

# Teaching the mathematical concept of time in Grade 2

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# **TEACHING THE MATHEMATICAL CONCEPT OF TIME IN GRADE 2**

by

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## *This study is dedicated to*

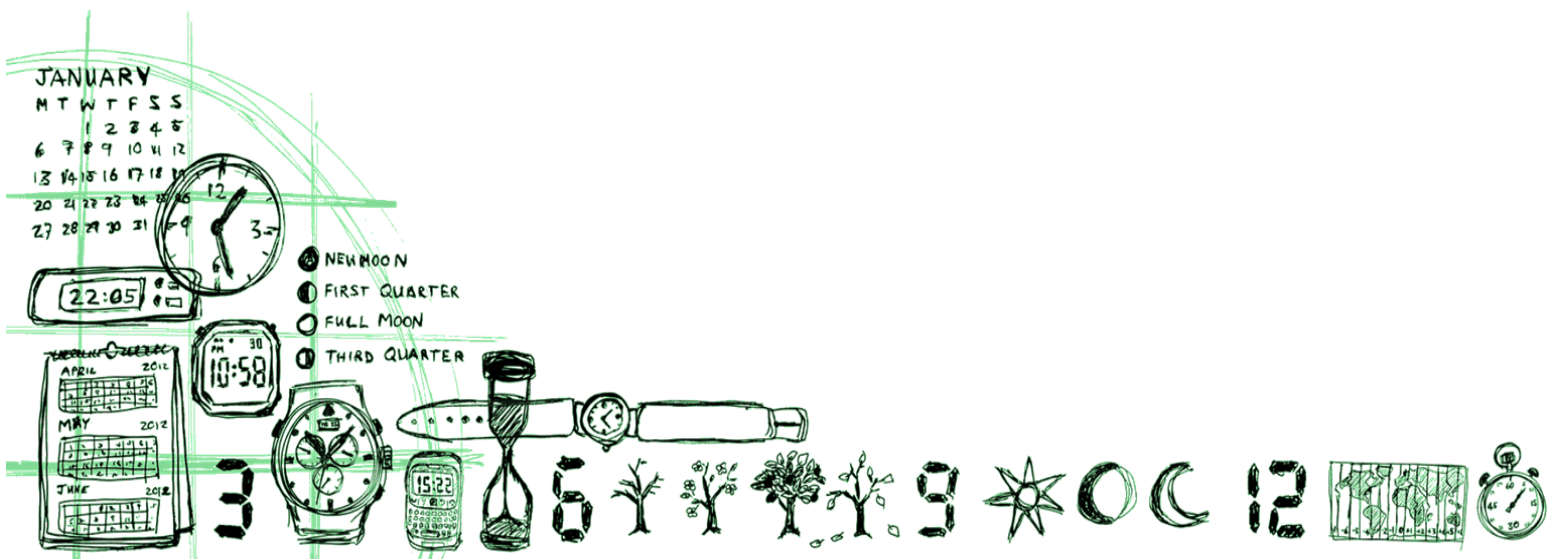
*My father, Joos Prinsloo:* You inspired me to trust in God and in my abilities. I will never forget your delight when I defended my research proposal successfully. You are dearly missed.

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*Above all, I dedicate this study to all the foundation phase learners who inspire their teachers to stay motivated and to teach with their excitement intact.*



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## ABSTRACT

Mathematics curricula, worldwide, focus on the teaching and learning of mathematical concepts, which foundation phase learners can use in their daily lives. However, literature and Grade 2 mathematics teachers alike, endorse the assertion by researchers that the mathematical concept of time (included in the measurement concept area) is often difficult for some young learners to understand. This study, therefore, focuses on the teaching and learning of analogue and digital time in Grade 2, in a South African context.

This study, used a qualitative practitioner research approach within *the emergent conceptual framework for the understanding of the mathematical concept of time*. This conceptual framework utilises key aspects of both the Pirie-Kieren model for the growth of mathematical understanding and the social constructivist theory. The conceptual framework, as well as practitioner research principles, provided the research team with a mechanism to design and implement the CLOCKWISE mathematical programme during the research process. Consequently, different teaching strategies were applied which, it was hoped, would explore and develop Grade 2 learners' understanding of the mathematical concept of time.

The study specifically sought to answer the research question addressing how the CLOCKWISE mathematical programme enhances Grade 2 teachers' teaching strategies and learners' understanding of the mathematical concept of time. Data was generated from the CLOCKWISE mathematical programme, participant observations, interviews, classroom discussions and document analysis. The data was collected and analysed simultaneously. This process resulted in the thematic analysis process and in the discussion of three themes.

The findings from this research indicate that innovative teaching strategies facilitate the active participation of Grade 2 learners in their own meaning-making, and their understanding of the mathematical concept of time. Thus, the study contributes to the literature of the teaching of mathematical time.

**KEYWORDS:** foundation phase mathematics, the mathematical concept of time, foundation phase, teaching, Grade 2 learners, mathematical understanding

## ACRONYMS

|                |   |
|----------------|---|
| ANA            | Annual National Assessment                              |
| CAPS           | Curriculum and Assessment Policy Statement              |
| DA             | Document analysis                                       |
| FI             | Focus group interview                                   |
| FN             | Field notes   |
| HOD            | Head of Department                                      |
| I <sup>1</sup> | Semi-structured interview 1                             |
| I <sup>2</sup> | Semi-structured interview 2                             |
| L              | Learner   |
| RD             | Research diary  |
| TIMMS          | Trends in International Mathematics and Science Studies |
| VA             | Video analysis  |

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## CHAPTER ONE: INTRODUCTION AND BACKGROUND TO THE STUDY



### 1.1 Introduction

In South Africa and in other countries, educational policy documents propose mathematical concepts which young learners should acquire in the early primary Grades of their formal schooling. The teaching and learning of foundation phase mathematics involves more than just acquiring the knowledge of various concepts and skills (Ministry of Education, 2012). Furthermore, it implies that teachers should encourage learners to apply their knowledge of mathematical concepts in new situations (Donovan & Bransford, 2005). Research, recent newspaper articles and debates in educational circles, therefore, draw attention to the need to strengthen young learners' mathematical understanding (Rademeyer, 2014; Skemp, 1989; Young-Loveridge, 2004; Zhang, 2005). In addition, educational policy documents intentionally focus on mathematical concepts and standards which will enable young learners to develop in confidence as they apply their knowledge in order to participate meaningfully in all areas of society (Department of Basic Education, 2011:4).

In a South African context, the Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2011) came into effect in January 2012 within the foundation phase (Grades R-3) of primary schools. The foundation phase curriculum focuses on the teaching and learning of four subjects: home language, first additional language, mathematics and life skills. Mathematics covers five content areas which focus upon specified knowledge, concepts and skills, namely: numbers, operations and relationships; patterns, functions and algebra; space and shape; measurement and data handling (Department of Basic Education, 2011). Foundation phase teachers are required to focus on the teaching of the properties of length, capacity, mass, area and time within the measurement content area of the national curriculum (Department of Basic Education, 2011).

South African and international literature affirm that the measurement content area is still challenging for both the mathematics teachers and learners (Charlesworth & Lind, 2013; Cockburn, 1999; Department of Basic Education, 2013; Dunphy, 2009). In recent years, international research and South African diagnostic reports in which young learners' understanding of mathematical concepts are analysed and discussed, suggested that young learners' acquisition of analogue and digital time still is inadequate (Charlesworth & Lind, 2013; Cockburn, 1999; Department of Basic Education, 2013; Holmes, 1985; Van de Walle, 2004). This assertion is corroborated by foundation phase teachers at the research site of this study. The Grade 2 mathematics teachers regularly discuss the apparent inability of learners to understand the concept of telling time, and their struggle to teach this content area of the curriculum in a South African context.

This practitioner research project constituted a process of teacher reflection and the design of a mathematical programme which pertains specifically to the teaching of analogue and digital time. The CLOCKWISE mathematical programme was implemented and discussed among foundation phase teachers at the research site. The findings from the study can be useful for Grade 2 mathematics teachers and learners alike. It may also encourage teachers to improve their teaching of the mathematical concept of time in Grade 2 classrooms. Furthermore, an understanding of the concept of telling time would help young learners to use their knowledge of mathematical time in real-life situations (Kheong, 2009).

## **1.2 Background to the study**

In recent years, questions have been raised about the effectiveness of the teaching and learning of mathematics in a South African context (Kruger, 2011; Rademeyer, 2014; Van der Merwe, 2014). The international literature also affirms that the teaching and learning of certain mathematical concepts are challenging for mathematics teachers and learners respectively (Charlesworth & Lind, 2013; Cockburn, 1999; Dunphy, 2009; Holmes, 1985; Orton & Wain, 1994; Van de Walle & Lovin, 2006).

As a result, countries such as the United Kingdom, Australia, New Zealand, the United States of America, China as well as South Africa initiated curriculum reforms in

mathematics (Cai, Kaiser, Perry & Wong, 2009; Department for Education and Employment, 1999; Department of Basic Education, 2011; Department of Education, Training and Youth Affairs, 2000; Ministry of Education, 2001; Young-Loveridge, 2004; Zhang, 2005). These initiatives focused upon curriculum reforms which will enable learners to apply their knowledge once they have left school (Lesh & English, 2005).

The Foundations for Learning Campaign (Department of Education, 2008) and the national curriculum of South Africa (CAPS) (Department of Basic Education, 2011) are initiatives of the South African Department of Basic Education. These initiatives mainly focus on the distribution of workbooks and on the knowledge and skills which learners in South African schools have to attain (Brombacher, 2011). As part of this reform action, the Department of Basic Education (2013) has put the Annual National Assessment (ANA) in place. ANA is a key strategy which annually measures South African learners' progress in their home language and in mathematics.

In recent years, results of the Trends in International Mathematics and Science Studies (TIMSS) (Howie, 2001) and the ANA initiative have nevertheless shown that South African learners' performance in mathematics is still well below the expected norm (Department of Basic Education, 2013; Howie, 2001; Kruger, 2011; Van der Merwe, 2014). The ANA diagnostic report of 2012 indicated that the understanding and representation of the concept of time were difficult for foundation phase learners (Department of Basic Education, 2012). As a Grade 2 teacher with twenty-three years of experience, I also observed that some learners are able to identify important dates, and times important to them, in their daily schedules, but many of them struggle with analogue and digital time. Teachers teaching foundation phase mathematics also suggest that the concept of analogue and digital time often has to be re-taught in Grade 3.

Research has indicated that learners find it difficult to understand the concept of time because the conceptualisation thereof depends on the learning of time vocabulary, such as fast and slow (relational words), minutes and hours (duration words) and birthday or Christmas (special days) (Charlesworth & Lind, 2013). Young learners most likely find it difficult to distinguish between the different sides of an analogue clock and the different

meanings of the numbers on clock faces which depends on the dial that points to them (five past or one o'clock) (Cockburn, 1999). Learners who confuse decimals and digital minutes, and are unable to count from zero to 60 and translate the hours after midday to the 24-hour clock, will also find it difficult to conceptualise digital time.

International literature (Casey, Kersh & Mercer Young, 2004; Greenes, Ginsburg & Balfanz, 2004) therefore provides suggestions, such as the use of one-handed clocks, for the facilitation of the mathematical concept of time. Literature suggests that teachers must encourage learners to represent certain times on clock faces to enhance their understanding of the mathematical concept of time (Charlesworth, 2005; Charlesworth & Lind, 2013; Department of Basic Education, 2012). Although there are guidelines on problem solving and reasoning, most of the mathematics curricula mainly focus on the instruments used to tell time and on the sequence of instruction (Common Core Standards Initiative, 2010; Department for Education, 2013a; Ministry of Education, 2012). In addition, the Department of Basic Education (2011) also encourages foundation phase mathematics teachers to utilise workbook activities and worksheets to reinforce mathematical concepts and skills.

Hardly any reported studies have, however, focused upon innovative teaching strategies and learners' understanding of the mathematical concept of time. This study, therefore, sought to address the question of whether innovative teaching strategies (pedagogical principles) will enhance Grade 2 learners' understanding of the mathematical concept of time. My study contributes towards the knowledge domain of mathematics teaching and learning for young learners.

### **1.3 Problem statement and research questions**

Literature affirms that the mathematical concept of time can be facilitated for young learners, but it still remains a challenge. In response to that challenge, therefore, this study attempted to determine how the mathematical concept of time can be facilitated to enhance Grade 2 learners' understanding.

From the discussion with foundation phase teachers in the pre-implementation phase of the study, it seemed that learners' understanding of the mathematical concept of time is influenced by teachers' teaching strategies. Consequently, this study focused on the design and implementation of the CLOCKWISE mathematical programme to implement different teaching strategies which, it was hoped, would explore, develop and improve Grade 2 learners' understanding of the mathematical concept of time.

The problem statement gave rise to the main research question of this study:

*How does the CLOCKWISE mathematical programme enhance Grade 2 teachers' teaching strategies and learners' understanding of the mathematical concept of time?*

The main research question was addressed through the following sub-questions:

- *Which pedagogical principles inform the design of a mathematical programme on the conceptualisation of time in Grade 2?*
- *How does the conceptual understanding of time develop in Grade 2 learners as a result of their participation in the CLOCKWISE mathematical programme?*
- *How do Grade 2 teachers experience the teaching of the mathematical concept of time during the implementation of the CLOCKWISE mathematical programme?*

## **1.4 Purpose of the study**

When this study commenced, it was evident that although literature provides suggestions on the teaching of measurement concepts, there is a lack of information on the innovative teaching strategies for the concept of time (Casey *et al.*, 2004; Greenes *et al.*, 2004). Therefore, the purpose of this study was to explore teaching strategies which, it was hoped, would improve Grade 2 learners' conceptualisation of the mathematical concept of time. By designing and implementing the CLOCKWISE mathematical programme, this study also aimed to better understand how Grade 2 learners' understanding of the mathematical concept of time developed. In addition, the effect of the teachers' teaching strategies could also be reflected upon.

More specifically, the study aimed to:

- Explore teaching strategies which will most likely develop Grade 2 learners' conceptual understanding of the mathematical concept of time.
- Identify how Grade 2 learners' growth of mathematical understanding develops whilst engaging with the teaching strategies of the CLOCKWISE mathematical programme.
- Investigate Grade 2 learners' way of thinking about time.
- Understand how the conceptual understanding of time develops in Grade 2 learners.

## 1.5 Significance of the study

When this study commenced, it was evident that although literature provides suggestions on the teaching of measurement concepts, there is a lack of information on the teaching of the mathematical concept of time (Casey *et al.*, 2004; Greenes *et al.*, 2004). Therefore, this study can fill the void specifically in the South African context since it addresses aspects which specifically pertain to the teaching and learning of the mathematical concept of time in Grade 2.

The significance of mathematical understanding has been emphasised in recent years in the media and in educational reports in countries such as South Africa, the United Kingdom, Australia, New Zealand, the United States of America and China (Cai *et al.*, 2009; Department of Basic Education, 2013; Young-Loveridge, 2004; Zhang, 2005). In South Africa, the Department of Basic Education (2013) emphasises Grade 2 learners' lack of insight into the mathematical concept of time. This study is significant because it explored Grade 2 learners' understanding of the mathematical concept of time and encouraged them to relate the concept of time to their daily lives (Waller & Bitou, 2011). The study also explored Grade 2 learners' growth of mathematical understanding, whilst engaging with innovative teaching strategies to understand how Grade 2 learners engage in and learn the mathematical concept of time.



Literature (Grinstein & Lipsey, 2001) asserts that a certain sequence of instruction should be pursued by teachers in their teaching of the mathematical concept of time. They believe that learners must firstly experience time concretely through tactile and kinaesthetic activities; then learners must represent times on clock faces and lastly they must identify times on worksheets. However, Broadhead (2006:202) states that guidelines cannot determine the sequence of instruction since teachers should also focus upon the learners' learning processes and learners' growth of mathematical understanding. This study connects new ideas to the learners' existing knowledge, which directs the sequence of instruction.

The focus of this study is also primarily on the development of Grade 2 learners' process skills and not on workbook activities. Learners are encouraged to solve problems, to develop their reasoning skills, to communicate with their peers and teachers and to connect and apply their knowledge in different situations.

## **1.6 Clarification of core concepts and terminologies**

To enhance the general understanding and application in the context of this study, the following concepts and terminologies are explained.

### **1.6.1 Foundation phase**

The foundation phase is the first phase within the General Education and Training (GET) band, in a South African context. The Department of Basic Education in South Africa subdivided the first phase into four Grades which include Grades R, 1, 2 and 3. As a result, this phase includes learners five to nine years of age (Department of Basic Education, 2011). For this study the focus will be on Grade 2 learners.

#### ***Grade 2 learners***

In this study, the focus is on foundation phase learners in Grade 2 classrooms. In the South African schooling system, Grade 2 learners are, under normal circumstances, in

the second year of their formal schooling. Grade 2 learners will, therefore, under normal circumstances be seven to nine years of age (South Africa, 2000).

### **1.6.2 Mathematics**

According to the national curriculum in South Africa (Department of Basic Education, 2011:6), mathematics can be described as “a language that makes use of symbols and notations”. It is also recognised that mathematics features in the course of daily activities as people observe and make representations or explore relationships and patterns (Department of Basic Education, 2011). As a result, developing a deeper understanding of these aspects of life is considered to be something that should be included in mathematics education (Kwon, 2004).

#### ***Foundation phase mathematics***

In this study, foundation phase mathematics refers to the teaching and learning of mathematical concepts in the early years of the formal schooling system in a South African context. Mathematical teaching in the foundation phase should develop young learners' confidence in gaining mathematical knowledge which they can utilise in their daily lives (Department of Basic Education, 2011). Foundation phase mathematics covers five content areas, namely: numbers, operations and relationships; patterns, functions and algebra; space and shape; measurement and data handling.

#### ***Early primary school mathematics***

For countries such as the United States of America, Singapore and England, the focus in early primary school mathematics is as follows. In the United States of America, Grade 2 mathematics focuses primarily on four areas: operations and algebraic thinking, number and operations, measurement and data and geometry (Common Core State Standards Initiative, 2010). Young learners in England (Department for Education, 2013b), should work with numbers, geometry, measurement and statistics in mathematics classrooms. The primary mathematics curriculum in Singapore (Ministry of

Education, 2006) focuses on whole numbers, fractions, measurement, geometry and data analysis. This study focuses on the teaching of mathematical time, which is part of the measurement content area in South Africa and in many countries (Common Core State Standards Initiative, 2010; Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012).

