmised, allows for growth of social skills as people (teachers and learners) work together and communicate about what fits where. Chappell, (2020) study indicates to dilemmas encountered with curriculum. Tia gains support through

networking via internet to integrate multiple strategies because the Mathematics curriculum is complex just like a jigsaw puzzle.

5.3. Kate: Visualising the contents of the Mathematics curriculum

Kate's visualisation of a pizza can be associated to contents**.** The pizza base is the guideline (curriculum), and the various slices and toppings are the contents. Teachers could use the pizza to teach counting, shapes, sorting, addition, subtraction, fractions, graphs and dividing. This concept can be linked to existing prior knowledge of shape, size taste and texture of the pizza allowing them to relate better with the task at hand. It allows learners to relate and make connections as old ideas are activated. Prior knowledge is made up of personal experiences and senses and makes it easier to apply them to something new. Visual and tactile experiences assist with application and reasoning assisting to make problem solving appear less challenging.

A pizza can be linked to problem solving. Like a pizza, people have many preferences for toppings. The teacher follows the basic guideline that is the classic pizza, and through interpretation and adaptation introduce fresh flavours and ideas. A pizza can represent slices. It is not clear how these slices fit together but patterns and the fractions make up the pizza. The curriculum provides a guideline, but Kate thinks, that each slice allows her, the teacher, the opportunity to create multiple journeys. Via instruction and numerous strategies through an inquiry-based approach mathematics can be relevant and interesting. Teachers will engage with the question, they work collaboratively, guided by the curriculum, develop an understanding of portraying mathematics in a more user- friendly way resonates with the Perienen, (2020) study which shares the innovative ways and the ease of working with the curriculum.

The pizza example, that question could be: "What pizzas do we need? Rather than the answer being a single, correct one, teachers can put forward a range of strategies, explaining their reasoning and the mathematics they applied to justify their decisions. The question of what pizzas? provokes an extended investigation. It requires decisions about how many and what pizza should be considered (planning for data gathering), surveying of pizza preferences (data collection and recording), summarising of the responses (data representation, graphs).

Most important, Kate's pedagogical outlook seems to help her to relate and transfer inspiring learning into her classroom. Kate probably links new knowledge to what is already known by presenting concepts in a conceptually and logically sequenced manner that builds upon previous learning. How will she get learners to compare, relate and infer and make connections between ideas? How does Kate expose learners to ways of developing critical thinking?

Kate probably plans and introduces lessons as a basic pizza then engage learners by sharing their ways of thinking and then use these ideas to challenge learners to construct and connect ideas through interactive discussion on their choices and substantiating their choices. Learners it is hoped can make connections to abstract calculations via their own manipulatives and share their methods. Kate sees the mathematics curriculum as a basic pizza, and she is left alone to construct an appetising product.

5.4. Rae: Visualising the mathematics curriculum content

A number sequence, ascending order (from small to big), identifying a growing pattern. The growth cycle could also be linked to sequencing and pace. There is a systematic development of number knowledge. There is a move from numbers to operations before problem solving. The key to successful teaching in sequential order is understanding the learner's pace. While it may take them days to learn one topic, another may take weeks. According to Rae when learners take time to grasp concepts, it can be tempting to rush them due to time constraints to complete the curriculum, and like seeds, sometimes outside factors hinder growth. Rae says that she believes, it is better to take the time to address challenges and set children up for success in the future. According to Rae time should not be compromised for completion of topics. Rae says that certain topics need to be taught before others. A germinating seed implies that it is important to select and sequence tasks according to growth and development. Time constraints could be an underlying challenge that cannot be voiced easily.

The germinating seed could be connected to instruction and strategies. Rae says that it is important to select and sequence tasks. This could represent steps. Instruction needs to be broken down into steps according to the needs of the learner. Seeds come in all shapes, sizes, and types. Seeds that are sown together may come from different

packets. In the same way, learners come to school with a variety of experiences determined by their cultures and their pattern of socialization. Some learners are better in groups, and they provide support to other learners by sharing their knowledge. Some seeds may blossom into big trees that tower over other plants and depriving them from sunlight. Likewise, some learners are competitive and seek the best of resources by depriving others of these resources.