### **1.6.3 The mathematical concept of time**

Mathematics incorporates a diversity of concepts which young learners should explore and understand (Mason & Johnston-Wilder, 2004; Orton & Frobisher, 1999). Teachers should, therefore, provide learning experiences which will encourage learners to build upon their existing knowledge and to actively engage in their own meaning-making (Li, 2004; Mason & Johnston-Wilder, 2004; Meel, 2003). Learners' active participation will most likely illuminate the properties of mathematical concepts such as the mathematical concept of time, which are more complex and sometimes difficult for young learners to understand (Lind, 2011).

Lever (2003) states, that mathematical time is an important concept for learners to understand, since it is used most directly in their daily lives. Grade 2 learners in the South African schooling system should, therefore, describe the time of day using vocabulary such as 'early' and 'night', compare activities in terms of the length of time they take, and sequence and identify events according to days, months, weeks and years. Grade 2 learners in South Africa, Singapore, the United States of America and the United Kingdom are expected to identify hours, half-hours, quarter of an hour and minutes on analogue clocks (Common Core State Standards Initiative, 2010:10; Department of Education, 2013; Department of Basic Education, 2011:15; Ministry for Education, 2012:40). Grade 2 learners in the United States of America are also required to identify time to the nearest minute on digital clocks (Common Core State Standards Initiative, 2010:20). This study, investigates Grade 2 learners' development of mathematical understanding of time on both digital and analogue clocks, in a South African context.

#### 1.6.4 Teaching of foundation phase mathematics

Teaching, in this study, implies that the teacher facilitates the learning process (Bishop, Clements, Keitel, Kilpatrick & Laborde, 1996). Furthermore, teaching combines an understanding of the mathematical concept of time, an understanding of how learners learn and an understanding of how learners' growth of mathematical understanding of the concept of time can be enhanced (Van de Walle & Lovin, 2006). Knowledge of pedagogical principles and teaching strategies will assist mathematics teachers in providing opportunities for young learners to develop their understanding of the mathematical concept of time (Orton, 2004). Thus, the objective of teaching is to "promote learning" (Orton, 2004:171).

Slabbert, de Kock and Hattingh (2009) state, that teachers should initiate and maintain learning in their classrooms. To initiate learning, the teacher should not only focus on the mathematical content knowledge or what the learner should know, but also on how the learner will obtain and apply this knowledge. Learning task design is therefore the primary focus of a teacher as a facilitator of learning. Slabbert *et al.* (2009) assert that learning task design does not imply that the core elements of a mathematics curriculum should simply be sequenced and presented in a logical way. Teachers need to be prepared and well-informed in order to initiate learning and to give the learners "as many perspectives as possible on the content of knowledge" (Olsson, 2009:184). Consequently the teacher will also be receptive to what the learners will add to these perspectives, the learners' understandings and their learning processes. This could be accomplished by listening to the learners whilst formally and informally discussing the concepts and by encouraging the learners to reflect upon their own ideas.

To maintain learning, the teacher in this study must encourage learners to participate in classroom discussions. For that reason, the mathematical concepts of time are embedded in the oral story of the CLOCKWISE mathematical programme. Whilst discussing the characters and the events in the story, learners are informally introduced to hours, half-hours, minutes past the hour and minutes to the hour on analogue and digital clocks. This study also employs games and manipulatives to enhance the

learners' understanding of the underlying properties of the mathematical concept of time (Van de Walle & Lovin, 2006). The games and manipulatives employed by the teachers in this study will encourage the learners to share the meaning they construct with others, ensuring that the learners stay engaged with the learning task (Slabbert *et al.*, 2009:108). Thus, learning is maintained.

This study also utilises learners' visual and verbal representations as tools to initiate, enhance and maintain learning (Charlesworth, 2000). Slaten (2006), states that visual representations include pictures, drawings, gestures, diagrammes and photographs. Learners can therefore "communicate their understanding" in their visual representations of mathematical concepts (Wilson & Stein, 2013:673). In addition, Carruthers and Worthington (2006) and Wilson and Stein (2013) proclaim that learners' understanding of the underlying principles of mathematical concepts will develop if they are allowed to talk about their visual representations. Therefore, it is imperative that teachers should listen to learners' explanations not only to assess their understanding, but also to plan activities which would build upon their current understandings (Olsson, 2009).

The utilisation of storytelling, games, manipulatives, classroom discussions and representations will encourage teachers to continuously assess the learners' growth of understanding or lack of understanding of the mathematical concept of time and their own teaching practices. Wolfe (2005:178) states that "this will assist teachers in making timely instructional adjustments and it will enable teachers to give supportive feedback to learners". Effective teaching of the mathematical concept of time, therefore, involves the active participation of both the teacher and learner and consequently encourages the growth of mathematical understanding.

### **1.6.5 Understanding the mathematical concept of time**

Ponte (1994) asserts that understanding is part of knowledge and it represents the learners' personal experiences and beliefs. Understanding of mathematical ideas and concepts is important because it enables learners to apply knowledge and to connect new knowledge to concepts they have previously obtained (Kastberg, 2002). Understanding, therefore, implies that connections are made between different

mathematical ideas and concepts. Understanding also supports remembering and enables learners to use knowledge in new situations (Cai *et al.*, 2009; Donovan & Bransford, 2005; Hiebert & Carpenter, 1992).

Pirie and Kieren (1989) noticed that the growth of mathematical understanding is not always a continuous process. Teachers should therefore initially focus learners' attention on knowledge they previously attained in order to build new knowledge (Hiebert & Carpenter, 1992; Skemp, 1989). Dooley (2009:1) posits that mathematics teaching in the past often focused only on direct instruction by teachers. Although different curriculum documents (Common Core State Standard Initiative, 2010; Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012) mention the use of clock faces as instruments, teachers should not only focus on the representation of time on clock faces to facilitate instrumental understanding. Learners will probably be able to represent time on clock faces, but instrumental understanding will not enable learners to describe why they have to represent it in a certain way (Byers & Herscovics, 1977; Kheong, 2009; MacMath, Wallace & Chi, 2009; Siegler, 2003; Skemp, 1989). Consequently, learners will not be able to apply their knowledge (Skemp, 1989).

It is, therefore, important to initially focus on learners' own understandings and their existing knowledge when new concepts are introduced (Kheong, 2009; Mason & Johnston-Wilder, 2004; Skemp, 1989). For the learners, it will also be "easier to remember concepts" and to "adapt their knowledge to new tasks" (Skemp, 1989:10). Thus, the CLOCKWISE mathematical programme focuses on the Grade 2 learners' learning processes and the relational understanding of the concept of time. The teaching strategies utilised in the CLOCKWISE mathematical programme encourage learners to explain their thinking and own ideas in their everyday language. Furthermore, the manipulatives and games employed in the study enhance the underlying principles of the mathematical concepts of time. Knowing what to do and why it is done encourages learners to apply their knowledge in different situations and enhances their relational understanding (Skemp, 1989). Relational understanding, therefore, encourages the application of their knowledge of the mathematical concept of time in their daily lives.

### **1.6.6 The CLOCKWISE mathematical programme**

The mathematical programme employed in this study provides foundation phase mathematics teachers with structured lessons, manipulatives and activities to support the teaching of the mathematical concept of time (National Council of Teachers of Mathematics, 2000). In accordance with the ideas of Berkas and Pattison (2007b) and Burns (2008), I can proclaim that the programme provides an opportunity for teachers to teach and learners to learn. Teachers and learners will be actively engaged with the mathematical concept of time during the activities.

The CLOCKWISE mathematical programme was specifically designed for this study by myself and my co-researchers. We consulted existing literature (including the national curriculum of South Africa (Department of Basic Education, 2011)) on the teaching and learning of the mathematical concept of time and we discussed our own teaching experiences as we designed the programme. The CLOCKWISE mathematical programme focuses on the teaching of analogue and digital time in Grade 2 in a South African context. Storytelling, games, manipulatives, visual representations and classroom discussion in the learners' vernacular are utilised to extend the Grade 2 learners' mathematical vocabulary and conceptualisation of the mathematical concept of time. I refer to the CLOCKWISE mathematical programme, its design and the implementation thereof in Chapter 4.

## **1.7 Unit of analysis**

I conducted my research at a primary school in the Tshwane North District of the Gauteng Province in South Africa. The school is a governmental school with 1 400 learners and it is situated in a middle-class neighbourhood. The language of learning and teaching is Afrikaans, which is also the home language of the learners. I obtained permission from the Gauteng Department of Education, the school principal as well as the governing body of the school to conduct the study with 92 of the school's learners in Grade 2 (see Appendices B, D and C).

Consistent with a practitioner research project, I was present as the teacher and researcher in my own Grade 2 classroom to assess the effect of the teaching strategies

embedded in the CLOCKWISE mathematical programme, the classroom discourse and the Grade 2 learners' understanding or apparent lack of understanding of the concept of mathematical time (Carr & Kemmis, 1986; McNiff & Whitehead, 2009; Walliman, 2005). I studied the teaching of mathematical time in the global as well as in the South African context.

The CLOCKWISE mathematical programme (see CD 1, CLOCKWISE) was designed in collaboration with two colleagues at the school where I teach. They acted as my co-researchers. All three of us employed the CLOCKWISE mathematical programme to teach the mathematical concept of time in our own classrooms. Thus, the CLOCKWISE mathematical programme was employed in three of the seven Grade 2 classes at the research site. The concept of time was also taught in the other four Grade 2 classes, but the teachers employed the teaching and learning methodologies embedded in the national curriculum (Department of Basic Education, 2011).

## **1.8 Research design and methodology**

As an interpretivist, I was interested in Grade 2 teachers and learners and their understanding of the mathematical concept of time in the school where I teach (Thomas, 2009). Therefore, the Grade 2 teachers' and participant learners' experiences and understandings were interpreted within the natural school setting in the study.

I decided that a qualitative research approach and the practitioner research method should support the inquiry. Since practitioner research is carried out "within the context of the teacher's environment, in order to deal with educational matters at hand" (Ferrance, 2000:1), I was present in my own classroom as teacher and researcher. Research was undertaken with two colleagues at the school where I teach. We implemented the CLOCKWISE mathematical programme in our own classrooms, to enhance our understanding of the teaching and learning of the mathematical concept of time (Mouton, 2001; Thomas, 2009). We regularly discussed the effect of the employed teaching strategies and the learners' growth of understanding or lack of understanding of the mathematical concept of time.



The CLOCKWISE mathematical programme, participant observation, interviews and document analysis were exploited to gather relevant data. The data was transcribed, collated and analysed using thematic analysis in order to answer the research questions of the study. In Chapter 3, I describe the data collection instruments in detail, whilst the data analysis process and thematic analysis process is explained and employed in Chapter 5.

## 1.9 Chapter outline

This study focused on the teaching and learning of the mathematical concept of time in Grade 2 in a South African context. The layout of the study is as follows:

**Chapter 1** provides a brief background to the teaching of mathematical time, the purpose of the study as well as the significance thereof. The chapter also includes the problem statement as well as a clarification of core concepts.

**Chapter 2** refers to literature which is pertinent to the problem stated. It includes a description of the theoretical principles which are of relevance to this study. Furthermore, this chapter explores learning and teaching components related to the mathematical concept of time. The pedagogical principles embedded in the CLOCKWISE mathematical programme are discussed. The chapter also provides a description of the conceptual framework of the study.

**Chapter 3** provides a description of the employed research methodology. It validates the utilisation of a practitioner research approach and the data collection instruments to address the proposed research questions.

**Chapter 4** explores the design of the CLOCKWISE mathematical programme and presents guidelines for the implementation thereof. The eight-week programme, the manipulatives and the activities are elucidated.

**Chapter 5** offers a discussion of the data collection, data analysis and thematic analysis process. The thematic analysis process resulted in the identification of three main themes, as well as sub-themes and categories within each of the themes.

In **Chapter 6**, I address my research questions, which I support with statements and arguments from literature. I offer conclusions, recommendations and limitations to the study and I also reflect upon my insights as practitioner researcher.

## CHAPTER TWO: LITERATURE REVIEW



### 2.1 Introduction

Chapter 2 reviews literature on the teaching of the mathematical concept of time and young learners' learning processes. International as well as South African literature based on empirical research is reviewed in four sections. The literature review focuses firstly on the theoretical perspectives within the study which provided insight into how learners learn and how teachers teach the mathematical concept of time. Furthermore, the theoretical perspectives which influenced my methodological choices, research process as well as the design of the CLOCKWISE mathematical programme and conceptual framework of this study are explained.

The chapter, secondly, explores learning and teaching components such as mathematical concept knowledge and pedagogical concept knowledge which are related to the mathematical concept of time. Thirdly, the pedagogical and theoretical principles which guided the design and implementation of the CLOCKWISE mathematical programme as described in Chapter 4, are discussed. The extensive literature review provided insight for the construction of the conceptual framework of the study which is described in Section 2.5.

### 2.2 Theoretical perspectives within the study

This study employed the key aspects of the social constructivist theoretical perspective deriving from Vygotsky's work (Kim, 2009; Vygotsky, 1986) and the Pirie-Kieren model for the growth of mathematical understanding (Meel, 2003; Pirie & Kieren, 1989) as points of departure. Both theories emphasise the learners' active participation in the enterprise of constructing understanding from the situations provided in mathematics classrooms (Kieren, 1997; Meel, 2003; Slaten, 2006). The Pirie-Kieren model also

“elaborates on the social constructivist theory and learners’ understanding as the continual process of organizing and reorganizing knowledge structures” (Slaten, 2006:31). In the next section I discuss both theoretical perspectives as well as the complementary elements which relate to the teaching and learning of the mathematical concept of time. The relevance of these theories to the teaching and learning of the mathematical concept of time is discussed in detail in Section 2.5.

### **2.2.1 Social constructivist theory**

Social constructivism is based on the idea that learners construct knowledge when they are actively involved in the learning process (Vygotsky, 1960). My preference for the social constructivist approach was motivated by my desire as practitioner researcher to explore teaching strategies within the classroom which will most likely assist Grade 2 learners to understand the mathematical concept of time (Bishop, Clements, Keitel, Kilpatrick & Laborde, 1996).

Wood (1989:39) states that social constructivism “brings aspects of Piaget’s and Vygotsky’s work together”. However, the “theoretical basis of social constructivism is inspired in large measure by the work of Vygotsky” (Cobb, 1994:13). According to Van de Walle and Lovin (2006), Piaget encouraged teachers to focus upon learners’ prior knowledge whilst Vygotsky suggested that social interaction within the learning environment will promote understanding. Thus, both theories propose that conceptual understanding of the mathematical concept of time will not be enhanced if teachers teach Grade 2 learners by merely telling them how to read analogue and digital time on clock faces (Ginsberg & Opper, 1969, Van de Walle & Lovin, 2006). Social interactions with teachers, peers and manipulatives in the classroom will therefore most likely encourage the growth of mathematical understanding of the mathematical concept of time (Cobb & Yackel, 1996; Ernest, 2011; Kim, 2009; Van de Walle & Lovin, 2006; Vygotsky, 1960).

Vygotsky (1986) views each learner as a unique individual with unique needs and background. An integrated view of social constructivism requires learners, therefore, to

be challenged and actively engaged in the classroom. Vygotsky (1986:5) believed that most learners will have confidence to participate in classroom discussions and thought-provoking activities, if they experience success in completing challenging tasks.

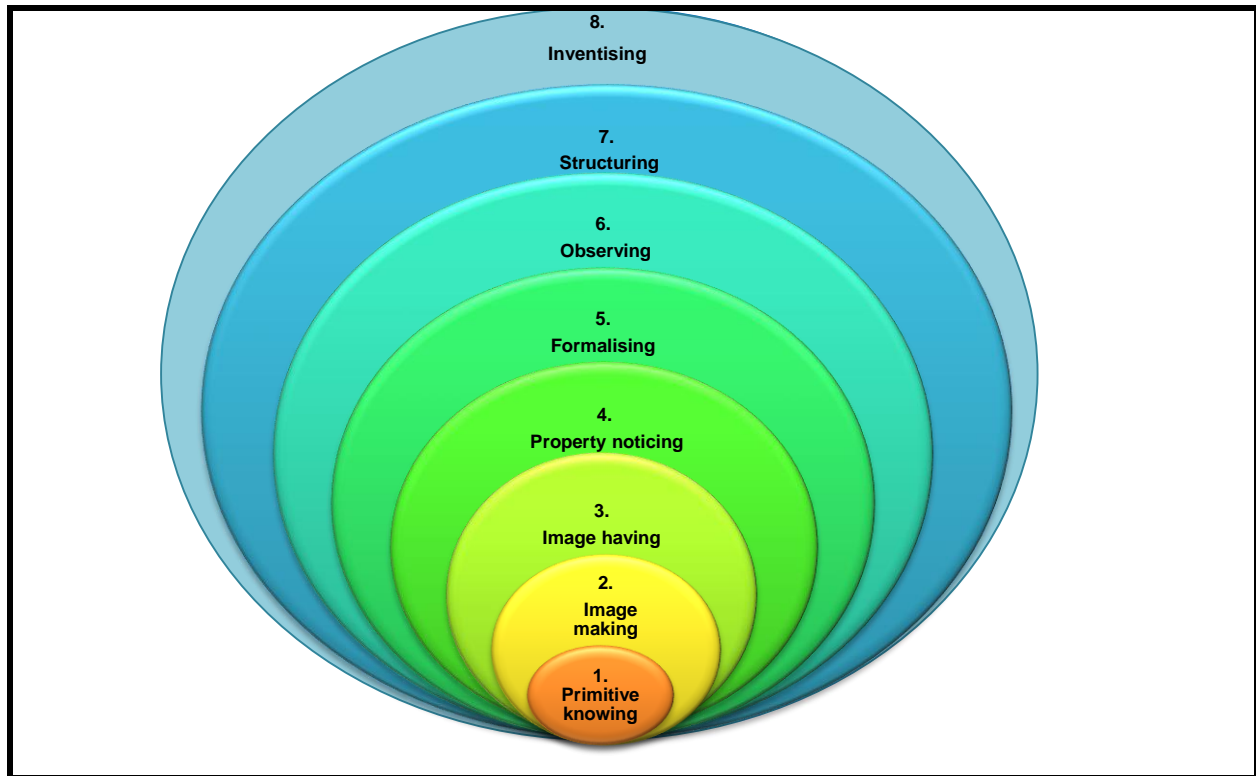
I deduced eight potential levels of understanding from the work of Tolman and Hardy (1995), Rogoff (1990) and Vygotsky (1960) which describe the development of learners' understanding within a social constructivist framework. The first level is called *prior knowledge* which refers to the learner's ideas and experiences which he or she brings to the classroom. It also suggests that teachers should adapt their teaching strategies to address learners' conceptions (Vygotsky, 1960). Secondly, the *acquiring knowledge* level of understanding suggests that the learner can interpret knowledge and use current knowledge in new situations (Tolman & Hardy, 1995). The third level of understanding refers to the *internalisation* of knowledge. Rogoff (1990) suggests that the shared knowledge which learners actively construct must be internalised by the learner. Thus, a learner's own understanding of the concept is developed. *Understanding knowledge* refers to the fourth level of understanding within the social constructivist framework. It implies that the teacher must provide learning experiences which will encourage the learners to share their individual ideas and it will most likely result in the construction of understanding (Tolman & Hardy, 1995). At the fifth level, the teachers should encourage learners to solve problems with group members. This level is known as the *using knowledge* level of understanding. Subsequently, learners will be able to *reflect* upon their new knowledge and utilise it in similar situations. At the seventh level of understanding, learners will be able to *extend* their knowledge and apply it to different situations. Lastly, the eighth level of understanding illustrates *conceptualisation* of a concept.