The germinating seed could also be connected to assessment of learning. It could show if the process was successful. It could motivate both teacher and learner to get healthy outcomes. Seeds need the proper temperature, moisture, air, and light conditions to germinate. According to Rae teachers provide the required knowledge and skills to their learners. Then, they watch them blossom into resourceful individuals. Rae says teachers cope with mixed abilities in a class and teachers need to understand the needs of learners so that they can vary and prepare their lesson plans in such a way that they respond to the learning needs of each learner. Like some seeds need special support compared to others, some learners may require remedial or special education.

The teacher who believes that curriculum is a germinating seed sees herself as facilitator who helps learners discover their potential. According to Rae teachers provide varied learning experiences that promote their overall development tracks like the study by West & Bautista, (2021). Rae says just as a seed develops on its own based on conditions provided and the teacher provides learning experiences that help learners to discover their own potentials and learning styles. To Rae the germinating seed has a lot of growth to undertake depending on many external factors that affect the outcome. According to Rae no matter how experienced the teacher is, no one can predict or control the external factors which can influence environments. Rae says that every teacher comes with their own life's experiences from home, previous schooling, cultural and social interactions therefore like the germinating seed, curriculum can be developed to stimulate or stifle growth.

Rae's outlook to teaching is to take the responsibility for the development of her learners. She probably creates conditions for optimum growth for all her learners. Rae seems to express her interaction with the Mathematics curriculum via the germinating seed. Rae sees the seed as a curriculum giving her direction to teach. The

Mathematics curriculum can be rigorously planned, taught, and nurtured. Rae through activity, engagement, and creative imagination desires to nurture and produce outstanding outcomes (learners).

5.5. Jenny: Visualising the structure of the mathematics curriculum

For Jenny the cake represents a hierarchical structure. The different tiers are indicative of a strong foundation on which other aspects are built on. Each tier is a building block to the next tier. Learners differ in abilities and learning. The different layers indicate the need for differentiated instruction. The layered approach addresses the needs of all and reliance on others' strengths. Jenny says that teaching must be structured to suit each child's level, no one should be marginalised, and learners should be given opportunities to display their interests or preferences.

The numbers, operations, and relationships form the base of the cake. Jenny says that a thorough understanding of this section is needed before learners move on to patterns, measurement, space and shape and data handling. Jenny says that this can be seen by the amount of time given to the other sections of content compared to numbers, operations, and relationships. Therefore, sequencing is inferred where one level leads to another. Layer 1 can be the basic understanding of content. Layer 2 could give learners the opportunity to practice and apply the content. Layer 3 could be the assessment and analysis of teaching and learning. Layer 4 can be for the reflection of choices made. This analogy may help to expand and improve interaction with the Mathematics curriculum and assist learners attain their potential.

The Mathematics curriculum is the cake with the basic recipe and every individual using this basic will adopt variations and flavour according to their needs. Jenny alludes that this comes in the planning and teaching strategies, instruction, and assessment. She says just as everyone will want to decorate the cake to be most appealing, she designs her lessons with different ideas, methods, and resources to achieve the best outcomes.

Jenny's pedagogical view is how to get learners to relate, communicate and reason. She chooses to use appropriate manipulatives and brings in aspects of learners' out-of-school experiences to help learners to build their knowledge as concrete activity builds up learners' conceptual understanding. Jenny's says procedures enable

learners to encompass that knowledge when problem solving arises. She exposes learners to rules, methods, and resources available and allow them to decorate according to their environment and needs. She looks at the tiered cake as a process of taking her learners from concrete stage to abstract. Akib et al., (2020), study explains that teachers prepare activities from concrete to abstract stages.