My research is also grounded in the Pirie-Kieren model for the growth of mathematical understanding, which I describe in the following section.

### 2.2.2 Pirie-Kieren model for the growth of mathematical understanding

Meel (2003:132) acknowledges that “new and integrative perspectives have grown out of Skemp’s distinction between instrumental and relational understanding”. Pirie-Kieren’s model for the growth of mathematical understanding “evolved from Glaserfeld’s definition of understanding” (Meel, 2003:143). Lawan (2011) mentions that the Pirie-Kieren model elaborates the constructivist idea of an individual understanding “as the continual process of organising and reorganising knowledge structures”. Lawan (2011) also affirms that the Pirie-Kieren model reflects the view that new understanding builds on prior competencies and understanding, reminiscent of Piaget’s theory of cognitive development. Piaget considered Grade 2 learners to be in the concrete operational stage of their cognitive development, which implies that they will be able to construct their own understanding of the mathematical concept of time whilst interacting with their teachers, peers and manipulatives (Ginsburg & Opper, 1969). Nevertheless, this study is primarily interested in the Grade 2 learners’ growth of mathematical understanding, therefore it employs the Pirie-Kieren model for the growth of mathematical understanding.

The Pirie-Kieren model is first and foremost a theory about how learners’ mathematical understanding grows and develops concerning a specific mathematical concept or topic (Pirie & Kieren, 1992; Slaten, 2006). The model is relevant to this study since the Grade 2 learners’ emerging understanding of the mathematical concept of time is examined. As suggested by Pirie and Kieren (1992), the designed CLOCKWISE mathematical programme therefore focuses on the active participation of the mathematics teachers and Grade 2 learners. The Pirie-Kieren model (see Figure 2.1) “contains eight potential levels for understanding” (Lawan, 2011:69).



**Figure 2.1: Adapted diagrammatic representation of the model for growth of mathematical understanding (Pirie & Kieren, 1994)**

“Each layer delineates a qualitative change” in the learner’s growth of mathematical understanding (Meel, 2003:163). Meel (2003:143) contends “that the core of the model is called *primitive knowing*, which connotes a starting place rather than low level mathematics”. According to Slaten (2006) and Lawan (2011), the process of growth of understanding begins at this level, since it constitutes the knowledge of the concept of time which a learner brings to the classroom. The second layer of the model is called *image making*. Wilson and Stein (2013) as well as Slaten (2006) state that the learners actively engage with their current knowledge of mathematical time in new ways. This is followed by the *image having* layer, which constitutes a mental image of the concept (Lawan, 2011). It also encourages the learners to describe their understanding of the concept of time in their everyday language (Slaten, 2006). The fourth layer is called *property noticing*. At this level learners “can determine the various attributes as well as connections between multiple mental images” (Meel, 2003:145). Thus, learners will be able to identify the properties of a concept. At the fifth level of understanding, learners

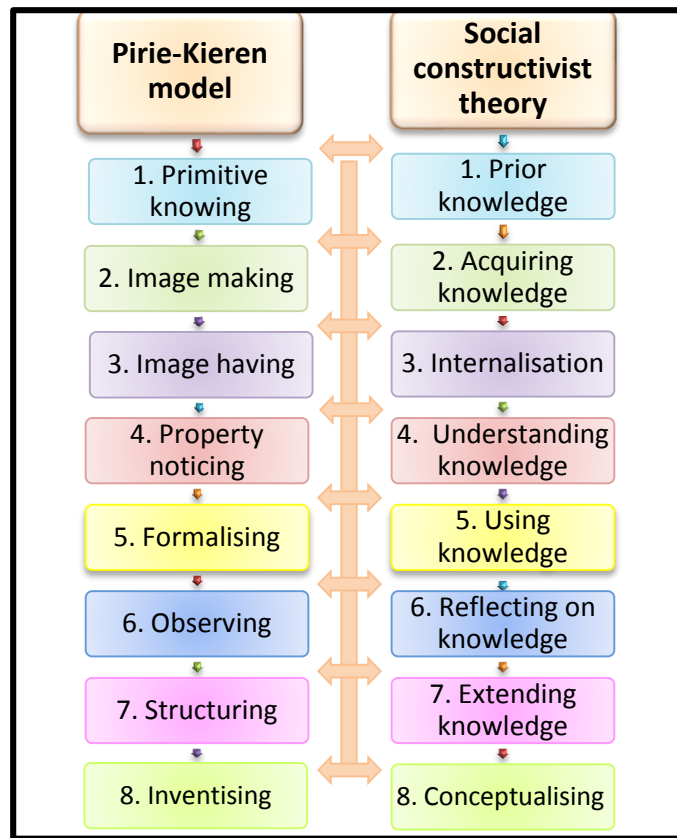
are able to construct a formal definition of a concept (Meel, 2003). Hence, this layer is known as *formalising*. Slaten (2006:33) asserts that the next layer is *observing* which refers to the level where learners can “reflect on and coordinate the formal understanding of a concept to make predictions”. This enables learners to “justify mathematical arguments through logic and proof” at the *structuring* layer (Slaten, 2006:33). “The outermost layer (eighth layer) of the Pirie-Kieren model of mathematical understanding is called *inventising*” (Meel, 2003:146). It refers to a fully structured understanding of a concept which implies that Grade 2 learners will be able to use knowledge of the mathematical concept of time in their daily lives.

In addition, the model contains a construct referred to as ‘folding back’. Meel (2003:147) asserts that “when a learner encounters a problem whose solution is not immediately attainable the learner has to ‘fold back’ to an inner (previous) layer to extend his or her current, inadequate understanding”. Thus, this construct encourages both teachers and learners to use previously attained knowledge on which to build their new understandings (Pirie & Kieren, 1989).

### **2.2.3 Complementary elements of the Pirie-Kieren model for the growth of mathematical understanding and the social constructivist theory**

Both theories adopt the approach that the processes of understanding are “recursive and non-linear” (Lawan, 2011:69). The Pirie-Kieren model constitutes eight levels of growth in understanding (Slaten, 2006), whilst the eight levels of understanding represent the levels of understanding in the social constructivist theory (Tolman & Hardy, 1995; Vygotsky, 1960) (see Figure 2.2). These levels complement each other.





**Figure 2.2: Complementary elements of the Pirie-Kieren model for the growth of mathematical understanding and the social constructivist theory, adapted from Tolman and Hardy (1995), Vygotsky (1960) and Pirie and Kieren (1989)**

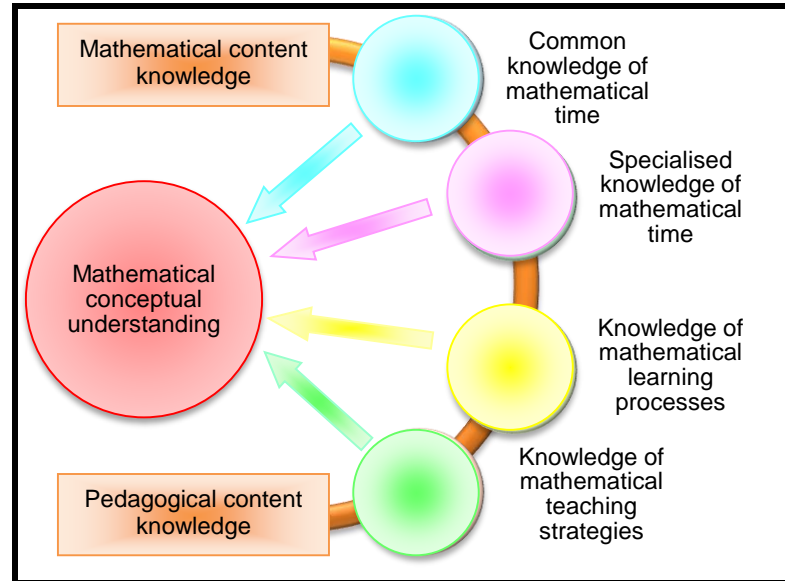
The first levels mentioned are *primitive knowing* and *prior knowledge*. In both theories these elements refer to the knowledge that a learner brings to the classroom. Teachers can utilise this knowledge to initiate a discussion on the mathematical concept of time. *Image making* and *acquiring knowledge* refer to the second levels of understanding where a learner can utilise previously attained knowledge to use in new situations (Lawan, 2011; Tolman & Hardy, 1995:26). It implies that a learner can, for instance, relate certain actions in their daily lives to specific times of the day. The third levels refers to *image having* and *internalisation*. Meel (2003) states that physical actions are replaced by a mental picture of the concept. In accordance, Rogoff (1990) and Vygotsky (1960) mention that learners' understanding of mathematical concept will be enhanced if they are encouraged to engage with their teachers and peers. Thus, teachers should utilise their pedagogical content knowledge (see Figure 2.3) to give learners the opportunity to engage with their teachers and peers.

*Property noticing* and *understanding knowledge* constitute the fourth level of understanding. According to Pirie and Kieren (1991), property noticing implies that connections between multiple mental images can be noticed. Understanding, in the social constructivist theory implies, that “explanatory concepts can become tools for building new concepts” (Confrey & Kazak, 2006:316). *Formalising* and *using knowledge* refer to the ability of learners to “work with the concept as a formal object, without specific reference to a particular action or image” (Lawan, 2011:70). *Observing* and *reflecting on knowledge* call attention to the learner’s “engagement in metacognitive thought processes” (Meel, 2003:146). The learner subsequently begins to see relationships between several subjects and underlying concepts at the *structuring* and *extending knowledge* level. Finally, the *inventising* and *conceptualising* level signifies structured knowledge which represents complete understanding (Meel, 2003).

Thus, the theoretical perspectives of this study highlight the active participation of learners. Situations provided in the classroom environments should therefore encourage Grade 2 learners’ participation and their growth of mathematical understanding (Meel, 2003). The next section outlines components which direct the teaching and learning of the mathematical concept of time.

### **2.3 Teaching and learning components of the mathematical concept of time**

Turnuklu and Yesildere (2007) argue that mathematics teachers should acquire pedagogical content knowledge as well as mathematical content knowledge in order to enhance learners’ conceptual understanding of the mathematical concept of time. Pedagogical content knowledge combines knowledge about learners’ learning processes as well as knowledge of mathematical teaching whilst mathematical knowledge is subject specific (see Figure 2.3).



**Figure 2.3: Teaching and learning components of the mathematical concept of time, adapted from Ball, Thames and Phelps (2008)**

These components are inter-related. Bridging them assures that “discussions of content are relevant to teaching and that discussions of teaching retain attention to content” (Ball, Thames & Phelps, 2008:3). Teachers should therefore acquire common knowledge of mathematical time to recognise a wrong answer, whilst specialised knowledge and knowledge of mathematical learning processes are required to identify the nature of the error in mathematics. “Deciding on how best to remediate the error may also require knowledge of” mathematical teaching strategies (Ball *et al.*, 2008:11).

Skemp (1989), Van de Walle *et al.* (2010), as well as the Primary Mathematics Teaching and Learning Syllabus of Singapore (Ministry of Education, 2012) affirm that it is necessary to analyse a new concept before teaching it. Therefore, it is essential to illuminate the foundational ideas and suggested teaching strategies of the mathematical concept of time as well as the learning processes of Grade 2 learners (Olsson, 2009; Waller & Bitou, 2011). In the following sections, I will deal with the proposed components of the teaching and learning of the mathematical concept of time (see Figure 2.3) since this study focused on the design, implementation and evaluation of a supplementary programme entitled CLOCKWISE which pertains specifically to the facilitation of analogue and digital time in Grade 2. The main constructs, that is, the

mathematical content knowledge, mathematical conceptual understanding and pedagogical content knowledge, frame the next section.

### **2.3.1 Mathematical content knowledge**

Slabbert *et al.* (2009:105) state that “learning does not operate without something to be learned”. This ‘something’ in the context of my study is mathematical content knowledge. Teachers need to know the mathematical content they teach and learners need to understand the mathematical content (Ball *et al.*, 2008). Therefore, it is essential to define what mathematical content knowledge means in the context of this study. As suggested by Ball, Hill and Bass (2005), mathematical content knowledge for the teaching of mathematical time consists of two key elements: ‘common knowledge’ and ‘specialised knowledge’ of mathematical time. These elements will be explicated in the next sections.

#### **2.3.1.1 Common knowledge of mathematical time**

Common knowledge of mathematics includes knowledge of the mathematical time concepts or standards prescribed in the curriculum as well as knowledge pertaining to the organising structures of the teaching of mathematical time (Ball *et al.*, 2008). Mathematical time is part of the measurement strand of mathematics curricula which should be developed “in a sequential manner through measurement experiences” (Charlesworth & Lind, 2013:421). National curricula propose concepts and standards for the teaching of mathematical time in the first three years of formal schooling. These standards are described in South African educational policy documents, and also internationally in countries such as England, the United States of America and Singapore (see Table 2.1) (Common Core State Standards Initiative, 2010; Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012). I decided to explore the mathematics curricula of Singapore, England and the United States of America since the concepts and standards for the teaching of mathematical time embedded in these curricula are comparable to the concepts and standards in CAPS (Department of Basic Education, 2011).

**Table 2.1: South African and international concepts and standards for the teaching of mathematical time**

|                 | England  | United States of America  | Singapore  | South Africa  |
|-----------------|--|---|--|---|
| Policy document | <i>Department for Education, 2013a. Statutory guidance. National curriculum in England: Mathematics programmes of study (no page numbers provided)</i> | <i>Common Core State Standards Initiative, 2010. Common core state standards for Mathematics.</i> | <i>Ministry of Education, 2012. Primary Mathematics Teaching and Learning Syllabus. Singapore: Curriculum Planning and Development Division.</i>           | <i>Department of Basic Education, 2011. Curriculum and Assessment Policy Statement (CAPS) Mathematics Foundation Phase.</i> |
| Grade 1         | <u>Compare</u> , describe and solve practical problems for time e.g. quicker, slower, late and early (2013).   |   |  | <u>Compare</u> events in terms of the length they take e.g. longer, shorter, faster, slower (2011:15).                      |
|                 | Measure and begin to record:<br>Time (hours, minutes, seconds) (2013).   |   |  | Describes the time of day using <u>vocabulary</u> such as 'early, late, morning, afternoon, night' (2011:15).               |
|                 | Sequence events in chronological order using language (before, after, morning, afternoon) (2013).  |   | Sequence events according to time and explain the appropriateness of events at different times of day, e.g. lunch at 3 o'clock in the afternoon (2012:36). | Sequence events using language such as 'yesterday, today, and tomorrow' (2011:15).  |
|                 | Recognise and use <u>language</u> relating to days, weeks, months, years (2013).   |   |  | Place birthdays on a calendar (2011:15).  |
|                 | Tell the time to the <u>hour and half past the hour</u> and draw the hands on a clock face to show these times (2013).                                 | Tell and write time in <u>hours and half-hours using analogue and digital clocks</u> (2010:16).   | Tell time to the <u>hour/half-hour</u> from a <u>clock face</u> . Relate time to events using 'o'clock' 'half past' (2012: 36).                            |   |
| Grade 2         | <u>Compare and sequence</u> intervals of time (2013).  |   |  | Identify important dates on calendars including learners' birthdays, religious festivals (2011:15).                         |
|                 |  |   |  | Name in order and <u>sequence</u> events according to days, weeks, months and years (2011:15).                              |

|         | England  | United States of America  | Singapore  | South Africa   |
|---------|--|---|--|--|
|         | <p><u>Tell and write the time to five minutes</u>, including quarter past/to the hour and draw the hands on a clock face (2013).</p> <p>Know the number of minutes in an hour and number of hours in a day (2013).</p> | <p><u>Tell and write time from analogue and digital clocks to the nearest five minutes</u> using am and pm (2010:20).</p>   | <p><u>Telling time to 5 minutes</u>.<br/>Use of am and pm.<br/>Drawing hand on the clock face to show time (2012:40).</p> <p>Duration of 1 hour/half-hour (2012:40).</p> | <p>Reads <u>analogue time in hours and minutes</u> (2011:15).</p> <p>Calculate <u>elapsed time</u> in hours and minutes using clocks, as well as days, weeks and months using calendars (2011:15).</p> |
| Grade 3 | <p>Tell and write the time from an analogue clock, using 12-hour and 24-hour clocks. <u>Read time to the nearest minute</u> (2013).</p>  | <p>Tell and write time <u>to the nearest minute</u> and <u>measure time intervals</u> in minutes e.g. By representing the problem on a number line diagram (2010:24).</p> | <p>The online syllabus document is not available yet. Implementation scheduled for 2015 (2012:6).</p>  | <p>Read and write <u>analogue and digital clock time</u> in terms of <u>hours, half-hours, quarters of an hour and minutes</u> (2011:15).</p>  |
|         | <p>Use vocabulary such as o'clock, am/pm, noon, midnight, afternoon, morning (2013).</p>   |   |  |  |
|         | <p>Know the number of seconds in a minute and number of days in each month (2013).</p>   |   |  | <p>Solve problems involving calculations with and conversions between minutes-hours, hours-days, days-months (2011:15).</p>  |
|         | <p>Compare <u>durations</u> of events (2013).</p>  |   |  | <p>Identify important dates on calendars including dates of religious festivals, historical events (2011:15).</p>  |
|         |  |   |  | <p>Recognise and describe different calendars used in different cultures (2011:15).</p>  |

Table 2.1 is adapted from Common Core State Standards Initiative, 2010; Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012

National curricula not only propose concepts and standards for the teaching of mathematical time, they also focus on process skills which young learners should acquire. These process skills include problem solving, mathematical reasoning, communication, representation and connection skills (Common Core State Standard Initiative, 2010;

Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012). TIMSS 2011 results have shown that young learners' achievement scores in Singapore, England and the United States of America were rated amongst the top eleven of the 63 participating countries (Mullis, Martin, Foy & Arora, 2012). Though, South Africa's achievement scores were amongst the bottom six countries for mathematics despite the similarities within the curricula and process skills of the four countries. This study therefore sought to investigate the potential effects of teaching strategies on the Grade 2 learners' acquisition of the mathematical concept of time in a South African context.

Carruthers and Worthington (2006) assert that events should first be identified and compared using non-standard units. This is corroborated by policy documents in England, Singapore as well as South Africa which suggest that learners' understanding of non-standard units should be established before they begin to read or tell time (Department for Education, 2013a; Department of Basic Education, 2011; Ministry of Education, 2012). Learners should therefore sequence events and calculate time intervals according to days, weeks, months and years before they are expected to tell and write times on clocks. CAPS (Department of Basic Education, 2011) specifies that the teaching of the mathematical concept of time should start with the comparison of events in terms of the length of time they take (longer, shorter, faster, slower) and the specific time of happening (yesterday, Friday, December). Grade 2 learners should also acquire the skill of naming the days of the week, months of the year and seasons in sequence and of identifying important dates on calendars. It is anticipated that learners will consequently gain an understanding of the mathematical concepts of time whilst making these comparisons (Carruthers & Worthington, 2006).

Events may be compared perceptually, directly and indirectly. The duration of two events, such as brushing your teeth and reading a story, may be compared and described as being of the same duration, longer or shorter. Learners may also be required to compare the time it takes to bounce a ball ten times directly, with vocabulary such as longer, shorter, faster or slower. Events could also be compared indirectly through a reference or

third event (Carruthers & Worthington, 2006). Events are compared perceptually, directly as well as indirectly in the CLOCKWISE mathematical programme (see Chapter 4).

Van de Walle *et al.* (2010:383) assert that although the passage of time “can be thought of as the duration of an event from its beginning to its end, it ultimately has more to do with the skill of learning to read a dial-type instrument”. Therefore, Grade 2 learners should also identify time on clocks (Holmes, 1985; Common Core State Standards Initiative, 2010; Van de Walle, 2004). Grade 2 learners in England, Singapore and South Africa are expected to tell and write time to the nearest five minutes on analogue clocks, whilst Grade 2 learners in the United States of America are expected to identify time to the nearest five minutes on digital clocks too. The Common Core State Standards Initiative in the United States of America (2010) and the Ministry of Education in Singapore (2012), state that the abstract concepts of a.m. and p.m. times should also be introduced and addressed through additional conversion activities.

The CLOCKWISE mathematical programme of this study (based on literature as well as curricula guidelines) focuses on hours, half-hours and times to the nearest five minutes on analogue clocks. Digital clocks are also included in the programme, although this is part of the Grade 3 curriculum, as I assessed that learners’ understanding of the mathematical concept of time will be enhanced if they understand that in one day there are 24 hours which can be divided into three time periods.

Although national curricula propose organising structures as well as standards and concepts which learners in Grade 2 should attain, documents such as the ANA Diagnostic Report in South Africa (Department of Basic Education, 2012:10) proclaim that “the concept of time, its proper representation and related calculations proved very difficult to the learners”. I therefore assert that curriculum development and especially the articulation of standards in policy documents (see Table 2.1), do not necessarily facilitate improvement in learners’ acquisition of time concepts. Ball *et al.* (2005:14) agree and state that “no curriculum teaches itself and standards do not operate independently of teachers and learners”. Therefore, it is imperative to focus upon the specialised content



knowledge which Grade 2 teachers of mathematical time should acquire in order to enhance learners' mathematical understanding of the concept of time. Specialised content knowledge will enable Grade 2 mathematical teachers to interpret and respond to learners' verbal as well as visual representations of mathematical time.

### **2.3.1.2 Specialised knowledge of mathematical time**

Teachers need common mathematical knowledge to teach the mathematical concept of time and procedures. They also need specialised mathematical knowledge to effectively teach mathematical concepts of time in order to interpret learners' growth of mathematical understanding. Specialised mathematical knowledge is "closely related to practice" and it permits teachers to "unpack the elements of the mathematical concept of time to make its features apparent" to Grade 2 learners (Ball *et al.*, 2008:8).

Specialised mathematical knowledge will enable teachers to:

- interpret errors made by learners
- link representations to underlying ideas
- evaluate learners' explanations
- respond to learners' questions; and
- explain mathematical rules and terminology related to the mathematical concept of time (Ball *et al.*, 2005; Ball *et al.*, 2008).

Since it is a prerequisite for the conceptualisation of analogue and digital time, teachers should be aware of Grade 2 learners' proficiency in reversibility, conservation, hierarchies of classes and seriation (Holmes, 1985). The attainment of reversibility is illustrated when a learner recognises that if three hours is longer than one hour, one hour will be shorter than three hours (Copeland, 1984). The ability to understand hierarchies of classes (time = morning, a.m., 03:00) also rests "on this ability to move both ways when thinking about relationships" (Louw & Louw, 2007:217). Vrey (1979) states that conservation is the understanding that matter can change in appearance without changing in quantity (three a.m. on an analogue clock is equivalent to 03:00 on a digital clock). Subsequently, learners will be able to understand that the type of clock does not influence the time measured.

Grade 2 learners will probably use the logic of transitivity. It suggests that the learner will be able to realise that if 5 hours is shorter than 6 hours and 4 hours is shorter than 5 hours, then 4 hours is shorter than 6 hours (Kamii & Clark, 1997; Sarama & DiBaise, 2004). Grade 2 learners should also be able to compare more than two events in order to sequence (seriate) the events in the order in which they happened (Charlesworth & Lind, 2013; Copeland, 1984).

Whilst teaching the mathematical concept of time, teachers should acknowledge that learners' difficulty with clock reading may be due to the use of dial-type instruments (Van de Walle, 2004). Grade 2 mathematics teachers should also recognise that 'close to' times on digital clocks require an understanding of big numbers as well as knowledge of how many minutes in an hour. Charlesworth and Lind (2013) state that the meanings and functions of the two dials on analogue clocks can also confuse learners. Teachers should recognise that the small dial indicates broad, approximate time (nearest hour) and the big dial indicates time (minutes) before or beyond an hour. Mathematics teachers must furthermore focus learners' attention on the different functions of the dials on an analogue clock. Van de Walle (2004) asserts that the hour dial draws attention to the number towards which it is pointing. Teachers should also focus learners' attention on the minute dial and the distance that it has gone around the clock or the distance it has yet to go for the dial to get back to the top.

Grade 2 teachers' specialised knowledge of mathematical time will permit them to analyse learners' errors involving digital clocks. Teachers will recognise that "to know that a digital reading of 07:58 is nearly 8 o'clock, the learner must know that there are 60 minutes in a hour, that 58 is close to 60 and that 2 minutes is not a very long time" (Van de Walle, 2004:341). Since the readout report on digital clocks is unusual (the number that comes after 59 is 00, the numbers on the right change, the number on the left rarely changes and when it does it only goes as high as 12, then it turns into a 1 again), teachers should know how to represent and explain this procedure.

Teachers of mathematical time should identify teaching strategies which will improve Grade 2 learners' mathematical understanding. In addition, they should also keep Grade 2 learners' learning processes in mind. Pedagogical content knowledge therefore plays an important part in the teaching of mathematical concepts of time (Turnuklu & Yesildere, 2007).

### **2.3.2 Pedagogical content knowledge**

Pedagogical content knowledge combines an understanding of “how learners learn, how to promote learning and how to plan for and assess that learning on a daily basis” (Van de Walle & Lovin, 2006:1). Thus, pedagogical content knowledge combines knowledge of mathematical learning processes and knowledge of mathematical teaching strategies. These components of the teaching and learning of mathematical time will be described in the next sections.

#### **2.3.2.1 Knowledge of mathematical learning processes**

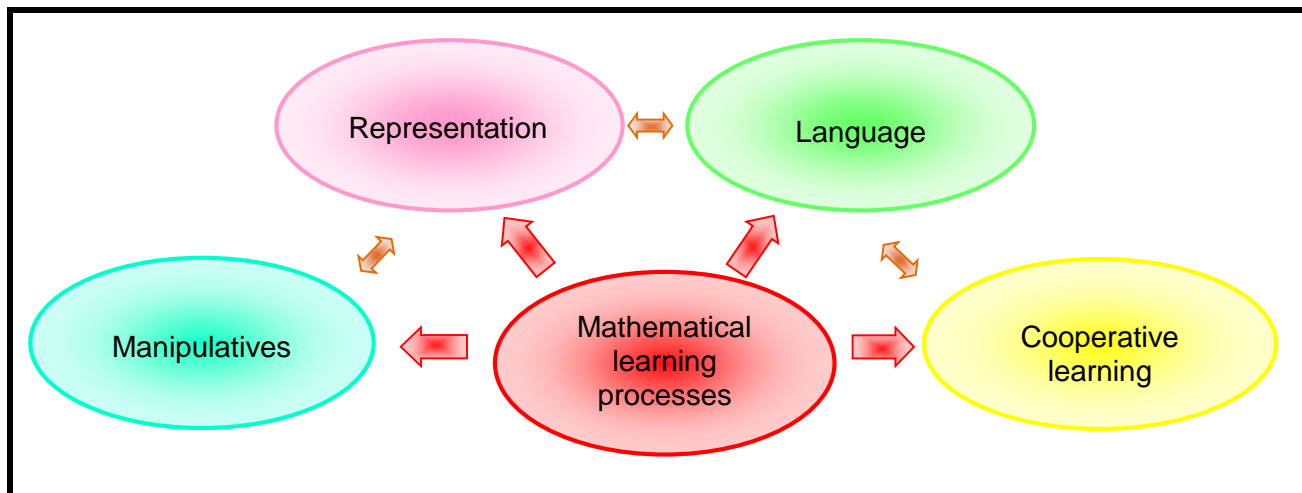
Knowledge of mathematical learning processes combines knowledge of *how* Grade 2 learners learn and knowledge about *what* Grade 2 learners need to know about the mathematical concept of time. Ball *et al.* (2008:9) assert that teachers in the foundation phase need to “anticipate what learners are likely to do” with a specific task at hand. The “process of learning becomes more important than just what is to be taught and remembered” (Ministry of Education, 2012:2). Therefore, I reviewed literature to determine the cognitive development stage and learning processes of Grade 2 learners so as to develop learning tasks in the CLOCKWISE mathematical programme that are encouraging and thought-provoking (Holmes, 1985; Ministry of Education, 2012; Van de Walle, 2004; Van de Walle *et al.*, 2010).

Holmes (1985:64) asserts that although telling time is a difficult skill to teach in the early Grades, most Grade 2 learners “who have attained concrete operational thought” will be able to understand the telling of time. Piaget proposed that learners naturally try to make sense of their world whilst going through four distinct stages in cognitive development which he described as the sensorimotor stage (birth to age 2), pre-operational stage

(ages 2-7), concrete operational stage (ages 7-11) and the formal operational stage (age 11 onward) (Louw & Louw, 2007). Grade 2 learners (age 7-9) are therefore most likely in the concrete operational stage of their cognitive development, which suggests that they learn best when actively engaging with manipulatives (Ginsburg & Oppen, 1969). A Grade 2 learner will most probably also understand the type of time that is fixed by clocks in the concrete operational stage (Charlesworth & Lind, 2013; Piaget, 1960).

Jerome Bruner shared many of Piaget's views (Bruner, 1960). He theorised that learners develop an understanding of concepts through three learning stages and types of representational learning experiences (Finesilver, 2006). He proposed that *enactive* learning involves direct experiences with concrete materials. This stage is followed by *iconic* learning which suggests that learning is based on the use of visual representations of concepts. *Symbolic* learning experiences include the use of "language as well as mathematical symbols" (Finesilver, 2006:10). Hence, Bruner's learning stages incorporate an active process of acquiring and applying mathematical knowledge and a strong element of social constructivism (Du Plessis & Webb, 2011).

In the process of acquiring and applying mathematical knowledge, learners may encounter important process skills to encourage lifelong learning in mathematics (Botha, 2011; Ministry of Education, 2012). According to Copley (2000) and the Ministry of Education in Singapore (2012), the five mathematical process skills are inter-related and consists of reasoning, communication, connecting, representation and problem-solving skills. These process skills will most likely be acquired through the use of modelling with manipulatives, interacting with mathematical ideas through literature, engaging in discussion of mathematical ideas and skills and viewing and creating visual representations (Charlesworth, 2000). Thus, this study focuses upon the use of manipulatives, representations of mathematical concepts of time, natural everyday language and mathematical language as well as cooperative learning to illuminate Grade 2 learners' learning processes and their growth of mathematical process skills (see Figure 2.4). Each of these aspects will be dealt with in the next sections.



**Figure 2.4: Factors influencing growth of mathematical process skills, adapted from Finesilver (2006)**

### ***Manipulatives***

Van de Walle, Karp and Bay-Williams (2010:27) describe manipulatives as “physical objects used to illustrate mathematical concepts”. However, Mason and Johnston-Wilder (2004:257) emphasise that “manipulatives are not, of themselves, carriers of meaning for insight”. Interaction with the manipulatives such as one-handed clocks and number lines as well as communication with others about it, should therefore be employed to focus learners’ attention on specific entities and the intended relationships (Hiebert & Carpenter, 1992). Researchers also emphasise that learners will have the opportunity to evaluate the ideas that they are developing when manipulatives are employed (Schminke *et al.*, 1978; Van de Walle & Lovin, 2006). Consequently, learners will generally find learning the concept of time less difficult than if an abstract approach is made (Backhouse, Haggarty, Pirie & Stratton, 1992).

Interaction with manipulatives allows learners to construct logical arguments and “to connect mathematics with the real world” (Ministry of Education, 2012:3). Learners’ reasoning, communication, connecting, problem solving as well as representation skills are involved in the process of interacting with manipulatives.

Learners will actively construct meaning if they represent time concretely on clock faces themselves (Cathcart, Pothier, Vance & Bezuk, 2003). By working directly with clock faces, learners will be able to test predictions that emanate from the mental model they have been developing (Skemp, 1989). Approaching telling time in this way gives each learner the best chance to personally experience and deepen their understanding of this mathematical concept (Scholastic Research and Results, 2008), as their minds will be active, resulting in active learning (Bell, 1980).




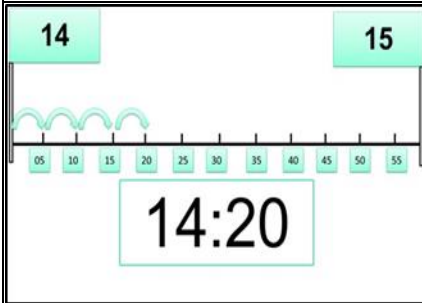
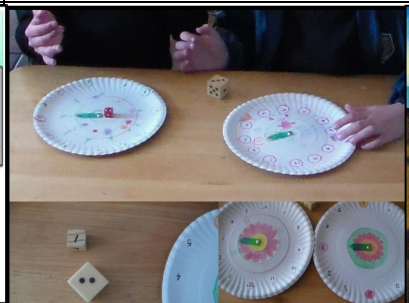
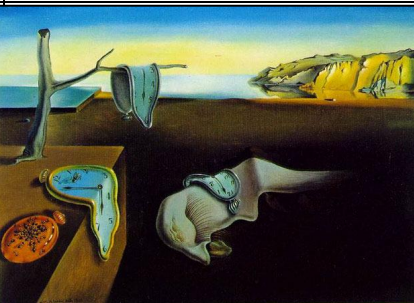
The CLOCKWISE mathematical programme utilises one-handed clock faces as well as number charts to facilitate the mathematical concept of analogue and digital time. Hyde (2006) further suggests that learners should be exposed to multiple representations of the same concept since it will encourage active thinking and learning. Therefore, representations are also employed to improve learners' mathematical knowledge of time as well as their process skills.

### ***Representations***

Carruthers and Worthington (2008:194) affirm that "if learners devise their own ways of recording knowledge and understanding, they will select ways which make sense to them" and it will enable them "to switch between the concrete and the abstract" (Van Oers & Poland, 2007:15). Their own representations will therefore likely support their cognitive learning, understanding and abstract thinking. Learners' own representations will most likely improve their understanding and retention (Van de Walle *et al.*, 2010). This study utilises learners' visual and verbal mathematical representations as a tool in the process of learning. Representations are also employed as an assessment tool to observe the Grade 2 learners' learning processes and process skills in action. I used this whilst engaging in the CLOCKWISE mathematical programme (see Section 2.4.2.8).

Olsson (2009) proclaims that young learners should be encouraged to apply their mathematical knowledge in different contexts. Learners' visual representations of time, therefore, are critical as they enable one to follow the development of their understanding

of mathematical time (Wilson & Stein, 2013). Authors (Freudenthal, 2010; Slaten, 2006; Van Oers & Poland, 2007) proclaim that visual representations include pictures, drawings, gestures, diagrams and photographs, which represents learners' mental images of mathematical concepts. Although literature only suggests the visual representation of mathematical time on clock faces and number lines, the CLOCKWISE mathematical programme also utilises learners' drawings, pictures, photographs of objects as well as a painting by Salvador Dali to represent the concept of time (see Figure 2.5). These visual representations are summarised in Figure 2.5 but explained in Chapter 4 of this study.

| Pictures  | Drawings   | Photographs   |
|---|--|---|
|   |   |   |
| Number lines  | Clock faces  | Paintings   |
|  |  |  |

**Figure 2.5: Visual representations of time in the CLOCKWISE mathematical programme**

Carruthers and Worthington (2006) also propose that it is important to listen to what learners say about their writings and visual representations to ensure that what they were intending to convey has been accurately understood. Furthermore, whilst discussing their visual representations, the learners' understanding of the mathematical concept of time develops (Ball *et al.*, 1990; Carruthers & Worthington, 2006; Wilson & Stein, 2013).