5.6. Ann: Visualising the interrelated components of the mathematics curriculum

The apple tree shows that numbers and operations are supported by patterns, space and shape, measurement, and data. Here one can clearly gage the interrelated components of the mathematics content. The understanding of numbers needs to be strong. It is the foundation to further Mathematics. The trunk being the foundation (numbers and operations) needs to be solid and rigid to make further associations. The analogy shows that the teacher begins at the roots, follow the branches that will lead her to the attained curriculum. Numbers in the mathematics curriculum is grounded in the roots of the tree. The apples represent the fruit of the curriculum. That is what is finally achieved. Ann says that the teacher cannot jump from one topic to another topic in a haphazard way. There is a process of progression and connection that will give the teacher direction. The curriculum gives distinct branches via the topics and numbers as a starting point. The branches represent strength (the knowledge of numbers) and stability (the application of numbers). Ann teaches her learners to recognise patterns, see time, solve problems. Growth and the various branches give way to the various strategies that can be used to achieve understanding. Ann mentions that she does not have to take the same safe route of following her textbook, that she took while she was in school. She has the option to use other routes (internet, workshops), use a ladder or prop(mentor), and move on via the branches. As Ann gets pass the trunk (that is the foundation), she will find ways to go through her first lesson and then the entire syllabus. The leaves, flowers and fruit represent the lessons, activities methods and resources**.** It must be remembered that no two trees are the same. Ann brings in her own experiences, knowledge and culture into the interpretation and depending on her learners and the environment, she will adapt and

apply the curriculum accordingly. Cannon et. al, (2020) study suggests that teachers explore and express their own experiences from their own cultures.

Ann sees the mathematics curriculum as tree that has numbers and operations as the roots and everything else interconnects from the trunk.

5.7. Pam: Visualising curriculum as a toolbox for teaching mathematics

A tool is something we use to do a job, to fix or mend something. Pam uses the mathematics curriculum to teach. Pam uses these tools to create a conducive environment. She develops a path to accommodate the learners and generate interesting and real-life contexts. Pam replaces the examples to suit her learners making it easier for them to relate. Pam considers the socio-economic backgrounds and cultures that her learners come from. When challenges arise, Pam uses a specific tool from her toolbox that provides clear boundaries, e.g., sometimes the learners do not understand the mathematical language, so she must replace words and give support in a different way when needed. The Mathematics curriculum will influence the nature of the tasks to be accomplished. These tools become useful via Pam's various interpretations and methods she uses. Pam communicates instructional ideas and supports creative thinking while enacting the curriculum. Miller, (2021) study reports creativity can be infused into the classroom with the core curriculum.

Pam creates or modifies the curriculum according to her own capacity, the availability of resources and the environment e.g.: Pam says that she uses a ruler as a concrete representation of a number line when learners have not grasped a number sense. They can read the numbers from a ruler. Pam assesses the learners and gets feedback as to which tools are effective. Pam uses the toolbox to address learners' errors and misconceptions after reflecting on the learner outcomes. This is one area where Pam wishes she had more professional development where specific ways to reason and communicate, to understand the relationships of the discipline and to access societal issues. She believes that in this way she could make maximum use of the tools at her disposal.

5.8. Conclusion

The analysis of the sketches and views that appear embedded in the sketches suggest that the teachers have different conceptions of curriculum, and different approaches

to the teaching of Mathematics. The way they visualise the curriculum reveals the ways in which they try to meet the needs of those they teach. Most of them refer to the curriculum as a resource and a professional development tool, which is useful to develop themselves, while others use it to keep abreast with curriculum changes and align their teaching approaches to their personal ideologies and beliefs. In the next chapter, I discuss the major findings of the study and provide some implications that emerged.

CHAPTER 6

CONCLUSIONS, LIMITATIONS, AND IMPLICATIONS

6.1. Introduction

The previous chapter inferred the ways teachers tried to meet the needs of students' learning through the curriculum. This chapter provides insights and the implications of as well as concluding the study.

6.2. The relationship between years of experience / age and the visualisation of the mathematics curriculum

In this section I look at the relationship between age, years of experience and the Mathematics curriculum.

Teachers that have more experience seem to depend less on curriculum however the remaining teachers depend on the Mathematics curriculum just for basic guidelines of lesson planning and sequencing. The teachers with lesser experience look to the curriculum for activities as well as planning. The grade R teacher (Tia) with just 2 years of interaction depends totally on the curriculum. Jenny is also one of the new teachers. Rae still a novice teacher, relies on the curriculum to guide her. In relation to Crisan, Lerman & Winbourne's study, novice teachers do not have a real understanding as they do have not have the necessary experience therefore, they rely on curriculum. (Gichuru & Ongus, 2016) found that experienced teachers affect learner performance more than novice teachers). Teaching experience appears to play a vital role in informing teachers' instructional decisions and actions.