Olsson (2009) believes that teachers should listen to learners' oral explanations of their visual representations since these understandings can be incorporated in meaningful planning of future activities. Learners therefore need to provide a description of what they do, why they do it and what they have accomplished in the CLOCKWISE mathematical programme; in that way the teacher is able to discover what has been learnt (Charlesworth & Lind, 2013). Grade 2 mathematical teachers should therefore ask open-ended questions like *How do you know?* and *Why do you think so?* to encourage learners to use their reasoning, communication, connecting and problem-solving process skills (Botha, 2011; Meel, 2003; Orton, 2004). This is evident when learners participating in the CLOCKWISE mathematical programme, can for instance explain why they can only visually represent 12 numbers on their analogue clocks. Learner 2 stated that 'there is not enough space for 24 numbers', therefore 'the hour hand has to go around the clock twice in one day' (see CD 2, Video analysis; VA-21 August, L2-line 543).

The Grade 2 mathematics teacher can significantly influence learning by taking the reflections of the learners with regard to relevant ideas and using them as new ideas develop (Hiebert & Carpenter, 1992). Therefore, teachers in this study were encouraged initially to discuss the mathematical ideas with the learners using their everyday language, and subsequently to extend their knowledge by introducing mathematical vocabulary (Orton & Wain, 1994).

### **Language**

The National Council of Teachers of Mathematics (2000) as well as the Ministry of Education in Trinidad and Tobago (2008) assert that learners need communication in order to learn mathematics and to communicate mathematically. Classroom discussions can, therefore, be exploited to encourage learners' meaning making and to reveal their growth of mathematical understanding (Ball *et al.*, 1990; Hiebert & Carpenter, 1992; Waller & Bitou, 2011).

The interplay of learners' everyday language and mathematical language is recommended (Columba, 2012; Patkin, 2011). According to Warren (2006:171), this will



assist in “extracting the concepts of time’s essential attributes”. Informal classroom discussions in the learners’ vernacular or home language can, therefore, enhance learners’ growth of mathematical understanding and vocabulary of time concepts (Goral & Gnadinger, 2006; Orton & Wain, 1994; Peters & Young-Loveridge, 1994). It will also encourage Grade 2 learners to talk about what they are doing using their new mathematical vocabulary (Greenes *et al*, 2004; Skemp, 1989). Michael and Mundher (2004) as well as Rudd, Lambert, Satterwhite and Zaier (2008) corroborate this assertion. They believe that the interplay of learners’ daily language and mathematical language will enhance learners’ mathematical understanding.

Language use encourages active engagement of learners in mathematics. It also encourages cooperative learning which will enhance learners’ communication, connecting, problem-solving, representation as well as reasoning process skills.

### ***Cooperative learning***

The social constructivist theory and Pirie-Kieren’s model for the growth of mathematical understanding employed in this study, support interaction with peers and teachers (Kheong, 2009). Charlesworth (2000:4) also proclaims that understanding is enhanced through “interaction with peers and supportive adults”.

The Ministry of Education in Singapore (2012) asserts that learners must be given opportunities to work together on a problem and present their ideas using appropriate mathematical language and methods. When learners talk about what they are doing, play games, solve problems or report to the class in whole groups, pairs or small groups they are putting their thoughts into words. They “correct each other’s mistakes in ways which are much less threatening than being told one is wrong by a teacher and it ensures that there is a common ground for discussion and shared experiences” (Skemp, 1989:76). Thus “learners take responsibility for their own learning” (Scholastic Research & Results, 2008:12).

According to Charlesworth and Lind (2003) and Charlesworth (2005), solving real-life problems in a group enhances learners' process skills. It also engages learners' reasoning skills which will facilitate the understanding of mathematics concepts (Van de Walle & Lovin, 2006). There is evidence that working in groups for at least some of the time is desirable. There are various reasons for this. Firstly, it is the way people work in life. Secondly, the learners can learn from each other while trying to explain something to someone else. They also learn social skills such as helping other people and making their own contribution to solving problems. Backhouse *et al.* (1992:61) also mention that cooperative learning activities "reduce the number of learners with hands up waiting for help".

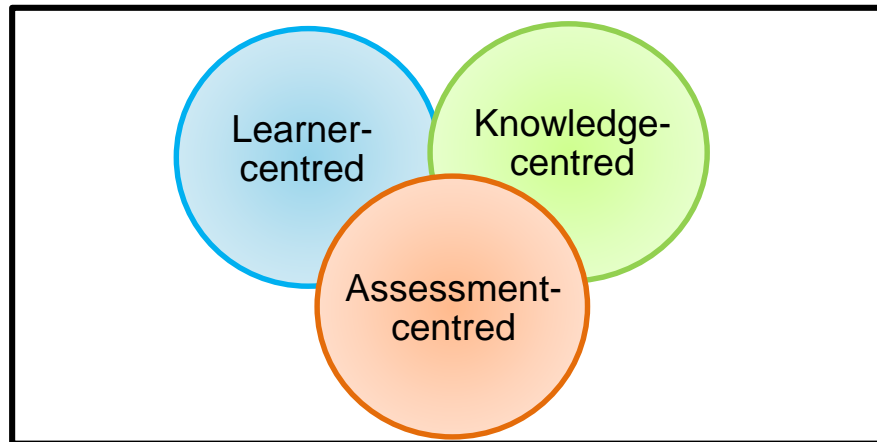
Knowledge of mathematical learning processes focuses primarily on learners' learning, although teachers use a range of teaching strategies to engage learners in learning. In the next section, I discuss teachers' knowledge of mathematical teaching strategies.

### **2.3.2.2 Knowledge of mathematical teaching strategies**

Research done by Mitchelmore and White (2007) indicates that learners need to acquire sufficient understanding of mathematical concepts in the mathematics classroom to enable them to make connections with real-life experiences, to solve problems and to assist the Grade 2 learners in the learning of mathematical time. Teaching strategies should therefore promote increasing insight into the mathematical concept of time (Kwon, 2004; Orton, 2004). Thus, knowledge of mathematical teaching strategies combines knowledge of *how* to promote, plan and assess learning and knowledge about the mathematical concept of time. Mathematical teaching strategies will be discussed in the following sections.

Since there is an increasing recognition that learners should understand mathematics and not merely learn algorithms, research suggests that teaching is "primarily facilitated learning in practice" (Backhouse *et al.*, 1992; Olsson, 2009; Slabbert *et al.*, 2009:100). Facilitated learning has three purposes (Slabbert *et al.*, 2009:102). The first purpose is to initiate learning and, according to Donovan and Bransford (2005), it is primarily learner-centred. Facilitated learning secondly focuses upon the learning process itself,

which is primarily knowledge-centred. The third purpose of facilitated learning is to maintain learning, which can be described through an assessment-centred lens. These lenses are illustrated in Figure 2.6.



**Figure 2.6: Facilitated learning in action, adapted from Donovan and Bransford (2005)**

The above-mentioned lenses encapsulate knowledge of mathematical teaching strategies and encourage effective facilitation of mathematical concepts such as the concept of mathematical time. These lenses are discussed in the following sections.

### ***Learner-centred lens***

The first lens of facilitated learning is learner-centred. It “encourages attention to preconceptions and begins instruction with what learners think and know” (Donovan & Bransford, 2005:13). According to Charlesworth (2005:230), naturalistic experiences are controlled by the learner as they go about their daily lives. The teacher’s role is therefore to initiate learning and to “provide an interesting and rich environment” (Charlesworth & Lind, 2013:23), which would elicit learners’ curiosity and discussion between the teacher and learner (Schminke, Maertens & Arnold, 1978).

For learners to be ready to learn, “teachers need to provide motivating contexts for learning” (Ministry of Education, 2012:6). In this study, storytelling is an effective pedagogical tool, since children’s literature exploits foundation phase learners’ natural

curiosity (Goral & Gnadinger, 2006:4, 8; Schminke *et al.*, 1978). Goral and Gnadinger (2006:4) assert that “when learners listen to stories, they create mental images that belong to them” which can enhance their understanding of abstract mathematical concepts. Young-Loveridge (2004) as well as Casey *et al.* (2004) confirm that stories can be utilised to enhance learners’ mathematical understanding. It can also enhance the understanding of abstract mathematics concepts such as fractions, shape attributes and number patterns (Goral & Gnadinger, 2006). Storytelling will also facilitate learning and enable teachers and learners to “share many meanings and learn from and teach each other” (Schiro, 2004:69). It can also be utilised as a diagnostic instrument to gather information on learners’ prior knowledge.

It is necessary to determine whether learners are ready to learn, which necessitates diagnostic assessment of learners’ knowledge (Ministry of Education, 2012). The Department of Basic Education (2011) expects Grade 1 learners to be able to describe the time of day using vocabulary such as ‘early’ and ‘night’, to compare activities in terms of the length of time they take and to sequence and identify events according to days, months, weeks and years. Since these concepts have already been discussed in Grade 1, it is important to establish if Grade 2 learners have acquired this knowledge. In the CLOCKWISE mathematical programme, learners are presented with four pictures, which will most likely draw their attention to concepts of time such as seasons, months, years, day, night and specific events. After discussing the pictures learners are required to represent their understandings on the concept of mathematical time in writing and through drawings (see Figure 2.5).

The learner-centred lens will enable the teacher to design and present a learning task with the learners’ learning processes, process skills as well as prior knowledge in mind (Ministry of Education, 2012; Slabbert *et al.*, 2009). Thus, learning must be initiated and learners must be encouraged to engage in the learning of mathematical knowledge.

### ***Knowledge-centred lens***

The second lens is knowledge-centred, since it engages learners in the learning process. This lens focuses on the content-knowledge which is to be taught (Donovan & Bransford, 2005). It also focuses on specific teaching strategies which are meant to engage learners in the learning of mathematical concepts of time. Structured learning experiences must therefore be pre-planned by the teacher. Although the learning tasks can be planned according to predefined standards, it is important to note that the focus of the knowledge-centred lens is not only on goals to attain or the transfer of knowledge, but on the application of knowledge in the learners' daily lives (Slabbert *et al.*, 2009).

According to the Ministry of Education in Singapore (2012) as well as Grinstein and Lipsey (2001), three pedagogical approaches support most of the mathematics instruction and teaching in the mathematics classroom. The first approach is activity-based. In view thereof, they propose that learners must initially experience time concretely through tactile and kinaesthetic activities that involve the whole child. Thus, this approach is about "learning by doing" (Ministry of Education, 2012:6). Charlesworth and Lind (2013) suggest playing games such as the CLOCKWISE game, which will allow for informal observation of learners' understanding of concepts. Playing games will also give learners an opportunity to interact with each other and to "reinforce their knowledge of facts and skills" (Bell, 1980:141). From experiences with manipulatives (see Section 2.3.2.1), learners can also uncover abstract mathematical concepts such as the mathematical concept of time.

A teacher-directed approach should, secondly, direct the teaching of mathematical concepts. This approach can be defined as "learning through guided inquiry" (Ministry of Education, 2012:6). It suggests that teachers should lead learners to explore, investigate and discover specific attributes of the concept of time. Holmes (1985:23) suggests that "learners should discuss important times in their daily schedules which could be labelled and shown on clocks in their classrooms". Learners must also "encounter representational forms through visuals" (Grinstein & Lipsey, 2001:761). Although it is

emphasised that analogue clocks should be made available to learners, Van de Walle (2004) suggests that instruction should begin with a one-handed clock. This is employed in the CLOCKWISE mathematical programme to discuss the movement of the different dials on a clock face.

Lastly, an approach of direct instruction can be employed to explicitly teach the concepts of time. When learners understand the functions of the two dials, clocks can be set to specific times as learners observe the time periodically during the day (Holmes, 1985). Thyer and Maggs (1971) argue that half-hours can then be introduced, followed by quarter past and quarter to. Consequently, time after the hour can be taught in 5-minute intervals, counting by fives going around a circle. Teaching of digital clock reading can then commence since both analogue and digital models are integrated in modern society.

The knowledge which learners attain should be assessed, consolidated and practised to achieve proficiency. Therefore, it is necessary to encourage learners to reflect on their own learning.

### ***Assessment-centred lens***

“Assessment is an integral part of the interactive process of teaching and learning” (Ministry of Education, 2012:7). This third lens “emphasizes the need to provide frequent opportunities to make learners’ thinking and learning visible” (Donovan & Bransford, 2005:13).

In a South African context, continuous observation is integrated and oral, practical or written learning tasks can be employed to assess learners’ attainment of concepts on a daily basis (Department of Basic Education, 2011). Wolfe (2005) and Crooks (1988) state that continuous assessment will enable teachers to adjust their teaching strategies, thus supporting learners’ growth of mathematical understanding of the concept of time. Effective teaching will consequently develop learners’ ability to apply knowledge in any

situation (Skemp, 1989) and it contributes to learners' growth of mathematical understanding.

The assessment-centred lens will also ensure that the learning process is maintained (Slabbert *et al.*, 2009). Whilst learners perform learning tasks, meta-learning and cooperative learning can also occur. An adult or peer can provide a comment or a question that causes previous knowledge to be reinforced, applied or expanded (Wolfe, 2005). Therefore, a learner will be in a "continual process of sharing the meaning he or she constructs through experiencing real life with others" (Slabbert *et al.*, 2009:111).

The three lenses of facilitated learning will most probably challenge and enhance learners' growth of mathematical understanding. Literature also suggests that common content knowledge, specialised content knowledge, knowledge of mathematical learning processes and knowledge of mathematical teaching strategies can direct the effective teaching and learning of the mathematical concept of time. However, the telling of time on clock faces is still surprisingly challenging. It imposed the design, implementation and evaluation of a mathematical programme which enhances Grade 2 mathematical teachers' and Grade 2 learners' understanding of the mathematical concept of time.

## **2.4 Mathematical programmes**

Berkas and Pattison (2007a:1) state that any programme designed to facilitate learning "is about teaching and learning and the opportunity for learners to learn." Such programmes also support the facilitation process during class time. Mathematical programmes provide structured plans and teaching strategies for the teaching and learning of mathematical concepts (National Council of Teachers of Mathematics, 2000). In the following sections, I deal with decisions and considerations when designing the CLOCKWISE mathematical programme (see Chapter 4).

### **2.4.1 Attributes of mathematical programmes**

I reviewed research literature to ascertain which teaching and learning strategies will most likely enhance learners' conceptualisation of the mathematical concept of time

(Holmes, 1985; Van de Walle, 2004). I also reviewed literature to establish which attributes of a mathematical programme will most likely encourage learners to enthusiastically participate in classroom activities (Perry & Dockett, 2002). Studies such as 'Prompt Intervention in Mathematics Education' (Wagner, 2005), 'Destination Math™' (Gabbard, 2008) and 'Big Math for Little Kids' (Greenes *et al*, 2004) were considered for their conceptualisation of time.

Two studies were pertinent to the design of my programme. The 'Round the Rug Math' series (Casey *et al.*, 2004) is a research-based programme which teaches early childhood mathematics through a series of six problem-solving adventure stories supplementary to the main curriculum (Gr. K-2). 'Do The Math' is a "researched-based arithmetic intervention programme" designed to support students who are struggling with elementary arithmetic (Burns, 2008:4).

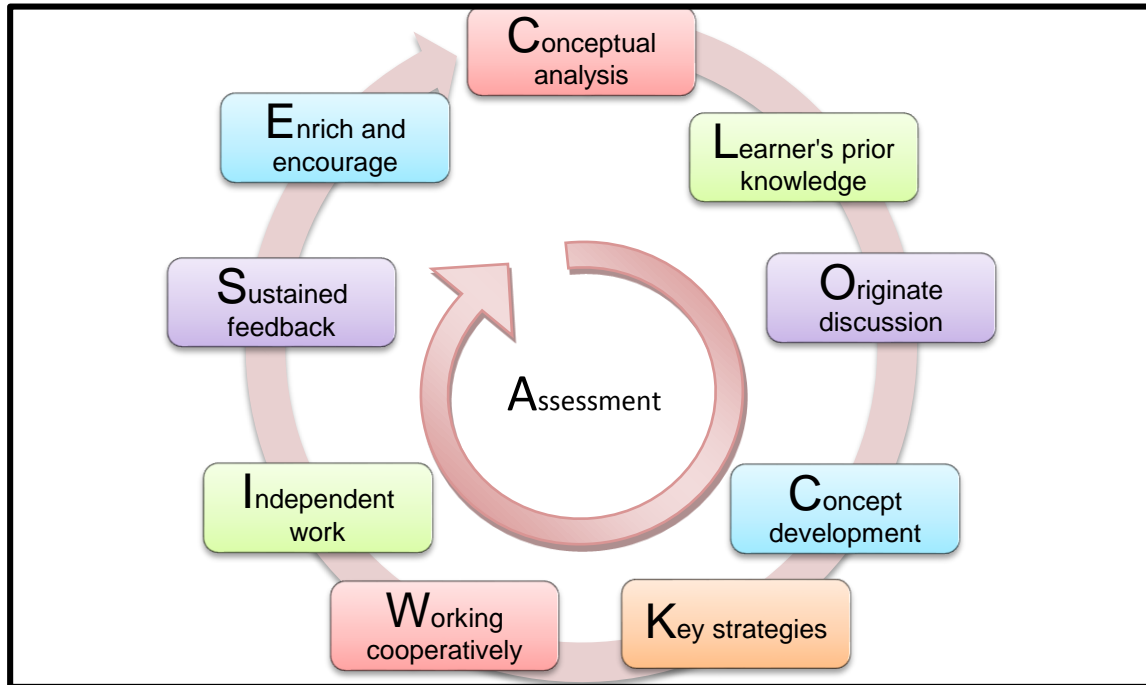
'Round the Rug Math' is a "unique supplementary programme that teaches early childhood mathematics (Gr. K-2) through a series of six problem-solving adventure stories" (Casey *et al*, 2004:167). According to the National Council of Teachers of Mathematics, teachers are required to help learners "see and experience how mathematical ideas interconnect and build on one another to produce a coherent whole" (Casey *et al.*, 2004:168). Teachers who employ the 'Round the Rug Math' series often integrate mathematical concepts and they teach mathematics systematically through a well-planned sequence of lessons which are presented in the form of a problem within a story (Sarama & DiBaise, 2004). "Learners are therefore critical participants in the story and they are invested in solving problems, which subsequently leads to newly acquired knowledge and skills" (Casey *et al.*, 2004:169). Research (Casey *et al.*, 2004) shows that the medium of storytelling facilitates learning of spatial relations and sense, shape attributes, part-whole relationships, spatial and number patterns, data analysis, graphing and mapping as well as visual estimation and measurement. Although each of these stories introduces important mathematical concepts, none addresses the concept of telling time. My study exploited storytelling as a teaching strategy to teach analogue and digital time and to connect mathematics to real life situations of learners.



The second study, the 'Do The Math' intervention programme (Scholastic Research & Results, 2008) mentions that the mathematics teacher should present work in such a way that the learner can relate it to his or her previous knowledge (Backhouse *et al.*, 1992:58; Griffin, 2004:175). This constitutes the first attribute of the 'Do The Math' programme. To ensure that all learners learn the concepts and make connections, multiple teaching strategies are utilised. Explicit instruction that presents carefully sequenced experiences is employed and the programme also features guided activities which will give the learners opportunities to reflect on and test new ideas (Van de Walle & Lovin, 2006). 'Do The Math' gradually encourages students to explain their ideas in cooperative groups before working independently (Burns, 2008; Skemp, 1989). Concrete manipulatives, models, carefully selected vocabulary and simple sentence structures that support learners' understanding of the concepts are also utilised (Scholastic Research & Results, 2008). 'Do The Math' carefully and intentionally scaffolds addition and subtraction, multiplication, division and fractions. As telling time is not addressed by 'Do The Math', I endeavoured to co-design a programme which intentionally scaffolds the mathematical concept of telling time.

#### **2.4.2 Pedagogical principles of the CLOCKWISE mathematical programme**

The CLOCKWISE mathematical programme focuses on the enhancement of Grade 2 learners' conceptual understanding of mathematical time as well as a deeper understanding of teaching practices. The instructional design incorporated pedagogical principles which were derived from literature. These are discussed in Sections 2.4.2.1 to 2.4.2.9 that follow (see Figure 2.7). Assessment is an important pedagogical principle in the CLOCKWISE mathematical programme in order to strengthen Grade 2 learners' learning and understanding of the mathematical concept of time. The assessment activities in the CLOCKWISE mathematical programme do not primarily focus on "workbook activities and Graded worksheets", as suggested in CAPS (Department of Basic Education, 2011:13). Although written work is utilised, the programme mainly focuses upon practical work and informal strategies to determine Grade 2 learners' growth of mathematical understanding. The complete programme, with all the designed activities and resources, is presented in Chapter 4.



**Figure 2.7: Pedagogical principles of the CLOCKWISE mathematical programme**

#### **2.4.2.1 Conceptual analysis**

As proposed by literature (Holmes, 1985; Thyer & Maggs, 1971; Van de Walle, 2004), the CLOCKWISE mathematical programme focuses on the following salient features of the mathematical concept of time: specialised language, counting in multiples of five, counting from zero to 60, use of fractions, 12- and 24-hour clocks, minutes to and past the hour and the different meanings of numbers on an analogue clock (1 o'clock/5 past). As suggested by Orton (2004) as well as Hiebert and Carpenter (1992) it is important to focus on previously attained knowledge of mathematical concepts when new concepts are introduced. Teachers of the CLOCKWISE mathematical programme should therefore start with what learners know and work with what they can do (Lawan, 2011; Stringer, Christensen & Baldwin, 2010). Therefore, learners' prior knowledge should be assessed (as suggested in Section 2.3.2.2).

#### **2.4.2.2 Learner's prior knowledge**

The CLOCKWISE mathematical programme encourages attention to learners' preconceptions and their own understanding of the mathematical concept of time

(Ausubel, 1968:iv; Donovan & Bransford, 2005; Griffin, 2004; Skemp, 1989; Van de Walle, 2004). Grade 2 learners' prerequisite knowledge of time concepts and transitivity, reversibility, conservation and seriation (as described in Section 2.3.1.2) are inferred from classroom discussions, interviews and task-based activities (Castle & Needham, 2007; Cathcart *et al.*, 2003; Sarama & DiBaise, 2004; Schunk, 2011).

#### **2.4.2.3 Originate discussion**

In accordance with Hiebert and Carpenter (1992), I believe that language (as discussed in Section 2.3.2.1 of this chapter) has a distinctive orientating function. Classroom discussions therefore direct learners' attention to prior knowledge and to possible new relationships of interest in the CLOCKWISE mathematical programme. In order to extend Grade 2 learners' mathematical vocabulary, Ball *et al.* (1990) claim that discussion develops understanding, encourages positive attitudes and promotes social and personal skills. In congruence, Orton and Wain (1994:112) state that "discussions extend the mathematical vocabulary of learners".

It is therefore not justifiable to assume that the social constructivist theory (as described in Section 2.2.1) suggests that learners should acquire new concepts by themselves and by conversing with their peers. The CLOCKWISE mathematical programme encourages teachers not only to observe and assess but also to pose open-ended and challenging questions such as *How do you know?* whilst encouraging learners to share ideas (Orton, 2004). Discussion and storytelling are employed in the programme to reinforce the presentation of new concepts.

#### **2.4.2.4 Concept development**

According to Skemp (1989), it is within the learners' mind that concepts have to be developed. Furthermore, Meel (2003) contends that a teacher can facilitate learning by providing good learning situations. Therefore, the content of this mathematical programme was introduced in manageable portions (Scholastic Research & Results, 2008), connecting successive ideas (Gabbard, 2008) as the mathematical concept of time was presented.

The CLOCKWISE mathematical programme introduces digital and analogue clocks simultaneously, since both models are utilised in the Grade 2 learners' daily lives (Grinstein & Lipsey, 2001). Cockburn (1999) contends that anyone who can read numbers as numerals would find it easier to read the time on digital clocks. Acknowledging that there are twenty-four hours in a day which are divided into periods called morning, afternoon and night probably also comes best when we focus on digital clocks. Hence, the CLOCKWISE mathematical programme initially focuses on the identification of hours on a digital clock. Thereafter, the position of the hour dial on an analogue clock is discussed, which is followed by the distance the minute dial has gone or has yet to go. Subsequently half-hours, time after the hour in five-minute intervals and time before the hour follow (Cockburn, 1999; Van de Walle *et al.*, 2010).

Although the programme is partitioned into separate parts, it does not imply that knowledge about individual parts constitutes an understanding of the mathematical concept of time as a whole. Since the study and programme is embedded in the Pirie-Kieren model for the growth of mathematical understanding, learners and teachers are encouraged to 'fold back' to previously understood concepts. 'Folding back' is therefore a key strategy and integral to the programme and specifically to the concept development principle.

#### **2.4.2.5 Key strategies**

Van de Walle *et al.* (2010) and Burns (2008) posit the use of key strategies and contexts which will most likely ensure that all learners who are mentally engaged learn and make connections between concepts. Explanation, direct experience and guidance, examples, discussion and structured practical and problem-solving experiences are therefore important strategies in the CLOCKWISE mathematical programme (Grouws & Cebulla, 2000; Louw & Louw, 2007; Skemp, 1989).

According to Kamii (2004), textbooks and workbooks are not the only tools to be used in a classroom, other activities would include the teacher discussing familiar situations with learners, introducing mathematical games and finding solutions to mathematical word

problems. Bell (1980) and Schminke *et al.* (1978) also assert that learners' will be encouraged to learn a mathematical concept if it is presented in the context of fun. Storytelling, discussion and games are therefore employed in the CLOCKWISE mathematical programme.

Manipulatives are useful when learners are faced with having to work out a mathematical problem or to grasp a challenging mathematical idea (Van de Walle & Lovin, 2006), whilst storytelling might reinforce time-telling skills and a personal understanding of the concept of telling time (Grinstein & Lipsey, 2001). According to Charlesworth (2005) and the Cockcroft Report (1982), problem-solving is the major means for building mathematical knowledge as it includes the application of mathematics to everyday situations. To consolidate fundamental skills associated with telling time, practice is needed and can be obtained from games and puzzles, appropriate investigations and practical tasks (Cockcroft Report, 1982).

The CLOCKWISE mathematical programme utilises verbal and visual representations, games, storytelling, problem-solving activities, direct instruction and practical work. These strategies are employed to facilitate conceptual understanding of the concept of time, together with cooperative work.

#### **2.4.2.6 Working cooperatively**

Ball *et al.* (1990) mention the value of discussion, and the sharing and comparing of ideas, in achieving a deeper understanding of basic concepts. This is congruent with the social constructivist theory (Cobb & Yackel, 1996; Ernest, 2011; Kim, 2009). Therefore, learners participating in the CLOCKWISE mathematical programme are given ample opportunities to share their own ways of thinking, verbally and visually, in order to increase the quality of each other's learning. They are also permitted to initially use their natural, everyday language which eventually permeates into the use of mathematical vocabulary (see Section 2.3.2.1). Learners are given opportunities to play mathematical games such as the *CLOCKWISE* game, *Time Snakes and Ladders* and *Time Bingo* to solve problems in pairs and in groups.

Learning cooperatively helps individuals to reach their full potential (Becker & Selter, 1996). The learners personally apply themselves to the activities and the outcome is individual growth in learning (Scholastic Research & Results, 2008).

#### **2.4.2.7 Independent work**

Within the CLOCKWISE mathematical programme, learners are gradually moved from guided practice and cooperative work to working independently, which builds confidence as they discover that mathematics is something they can do (Cockcroft Report, 1982). Independent work might also provide opportunities to confirm their conceptual understanding of the mathematical concept of time (Scholastic Research & Results, 2008). It is also a method to assess if learners understood the concepts. In the CLOCKWISE mathematical programme, learners are encouraged to complete tasks independently by means of manipulatives, drawings, verbal interpretations as well as written language. Slabbert (2010) states, that this is the way in which the learner becomes motivated and actively involved in lifelong learning. As a result, the learner might become a meta-learner who is able to plan, execute, monitor and assess his or her own learning.

#### **2.4.2.8 Sustained feedback**

This pedagogical principle of the CLOCKWISE mathematical programme, “emphasises the need to provide frequent opportunities to assess and monitor learners’ understanding as a guide for both the teacher and the learner” (Donovan & Bransford, 2005:13). “It assists in making real-time instructional adjustments and assures learners that they are making progress” (Wolfe, 2005:178).

One of the primary foci of the CLOCKWISE mathematical programme and sustained feedback is the provision of instructional support. Formal (worksheets, practical work) and informal (observation of classroom interactions and attitudes, unstructured interviews and observation of learners’ actions whilst playing games) strategies are employed to provide sustained feedback to both the teacher and learner. As integral part

of assessment it permits a teacher to evaluate the learners' understanding of the new concepts (Meel, 2003).

#### **2.4.2.9 Enrichment and encouragement**

Sustained feedback guides the teacher to revise or repeat the aspects of the programme or to enhance the information which the learner has already acquired. The "stages of planning, choosing materials, teaching and evaluation can therefore be repeated" (Charlesworth & Lind, 2013:39). This study sought to identify teaching strategies which encouraged learners' understanding of the mathematical concept of time. Teaching strategies which did not facilitate improved understanding could then be revised.

Although the above-mentioned pedagogical principles guided the design of the CLOCKWISE mathematical programme, the conceptual framework of the study facilitated the construction of understanding within the natural setting of the classroom.

The extensive review of literature directed the design of the CLOCKWISE mathematical programme. Furthermore, it guided me in constructing a conceptual framework related to the teaching and learning of the mathematical concept of time.

### **2.5 The emergent conceptual framework for the understanding of the mathematical concept of time**

The basic principles of the social constructivist theory (Tolman & Hardy, 1995) and the Pirie-Kieren model for the growth of mathematical understanding (Pirie & Kieren, 1989), as well as mathematical and pedagogical content knowledge derived from literature, are embedded in *the emergent conceptual framework for the understanding of the mathematical concept of time* (see Figure 2.8). The next section describes the emergent conceptual framework which was utilised to design the CLOCKWISE mathematical programme. It also outlines the relation of the levels of the social constructivist theory and Pirie-Kieren model (as discussed in Section 2.2, see also Figure 2.2) to the developing levels of the emergent conceptual framework of this study. This informs my

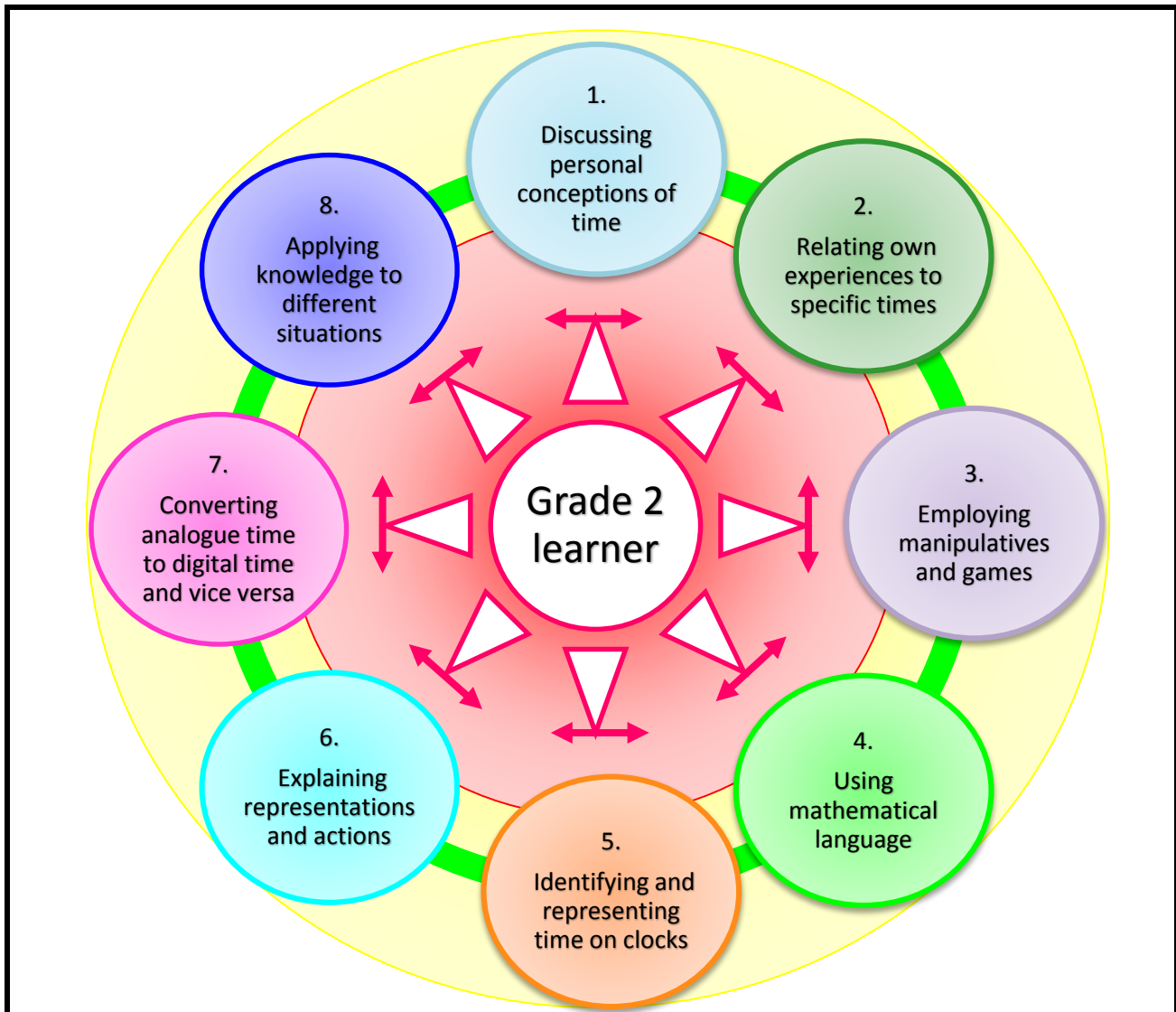
unique interpretation of the growth of mathematical understanding of the concept of time.

The following acronyms will be used in the next section:

- theoretical principles related to the social constructivist theory: SC
- theoretical principles related to the Pirie-Kieren theory for the growth of understanding: PK

Activities within the CLOCKWISE mathematical programme which relate to the theoretical principles will also be described.





**Figure 2.8: The emergent conceptual framework for the understanding of the mathematical concept of time**

The emergent conceptual framework starts with the teachers' mathematical and pedagogical content knowledge (outer and yellow circle) which direct the teaching and learning of the mathematical concept of time (as described in Section 2.3). The red circle puts the Grade 2 learners in the centre of the conceptual framework. The implication is that mathematics teachers should focus upon teaching strategies which will actively engage learners in order to enhance their understanding of the mathematical concept of time. This is congruent with Vygotsky's social constructivist theory and the

Pirie-Kieren model for the growth of mathematical understanding (Vygotsky, 1960, Pirie & Kieren, 1989). The arrows and green interconnected line demonstrate that although the eight developing levels of the concept of time (depicted in the eight circles) are presented and discussed in numerical order, the process is non-linear. It indicates that teachers and learners can move back and forth between the different levels in order to enhance the understanding of the mathematical concept of time, as suggested by Vygotsky (1960) as well as Pirie and Kieren (1989).

The objective of the first level is to focus upon the learners' personal conceptions of time. This level relates to the primitive knowing (PK) and prior knowledge (SC) levels (see Figure 2.2) which reflect upon the personal knowledge and ideas learners bring to the classroom. Mathematics teachers can therefore employ informal discussions, literature (*CLOCKWISE IN AFRICA*), photographs (sunset, burning candles) and pictures (the book *Window*) to explore learners' personal conceptions of time.

The second level of the conceptual framework acknowledges that learners should be encouraged to relate their own experiences to specific times. As suggested by the image making (PK) and acquiring knowledge (SC) levels (see Section 2.2.3), it will encourage learners to use the knowledge they have in different contexts (Lawan, 2011; Tolman & Hardy, 1995:26). The image having (PK) and internalisation (SC) levels encourage mathematics teachers to actively involve learners in the classroom at the third level. Teachers should therefore focus on their pedagogical content knowledge (see Section 2.3) to design manipulatives (number lines) and games (*Time Bingo*) which will illuminate the properties of the mathematical concept of time. Level four is based on the idea that "a concept definition may be constructed" by learners if they notice the properties (PK) and understand the underlying properties (SC) of the concept (Meel, 2003:145). Learners will most likely be able to use mathematical language to describe the mathematical concept of time at this fourth level.

At the fifth level, learners are required to identify and represent certain times on clock faces without manipulatives such as number lines and one-handed clocks. Hence, they

use their knowledge (SC) and formalise their understanding (PK). The sixth level calls attention to learners' explanations. At this level, Grade 2 learners will most likely be able to observe (PK) and reflect on their attained knowledge (SC) to explain, for instance, why the minute dial is on the six when it is half past two. Subsequently, learners will most likely be able to convert analogue time to digital time and vice versa. This constitutes the seventh level of understanding, which equals the structuring (PK) and extending on knowledge (SC) level of understanding. Finally the inventising (PK) and conceptualisation (SC) level will commence. In the emergent conceptual framework, the eighth level implies that the Grade 2 learners will be able to apply their knowledge of mathematical time in different situations (such as their own 'Salvador Dali' painting) and in their daily lives.