6.3. Teacher agency and visualisation of the Mathematics curriculum

In this section we look at the relationship of teachers who take the initiative of adapting the curriculum. Campbell (2012, p.183) defined teacher agency as "The capacity of teachers to use their professional discretion in their pedagogical and curricular practices, alongside their accountability to the state, which generally maintains the overall authority for educational policy".

It is revealed by each teacher that they require a range of teaching methodologies to engage learners in critical thinking opportunities. All six teachers looked to other resources for teaching strategies resonating with Diekema's claim. Diekema & Whitney, (2012) & Ulger (2018) claim that the main reason for the choice of a teaching resource is its recommendation by colleagues and they identify and address alternative strategies. Such affordances would enable teachers to engage learners and improve their understanding of specific concepts as described by Bani lower, Paisley & Weiss (2006). Since we teach an assortment of learners, different methods are required to accommodate all the learners. Yeoman (2018) expresses flexible teaching and assessment methods to accommodate a range of learners. While purpose answers to why do teachers look to the Mathematics curriculum, strengths and weaknesses also allude to the need to look for other avenues of how to enact the mathematics curriculum.

6.4. Beliefs and visualisation of the curriculum

Understanding teachers' beliefs and the way they inform teachers' visualisation of the Mathematics curriculum is critical to improve Mathematics instruction.

Tia reports that, "Time and experience will help me be more efficient the next time round. Therefore, I chose the puzzle." In this study teachers' beliefs seem to arise from their upbringing. This resonates with the study by Cobanoglu, Capa-Aydin & Yildirim (2019) which states that beliefs are accrued by reflection of life.

Kate thinks that each slice of the pizza allows her, the teacher the opportunity to create multiple journeys depending on her environment. Ann comments that via her apple tree, she brings in her own experiences, knowledge and culture into the interpretation and depending on her learners and the environment, she will adapt and apply the

curriculum accordingly. This is consistent with Schoen & LaVenia (2019) study that indicates that the belief system is developed with math teachers before he begins his career life.

Manderfeld & Siller (2019) define beliefs as a pool of perceptions that a person holds, which impact and may be acquired from the daily experiences or the person's personality which is consistent with Jenny's sketch. Jenny says that her love for food and desserts made her choose a four-tiered cake. She says that she chose this image because learning takes place at all levels of schooling. Jenny says she will design her lessons with different ideas, methods, and resources to achieve the best outcomes.

What comes to light are the various ways teachers may draw on their own knowledge, how they evaluate resources, and accordingly select (or not) them, how they make sense of them in terms of their own beliefs and possibly adapt them. This is also suggested in this summary of interviews by strengths and weaknesses in the one word to describe mathematics and if participants enjoyed Mathematics at school or not. In the interviews Ann and Pam relate disappointing experiences that seem to impact in their visualisation of the mathematics curriculum.

6.5. Limitations and Delimitations of the study

All research studies face limitations and shortcomings. This is a small-scale qualitative study in a suburb in Mount Edgecombe that is subjective and contextual, therefore this study cannot be generalised. The study was delimitated to 6 foundation phase teachers. It does, however, offer some insight to those who are interested in teacher visualisations of the curriculum.

As a foundation phase teacher, I acknowledge that I would have certain biases and personal interests in the conducting of this study. However, I did not allow my opinions to influence the participants.

6.6. Conclusions and Implications of teacher visualisation of the mathematics curriculum.

This chapter has focused on the discussion of the data collected. It is noticed that a variety of aspects are rooted in the reasons that teachers use the Mathematics

curriculum. Younger teachers and less experienced teachers need to know the structure of their disciplines and the curriculum provides them with roadmaps that guide their lessons and assessments and assist them to measure their learners' progress. These aspects are foundational to planning and instruction. Teachers need to reflect via communication and make informed decisions together as no curriculum will be perfect or cast in stone but provides a guideline to reach and achieve their goals. Therefore, the teachers visualise the curriculum according to their belief and knowledge they acquire through experience.