## 2.6 Conclusion

The research literature of the study provided information on mathematical content knowledge and pedagogical content knowledge which directed the design of the CLOCKWISE mathematical programme as well as the emergent framework for the understanding of the mathematical concept of time. The CLOCKWISE mathematical programme is a research-based programme which was specifically designed to facilitate the teaching and learning of the mathematical concept of time in Grade 2. The programme and the implementation thereof are described in Chapter 4. In the next chapter, I discuss the methodological framework of the study.

## CHAPTER THREE: RESEARCH METHODOLOGY



### 3.1 Introduction

Chapter 3 discusses the research method and design of this research project. Firstly, I present my selected paradigm. Thereafter, I discuss my research design and justify the choices that I made in terms of the research which guided my study and the purpose of my study. This is followed by an explanation of the sampling procedures as well as the integrated process of data collection and analysis. The ethical considerations of the study are discussed in the next section. In conclusion, the possible methodological constraints and trustworthiness of the study are set out.

### 3.2 Research methodology

Ferrance (2000:75) proposes that “research done in a substantial learning environment elicits theory and practice to permeate on each other quite naturally”. This study, therefore, used a qualitative practitioner research approach within *the emergent conceptual framework for the understanding of the mathematical concept of time*.

The emergent conceptual framework utilises key aspects of both the Pirie-Kieren model for the growth of mathematical understanding and the social constructivist theory (Bless & Achola, 2006; Ferrance, 2000; Meel, 2003). These aspects (as discussed in Chapter 2 Section 2.2) are appropriate for the understanding of Grade 2 learners’ growth of understanding of the mathematical concept of time. It also encourages Grade 2 teachers (as practitioner researchers) and participant learners of this study to actively interact with the concepts of time in the CLOCKWISE mathematical programme. The conceptual framework as well as practitioner research principles provided the research team (see Section 3.2.2.2) with a mechanism to design and implement the CLOCKWISE mathematical programme as described in Chapter 4. The CLOCKWISE mathematical

programme was designed as part of the research and implemented during the research process in an attempt to extend the Grade 2 teachers' understanding of strategies which would enhance the Grade 2 learners' understanding of the mathematical concept of time. In the following sections I present my selected research paradigm, methodological choices and research process which I employed in the study.

### **3.2.1 Research paradigm**

This study used a qualitative practitioner research approach within an interpretative paradigm to understand the teaching of and learners' learning of the mathematical concept of time in Grade 2. As an interpretive researcher I was present in my own classroom in order to explore the effect of the CLOCKWISE mathematical programme's teaching strategies in the normal school setting (Thomas, 2009). This aligns well with my research design which is practitioner research.

I was interested in improving my own teaching as well as Grade 2 teachers' teaching and learners' learning of the mathematical concept of time. I undertook research together with two Grade 2 colleagues and their respective learners at the school where I teach (see Section 3.3.2). The teachers volunteered and became my co-researchers. They are identified by pseudonyms in the study. Since we were interested in the way the Grade 2 learners interrelated with the mathematical concept of time, my co-researchers and I (the research team) immersed ourselves in the research context which was our own classrooms. We were aware of the fact that the Grade 2 learners in our classes have different understandings which could affect their learning experiences (Thomas, 2009). Therefore we gave primacy to the Grade 2 learners' representations and expressions in order to deepen our knowledge about their understanding and expression of mathematical time within the natural school setting (Burton & Bartlett, 2009; Thomas, 2009).

I also involved the other four Grade 2 teachers and their learners in my school. These teachers acted as critical friends and the research team shared their findings with them at a weekly Grade 2 meeting. They could relate the findings of the CLOCKWISE mathematical programme to their own teaching practices and the teaching of the

mathematical concept of time in their own classrooms (Dadds, 2004) although they followed the CAPS curriculum (Department of Basic Education, 2011). Their learners were involved in the pre- and post-testing of the study in order to determine by comparison how the teaching strategies embedded in the CLOCKWISE mathematical programme influenced, if at all, the Grade 2 learners' understanding of the mathematical concept of time in the three classes taught by the research team (see CD 2, Results).

Since I aimed to gain “an insider’s perspective” ((Babbie & Mouton, 2001:53) in terms of the teaching and learning of mathematical time, my inquiry was qualitative in nature (Henning, Van Rensburg & Smit, 2004; Merriam, 2002; Thomas, 2009). The qualitative approach enabled me to “reflect-in-action” (Kroath, 1995:85) before, after and during the implementation of the CLOCKWISE mathematical programme in my school (Mouton, 2001). I endeavoured to build upon what is already known to be successful regarding the teaching and learning of time. Therefore, I conducted my research on the basis of inductive reasoning (Thomas, 2009). Literature, and my professional knowledge of the teaching and learning of the concept of mathematical time, assisted in the construction of a conceptual framework. The *emergent conceptual framework for the understanding of the mathematical concept of time* (see Section 2.5) guided the design of the CLOCKWISE mathematical programme which focuses on the development of the mathematical concept of time (Ferrance, 2000; Mulligan & Vergnaud, 2006; Punch, 2006).

The CLOCKWISE mathematical programme utilises interviews with teachers and learners as well as games, classroom discussions, task-based activities and worksheets to generate data. The interviews, participant observations and document analysis provided “richly descriptive data in support of the findings of the study” (Merriam, 2002:5) and the choices that I made in terms of the study’s research design.

### **3.2.2 Research design**

Johnson (1995:4) explains that “qualitative methodologies are powerful tools for enhancing our understanding of teaching and learning”. As an interpretive researcher I therefore employed a qualitative research approach based on the practitioner research

method to reflect upon the teaching and learning of mathematical time in the context of the school where I teach.

### **3.2.2.1 Practitioner research**

Practitioner research is based on the assumption that practitioner researchers “reflect-in-action” (Kroath, 1995:85) in order to improve their own teaching practices (Fox, Martin & Green, 2008; Grady, 1998; Henning *et al.*, 2004). Thus, this practitioner research project was carried out within my own classroom and with the learners and teachers at the school where I teach (Ferrance, 2000; Grant, 2008; Zeni, 2001). As a practitioner researcher, I identified the teaching and learning of the mathematical concept of time as a problem within my own teaching practice. It encouraged me to take action in order to improve the learners’ understanding of the mathematical concept of time (Grant, 2008; Kemmis, 1993; Thomas, 2009).

As I was teacher and researcher in my own classroom, I realised that my own thinking and perceptions could influence my objectivity and findings. For my study to be ethical and trustworthy, I therefore discussed all my research findings with my four colleagues and two co-researchers. My co-researchers and participant learners had the right to withdraw from the study at any time and the data we collected from them was kept confidential at all times. Member checks were also employed to determine the validity of the teachers’ interview data and participant learners’ observational data (Burton & Bartlett, 2009). The participant learners were also familiar with their own teachers making observational notes in the normal process of teaching. Therefore, they did not perceive their own teachers’ research actions as intrusive.

Practitioner research is closely related to action research (Kemmis & McTaggart, 2005). Lewin (1946) was influential in the development of action research. He developed a theory that action research involves a spiral of steps involving “planning, acting, observing and reflecting” (McNiff & Whitehead, 2002:41). In later years Ferrance (2000:2) stated that action research involves the identification of problems by teachers which will “begin a spiral of posing questions, gathering data, reflection and deciding on a course of action”. He thus linked action research with practitioner research.

Stringer, Christensen and Baldwin (2010:18) propose that the teaching of concepts should also be “organised in a spiral manner so that the learners can continually build upon what they have already learned”. Hence, they suggest that a LOOK-THINK-ACT cycle when dealing with a concept in an action learning cycle can enhance learners’ growth of mathematical understanding (Stringer *et al.*, 2010). I employed a LOOK-THINK-ACT cycle in my study in order to integrate the research, teaching and learning in my practitioner research project (see Figure 3.1).

According to Lim (2007), practitioner research is executed in different phases. During these phases “the one piece of research leads to the one set of actions which is not the end of the process, but rather the start of a new phase. The research produces outcomes, which lead to action, but that in turn generates further research questions, which in turn generates further action” (Punch, 2005:161). Baskerville (1999:11) asserts that “the research cycle can continue, whether the action proved successful or not, to develop further knowledge”.

Practitioner research encourages teachers to constantly evaluate and make adjustments that may better enable the learners as they participate in the programme (Lankshear & Knobel, 2004). The CLOCKWISE mathematical programme was designed and implemented in this study to enhance the Grade 2 learners’ understanding of the mathematical concept of time. Teaching strategies such as games, storytelling, informal discussions and task-based activities were employed in the study to generate data. The programme and data assisted the research team in the evaluation of the effect of the employed teaching strategies. Therefore, I was present as the teacher as well as the researcher in my own Grade 2 classroom to evaluate the teaching strategies, the classroom discourse and the Grade 2 learners’ understanding or apparent lack of understanding of the concept of analogue and digital time (Carr & Kemmis, 1986; McNiff & Whitehead, 2009; Walliman, 2005). The next section outlines my role as practitioner researcher.



### **3.2.2.2 My role as practitioner researcher**

Foundation phase teachers at the school where I teach regularly discussed the apparent inability of learners to understand the concept of telling time and their struggle to teach this strand of the mathematics curriculum. Since practitioner research stipulates that teachers do not have to be content with the status quo, I aimed to inform and encourage teachers at my school to introduce alternative teaching strategies to facilitate the mathematical concept of time (McNiff, 1988). My study also required my two co-researchers to implement the co-designed CLOCKWISE mathematical programme. They also had to reflect on the effect the activities and teaching strategies included in the programme had on their learners' growth of mathematical understanding of the concept of time (Fox *et al.*, 2008). In the next section I describe my role as researcher, co-researcher, head of the foundation phase of the school where I teach and teacher in the study.

#### **Researcher**

Burton and Bartlett (2009) assert that the role of the researcher is to identify and represent participants' ideas and understandings. As practitioner researcher, my role in the study was initiated by my professional concerns of Grade 2 learners' apparent lack of acquisition of the mathematical concept of time.

I studied literature and collected data to confirm my assumption that teaching strategies employed by mathematics teachers contributed to the learners' lack of understanding of mathematical time. A literature review of international and South African literature as well as semi-structured interviews with Grade 2 colleagues at the school where I teach were conducted to explore the topic under study. I related my findings to the research team. The CLOCKWISE mathematical programme was designed by the research team in the light of this evidence and according to practitioner research principles (see Chapter 4 for detail).

After the design of the CLOCKWISE mathematical programme, I provided the research team with detailed descriptions of all the activities as well as all the manipulatives and

the story. Each of them also received a camera to capture their learners' actions whilst performing task-based activities and playing games. Care was taken to ensure the anonymity of the learners. Both co-researchers were skilled in writing field notes which were utilised to explain or illustrate their learners' comments, pictures and photographs.

The implementation of the programme had only the best interests of the learners in mind, since the content of the programme fulfilled the requirements of the National Curriculum of Basic Education (2011). Different teaching strategies were employed in the programme. The programme recognised learners' different learning styles which most likely improved the learners' understanding of the concept of time.

As a practitioner researcher, I acknowledge that my own perspectives could affect my interpretation of the data. Therefore, I employed various data collection methods and instruments to strengthen the trustworthiness of my findings and study. Data was collected daily over an eight week period (see Section 4.5). Interviews, participant observations as well as document analysis assisted in the collection of data. Semi-structured interviews were employed to assess all the Grade 2 teachers', my co-researchers' and the participant learners' understandings. Video recordings of classroom discussions were transcribed and descriptive field notes were made of discussions, whilst textual data of learners' work was analysed and inscriptions were made in my personal research diary.

### ***Co-researcher***

The CLOCKWISE mathematical programme was put into place by two Grade 2 teachers, who acted as co-researchers, and myself in our Grade 2 classes at our school (as described in Section 3.2.1). We acted as a research team. I was also a co-researcher in the study. The two teachers, whom I refer to as Mia and Lisa in the study, and I were responsible for the implementation of the prescribed mathematics curriculum in Grade 2 at the research site. They also volunteered to implement the CLOCKWISE mathematical programme in their own Grade 2 classes. Informed consent was also obtained from both

of my co-researchers. They knew they could at any time withdraw from the research project as stated in their signed consent letters (Appendix G).

As co-researcher, I designed and distributed the planned teaching materials as part of the CLOCKWISE mathematical programme. I scheduled an information session in the pre-implementation phase to introduce my co-researchers to the programme and the teaching methods described in the programme. My co-researchers and I discussed the teaching materials and teaching strategies in the developmental phases of the programme. During the implementation phase the effect of the mathematical programme on our teaching and the learners' learning were assessed and discussed at the weekly Grade 2 meeting. Descriptive field notes were made by my co-researchers and by myself. I collated and analysed the raw data as soon as possible so that difficulties could be dealt with immediately (Kemmis & McTaggart, 1981).

Member-checking was employed as observations made by my co-researchers were frequently compared with my own to enhance and substantiate the validity and trustworthiness thereof. Participants' (co-researchers and learner participants) meanings and understandings were confirmed during classroom discussions (McMillan & Schumacher, 2006). In the post-implementation phase of the research project I conducted a focus group interview with all six of the Grade 2 teachers to evaluate the programme (see Section 3.6). We, as a group of Grade 2 teachers, discussed the learners' growth of understanding of the mathematical concept of time as well as the effectiveness of the teaching strategies employed in the CLOCKWISE mathematical programme.

### ***Head of the foundation phase***

I have been aware of the implications of conducting the research in my own school, with two teachers acting as co-researchers as part of my research team. Since I am the foundation phase head of department (HOD), the ability of the teachers to withdraw from this research could have been severely limited. However, I view leadership as a

collaborative effort (Dufour & Eaker, 1992; Schlechty, 1990) and contend that each foundation phase teacher in my department is confident and prepared to implement new ideas in order to enhance the young learners' skills and understanding of concepts. My study was therefore predicated on the assumption that collaborative working in the foundation phase at my school is positive and it had a shared purpose, the purpose being the improvement of practice. Colleagues willingly exchange, criticise and build upon each other's ideas at my school in general. Consequently, task-based activities of the CLOCKWISE mathematical programme were readily adapted. Activities such as the completion of the 'Time chart' were adapted when my co-researchers explained that the learners in their classes did not understand the differences between am and pm times yet. My co-researchers also stated that they enjoyed being part of the research team. Mia mentioned that she was privileged to be part of the research team, since she 'learned so much!' (CD 2, Teachers' understandings, I<sup>2</sup>-24 September 2012).

### ***Teacher***

Although I am the foundation phase HOD, I am firstly a Grade 2 teacher. Effective teaching and learning in my own classroom and in Grade 2 are my first concern. Therefore, I have been present as both teacher and researcher in my Grade 2 classroom to evaluate the learning processes, of and Grade 2 learners' understanding of, the mathematical concept of time as well as the effect of the applied teaching strategies.

As practitioner researcher I also recognised the vulnerability status of the participant learners as high. Therefore, I have been committed to act in the best interests of the participating learners. As a teacher, I was aware of my fiduciary responsibilities and sought to demonstrate respect for learners during the implementation phase of the CLOCKWISE mathematical programme (Lankshear & Knobel, 2004).

In the next section I reflect upon the LOOK-THINK-ACT cycle of the practitioner research framework. The phases within this practitioner research study are also discussed in this section.

### **3.2.2.3 *Practitioner research in the context of the study***

The primary goal of this practitioner research project was to improve the teaching of the mathematical concept of time. A secondary aim was to understand the Grade 2 learners' understanding of the mathematical concept of time through implementing various teaching strategies. The practitioner research framework and the LOOK-THINK-ACT cycle thereof assisted our engagement with the pedagogical principles of the CLOCKWISE mathematical programme as well as the implementation thereof within the three Grade 2 classrooms. There were three phases in this practitioner research study which can be aligned to the LOOK-THINK-ACT cycle of practitioner research: the pre-implementation phase, implementation phase and the post-implementation phase (see Figure 3.1). The three phases of this practitioner research project are discussed in the next sections.

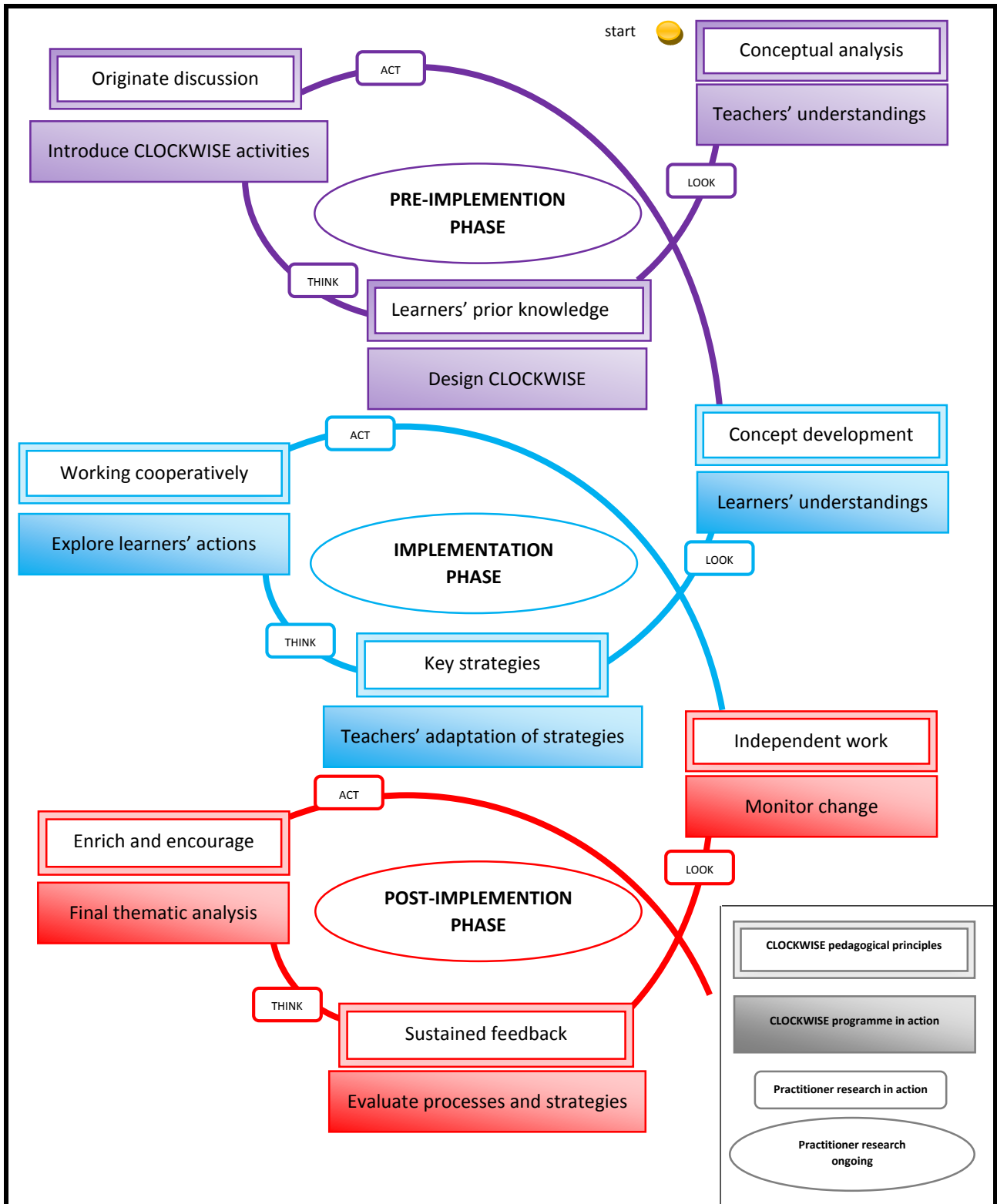


Figure 3.1: Practitioner research and the CLOCKWISE mathematical programme in action, adapted from McNiff (1988:45) and Stringer, Christensen and Baldwin (2010:123)

### ***Pre-implementation phase***

The other six Grade 2 teachers at the research site and I discussed our Grade 2 learners' apparent lack of mathematical understanding of the concept of time [look]. We referred to the results we obtained from a task-based activity which required the learners in all seven Grade 2 classes (my own class included) to represent certain times on analogue clocks (see CD 1, CLOCKWISE). I therefore conducted individual, semi-structured interviews with all six of my Grade 2 colleagues in the pre-implementation phase of the study to analyse the concepts of time which they believed should be understood by Grade 2 learners [look]). Their ideas were considered when the research team drafted the CLOCKWISE mathematical programme which built upon our teaching experiences and our Grade 2 learners' prior knowledge [think]. Thereafter the CLOCKWISE mathematical programme and its activities were discussed and introduced to the participant teachers [act]. This concluded the pre-implementation phase of the study.