I conclude this study with the implications after carefully considering the insights that I obtained throughout the study.

It is common knowledge that the Mathematics performance in the country is poor as attested by TIMMS. It shows that South Africa has not fared well. One of the ways to understand why this is so, might be that the clue provided by this study that when you ask teachers to visualise, you get a sense about what they think and how they think.

The study shows that with experience comes agency, decision making and confidence and so in some way, the programmes for professional development can build on the idea of how to maximise teachers understanding of how they see the curriculum and how that influences their teaching. In the same way the programmes will develop their confidence or show them, making teachers aware of either advantages or disadvantages for student learning. Teachers must be made aware of their visualisation and their interpretation.

The study shows that teachers have some understanding of the curriculum. Teachers are thinkers and can and do think about curriculum issues. The idea is to build on it, and to help them to become more effective over time.

6.7. Conclusions

The study has revealed that the curriculum policy which is in a written format comes alive inside the teacher's head. The teachers give the curriculum life. They perform it, they assess it, and they think about it. For the curriculum to reach its full potential it

needs to be less prescriptive and allow teachers to utilise their creative discretion in the implementation stage. Teachers are competent and display their expertise in the interest of the learner. They diplomatically manoeuvre through the curriculum handling numerous turbulent contextual factors specific to their school. They are key players in the implementation stage who can make informed choices to adapt and support the Mathematics Curriculum and other Mathematics teachers.

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APPENDICES

APPENDIX A: Interview questions

Name: _____

Teachers' visualisation of the Mathematics curriculum
NAME and SURNAME
NUMBER OF YEARS OF EXPERIENCE:
HIGHEST QUALIFICATION:
AGE:
SPECIALISATION SUBJECT:
Interview Questions
1. What image springs to mind regarding the Mathematics curriculum? Please sketch your image of the mathematics curriculum on the page provided.
2. Why this image of Mathematics?
3. How is this image related to the mathematics curriculum?
4. What aspects of the mathematics curriculum does the image relate to?
5. Is this the only image that you had in mind? If not, do other images spring to mind?
6. What curriculum materials do you use?

7. When do you use these materials?
8. Do you use any other curriculum materials?

APPENDIX B

Education, College of Humanities,

University of KwaZulu-Natal,

Edgewood Campus,

Dear Participant

INFORMED CONSENT LETTER

My name is Roshini Kowlesar. I am a M.Ed. candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa.

I am interested in learning about teachers' visualisation of the Mathematics curriculum.

This study will be in Durban. Your school is my case study. To gather the information,

I am interested in asking you some questions.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person but reported only as a population member opinion.
- The interview may last for about half an hour and may be split depending on your preference.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- The research aims at knowing the challenges of your community relating to resource scarcity, peoples' movement, and effects on peace.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether you are willing to allow the interview to be recorded by the following equipment:

	Willing	Not willing
Audio equipment		
Photographic equipment		
Video equipment		

I can be contacted at:

Email: roshini.kowlesar@gmail.com

[redacted]

My supervisor is Dr Nyna Amin who is located at the School of Education, Edgewood Campus of the University of KwaZulu-Natal.

Her contact details are:

Email: amin@ukzn.ac.za

Phone number: 031-2607255.

Should you have queries, you may also contact the Research Office through:

Mr P. Mohun

HSSREC Research Office,

Tel: 031-260 4557

E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

I…… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT

APPENDIX C: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

15 December 2015

Mrs Roshini Kowlesar 214582382
School of Education
Edgewood Campus

Dear Mrs Kowlesar

Protocol reference number: HSS/1710/015M
Project title: Teachers' visualization of the Mathematics curriculum

Full Approval – Expedited Application

In response to your application received 23 November 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

.....
Dr Shenuka Singh (Chair)
Humanitities & Social Scinces Research Ethics Committee

/pm

Cc Supervisor: Dr Nyna Amin
Cc Academic Leader Research: Prof P Morojele
Cc School Administrator: Ms T Khumalo

Humanities & Social Sciences Research Ethics Committee
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