### ***Implementation phase***

The CLOCKWISE mathematical programme focused upon the learners' understanding of the mathematical concept of time and the concepts were organised and designed in such a way so that learners could "continually build upon what they have already learned" (Stringer *et al.*, 2010:18) [look]. Different teaching strategies were employed in the programme's implementation phase and the effects thereof were monitored [think]. The key teaching strategies enabled 'folding back' as suggested by the Pirie-Kieren model for the growth of mathematical understanding (Meel, 2003:147). Furthermore, it implied that the teaching strategies of the CLOCKWISE mathematical programme could be adapted by the research team.

In addition, the LOOK-THINK-ACT cycle of instruction facilitated the active participation of the research team and learner participants [act]. Whilst playing games such as *Time Snakes and Ladders* and the *CLOCKWISE game*, learners were working cooperatively.

Their actions were explored unobtrusively, which is congruent with the social constructivist theory of the study.

### ***Post-implementation phase***

Post-implementation, learners were encouraged to work independently whilst completing worksheets and task-based activities. It enabled their teachers to monitor if the learners' mathematical understanding of the concept of time improved or not [look]. The effects of the employed teaching strategies were evaluated and discussed by the research team [think], whilst sustained feedback encouraged the learners to apply their acquired knowledge. The classroom teaching principles and the effects thereof on the learners' acquisition of the mathematical concept of time were critically examined and analysed (Mills, 2007). The negotiation process encouraged the research team to raise and pursue issues pertaining to the programme which resulted in the adaptation of the CLOCKWISE mathematical programme [act]. The implementation of the adapted CLOCKWISE mathematical programme may then lead to the start of a new cycle.

In the next section I describe the sampling of my study. I refer to the research site as well as the research participants of the study.

## **3.3 Sampling procedures**

Punch (2005) suggests that sampling decisions need to include consideration of settings, the processes, what events will be observed, in addition to the people who will be interviewed. Purposive and convenience sampling were appropriate for this practitioner research project. The research was conducted at the school where all three members of the research team teach, within their own classrooms and with their own learners (Petty, Thomson & Stew, 2012; Punch, 2005).

### **3.3.1 Research site**

The research was conducted in a South African context at an Afrikaans-medium primary school in the Tshwane North district in the Gauteng Province. The school has seven



Grade 2 classes. Three Grade 2 classes with a total of 92 learners constituted a manageable sample which could be representative of the Grade 2 learners enrolled at the research site.

Since I am a Grade 2 teacher at the research site, I obtained permission to conduct the research with Grade 2 learners in three of the seven heterogeneous classes at the school where I teach (see Appendices D, E and F). Since the school's language of instruction is Afrikaans, data was collected in the learners' vernacular. The mathematical programme was written in Afrikaans and then translated in English.

A classroom environment conducive to learning was maintained. Observations almost went unnoticed by learners in the classroom since the observations were done by their own teachers. Instructional time was not compromised, since the CLOCKWISE mathematical programme was implemented at times allocated for mathematics on the time schedule.

### **3.3.2 Research participants**

#### **3.3.2.1 Teachers as researchers**

Consistent with practitioner research and interpretivism, I immersed myself as a researcher, co-researcher and participant in the study in order to understand what constitutes the circumstances related to the teaching and learning of the mathematical concept of time in a Grade 2 classroom (Thomas, 2009). As discussed in Section 3.2.2.2 two teachers at the research site, one with six months and the other one with 31 years of teaching experience respectively, also volunteered to be part of the research team. We acted as co-researchers who reflected upon, planned, implemented and analysed data during the research process. The research team believed that it would empower them to teach the concept of time more effectively.

The two teachers (co-researchers) had the knowledge, skills and attitude to facilitate meaningful and authentic learner participation, as suggested by Viviers (2010). It enabled me to observe the effectiveness of the proposed teaching methodologies of the CLOCKWISE programme (Patton, 1987). In addition, it enabled me to investigate the

possibility that an experienced teacher might revise the methodologies she had employed for years to teach the concept of time and the probability that a beginner teacher would utilise the methodologies suggested by the CLOCKWISE programme. At the beginning, I hoped to gain deeper insight into their understanding of effective teaching strategies to enable me to develop the CLOCKWISE mathematical programme with their help. Manipulatives were made available to them to enhance learner participation in the mathematical programme and in their own classrooms (Viviers, 2010). Withdrawal from any of the co-researchers could not harm the learners, since the concept of time is part of the Grade 2 mathematics curriculum and therefore it would still be facilitated in their classrooms. As indicated in Section 3.2.1, the CLOCKWISE mathematical programme and its findings were shared with all of the Grade 2 teachers at a weekly Grade 2 meeting. Every one of the teachers could relate the findings to their own teaching of the mathematical concept of time in their own classrooms. They could also use the teaching strategies employed in the CLOCKWISE mathematical programme by choice.

### **3.3.2.2 *Learners as participants***

Three Grade 2 classes represented a sample of 92 Grade 2 learners who took part in the study. These learners were all between the ages of seven and nine years. The learner participants were informed about the study and letters of voluntary informed consent and assent were signed by the learners' parents or guardians and the learners respectively (Appendices E and F). The learners and parents were informed that there would be no deception or betrayal in the research process or its published outcomes. As suggested by Mouton (2001:243), the "results obtained were in harmony with their privacy and dignity". Learners' identities were not revealed in the dissemination of the research, since individual learners could only be identified by a number they drew from a hat themselves. These numbers were only known by the learners and their respective teachers. Table 3.1 provides a summary of the profile of the participants. I also acted as a research participant, but my role as practitioner researcher has already been described in Section 3.2.2.2. In the following section I discuss my research process.

**Table 3.1: Profile of research participants**

| Participants   | Gender                                       | Role  |
|--|--|---|
| Six Grade 2 teachers at the research site                        | Female                                       | Critical friends: <ul style="list-style-type: none"> <li>➤ Discussed the Grade 2 learners' understanding of the mathematical concept of time.</li> <li>➤ Conceptual analysis of the concept of mathematical time.</li> <li>➤ Discussed the activities which were employed in the CLOCKWISE mathematical. Their contributions were taken into account when the programme was adapted.</li> </ul> |
| Mia (Pseudonym) and Lisa (Pseudonym): teachers as co-researchers | Female                                       | Co-researchers: <ul style="list-style-type: none"> <li>➤ Assisted in the design of the CLOCKWISE mathematical programme, implementation of CLOCKWISE mathematical programme and analysis of data.</li> </ul>  |
| Grade 2 learners:<br><br>92 learners                             | Female: 52 learners<br><br>Male: 40 learners | Learner participants: <ul style="list-style-type: none"> <li>➤ Interacted in all of the activities within the CLOCKWISE mathematical programme.</li> </ul>  |

### 3.4 The research process

Since practitioner research informed the design and implementation of the research programme, the study also elicited a dynamic, non-linear and cyclic process to collect and analyse the research data. Research data was collected from interviews, participant observations, task-based activities as well as documents (see Section 3.4.1). Table 3.2 provides a summary of the research cycle for data collection in a linear format. It also provides strategies as well as data collection instruments which aligns with the three phases in this practitioner research study discussed in Section 3.2.2.3 and Figure 3.1. The data analysis process is explicated in Chapter 5.

**Table 3.2: The research cycle for data collection (in a linear format)**

| Research sequence                        | Data collection strategies and instruments  | Time   |
|--|---|--|
| <b>Phase 1: Pre-implementation phase</b> |   |  |
| Stage one                                | <p><b>Interviews and document analysis</b></p> <p>The first semi-structured interviews were conducted to establish what the six Grade 2 teachers at the research site believed effective teaching of the mathematical concept of time entailed. An interview schedule was developed in advance (Appendix H), field notes were taken and the data was transcribed.</p>   | 20 minute individual interviews with all six Grade 2 teachers, 18–20 June 2012 |
| Stage two                                | <p><b>Document analysis</b></p> <p>Pedagogical principles and teaching strategies derived from existing literature were analysed in order to design the CLOCKWISE mathematical programme</p>  | End of June – 12 July 2012   |
| Stage three                              | <p><b>Observations, interviews and document analysis</b></p> <p>After consent and assent had been attained from parents or guardians, teachers and learners respectively (Appendices E, G and H), informal discussions were conducted with my co-researchers to explain the research process and the implementation of the programme. Participant observation and my personal research diary were utilised to assess, observe and note the participant’s reactions.</p>   | 45 minute meeting with both co-researchers on 19 July 2012                     |
| <b>Phase 2: Implementation phase</b>     |   |  |
| Stage one                                | <p><b>Observations, interviews and document analysis</b></p> <p>The CLOCKWISE mathematical programme was implemented in three Grade 2 classes and adapted as discussed by the research team. Participant observations and unstructured interviews during classroom discussions provided insight into learners’ understandings. These interactions were video recorded. Two task-based activities employed learners’ drawings and written descriptions thereof. The data collected from different techniques as well as inscriptions in my personal research diary enabled me to triangulate the information gathered to gain insight into learners’ understanding of mathematical time.</p> | 23–27 July 2012  |
| Stage two                                | <p><b>Observations and interviews</b></p> <p>All of the Grade 2 learners at the research site were required to represent certain times on clock faces to establish their level of understanding of the mathematical concept of time. Semi-structured (task-based) interviews were also employed by the research team to individually assess the participant learners’ attainment of prerequisite skills in their own classrooms. These activities were video recorded. The questions were asked in the same order to all the learner participants in the three classrooms.</p>  | 30 July–3 August 2012  |
| Stage three<br>Stage three               | <p><b>Observation, interviews and document analysis</b></p> <p>Being present in the class enabled the research team to obtain data regarding learners’ growth of understanding and their learning processes whilst they utilised manipulatives provided in the CLOCKWISE mathematical programme, visually represented specific times and interacted with their teacher and peers. These actions were video recorded. Unstructured interviews were conducted with learners during classroom discussions to confirm their understanding and meanings. Visual representations, the task-</p>   | 13 August – 14 September 2012  |

| Research sequence                         | Data collection strategies and instruments   | Time                                     |
|---|--|--|
|   | based activity and the games they played were photographed and video recorded respectively to assess learners' understanding of the mathematical concept of time over five consecutive weeks.  |  |
| <b>Phase 3: Post-implementation phase</b> |  |  |
| Stage one                                 | <b>Observation, interviews and document analysis</b><br>The research team aimed to measure the differences in learners' attainment of the concept of time after the implementation of the programme (Alhojailan, 2012). All of the Grade 2 learners were assessed to establish their growth in mathematical understanding of the concept of time. The learner participants of the study also had the opportunity to depict a concept of mathematical time in the two task-based activities (with drawings and objects) they completed.                         | 17–21 September 2012                     |
| Stage two                                 | <b>Interviews</b><br>Semi-structured interviews with my co-researchers were employed after the CLOCKWISE mathematical programme was implemented to verify and extend information on what they believed the effect of the programme to be (TerreBlanche & Durrheim, 1999). A focus group interview was also employed with all six of the Grade 2 teachers at the research site as a confirmation technique. The negotiation process also enabled the teachers to discuss issues pertaining to the programme, as suggested by Cohen, Manion and Morrison (2001). | 24 September 2012<br><br>15 October 2012 |
| Stage three                               | The data collected from all the above-mentioned data collection instruments was collated to triangulate the information in addressing the research questions of the study.   | February – May 2013                      |

In the next section I give an account of the data collection strategies and instruments I employed in the study. As an interpretivist, I wanted to understand the teaching and learning of the mathematical concept of time in a Grade 2 classroom. My co-researchers and I therefore collected data in our own classrooms and engaged with the learner participants in “an open and empathic manner” (Terreblanche & Durrheim, 1999:128). In the next sections, the CLOCKWISE mathematical programme, interviews, participant observation and document analysis as data collection instruments are described.

### 3.4.1 Data collection instruments and methods

#### 3.4.1.1 *The CLOCKWISE mathematical programme as data collection instrument*

The practitioner research framework and the LOOK-THINK-ACT cycle (see Figure 3.1) thereof encouraged the research team to improve their teaching of the mathematical concept of time in order to enhance their learners' understanding of time. Furthermore, it assisted the research team to plan and design the CLOCKWISE mathematical

programme, to observe the research process and to reflect upon the data generated from interviews, participant observations and document analysis.

The CLOCKWISE mathematical programme employs storytelling, games, informal discussions, manipulatives, pictures and task-based activities to elucidate the concepts of analogue and digital time. Descriptive field notes of learners' expressions and observations whilst listening and responding to the *CLOCKWISE IN AFRICA* story were made by the research team. These field notes were translated and provided evidence in terms of the learners' understanding of the mathematical concepts of time. The CLOCKWISE mathematical programme also employs pictures and the collages in the book *Window* (Baker, 2000) to encourage learners' thinking about the application of the concept of time in their daily lives. The learners' verbal and visual representations of concepts of time provided evidence related to their personal understandings of mathematical time. The learners' actions whilst playing games such as the *CLOCKWISE game* and *Time Bingo* were video recorded. The games provided the learners and teachers with "opportunities to strengthen and reinforce" the learners' understanding (Burns, 2008:4). Their actions and expressions whilst they were manipulating the manipulatives such as number lines and one-handed clocks were also video recorded. Descriptive field notes were made of the video recorded activities which provided evidence in terms of their mathematical thinking and growth of understanding of the concept of time. Furthermore, task-based activities such as the drawing of a concept of time and an activity at a certain time of day were used for assessment purposes and generated data which the research team could analyse. The analysed data allowed the research team to articulate the significance of the teaching strategies employed in the CLOCKWISE mathematical programme.

### **3.4.1.2 Interviews**

Literature indicates that interviews encourage people to participate and to discuss their own ideas (Thomas, 2009). An interview can be described as a discussion amongst people (TerreBlanche & Durrheim, 1999). In this study I made use of semi-structured, unstructured as well as focus group interviews. As I was familiar with the Grade 2 teachers at the research site as well as the learner participants in my own class, I

acknowledged that I could be perceived as a biased interviewer. Therefore, I acted as objectively as possible and the interviews were conducted in the natural setting of their own classrooms and in a manner which could be described as informal conversations about the mathematical concept of time. Member checking was also employed to validate the teachers' documented opinions and understandings.

Semi-structured interviews were conducted with all six Grade 2 teachers at the research site in order to establish their understandings on the effective teaching of the mathematical concept of time in Grade 2. This was done during Stage one of the pre-implementation phase of the study (see Table 3.2) before the CLOCKWISE mathematical programme was developed by the research team. Although an interview schedule was developed in advance, all six Grade 2 teachers were asked the same series of questions in the same order in a conversational manner (Appendix H). I took care not to influence the interviewees by expressing my emotions, feelings and opinions in any way. These interviews were conducted individually and lasted about twenty minutes each. They were conducted in the teachers' own classrooms on three consecutive days before contact time with learners started in the morning. The interviews were conducted in the teachers' vernacular, which was Afrikaans. Therefore, the interviews had to be transcribed and then translated (see CD 2, Teachers' understandings).

In this research study, semi-structured interviews were also conducted with the 92 learner participants to identify the learners' prerequisite knowledge of conservation, reversibility, transitivity, classification and seriation (Holmes, 1985) in Stage three of the pre-implementation phase (see Table 3.2). The questions were pre-established and asked in the same order as the task-based activities in the CLOCKWISE programme (CD 1, CLOCKWISE). Learners also had to compare events perceptually, directly and indirectly (Carruthers & Worthington, 2006:390). All the Grade 2 learners at the research site were required to individually present certain times on clocks to establish their understanding of analogue and digital time as part of assessment. Detailed field notes were made of learners' responses, since the results obtained before, during and after the implementation of the CLOCKWISE mathematical programme were significant in

evaluating the effect of the CLOCKWISE mathematical programme on learners' conceptual understanding of the mathematical concept of time. Results were also evaluated to reflect upon learners' knowledge, to plan and develop teaching strategies which could enhance their understanding and to implement the suggested changes.

Semi-structured interviews were conducted once more in Stage two of the post-implementation phase (see Table 3.2) to verify and extend information on what my co-researchers believed the effect of the programme to be. It also provided an opportunity to clarify ideas and practices noted in their field notes and photographs (Burton & Bartlett, 2009), thus enhancing the trustworthiness thereof.

Unstructured interviews are considered a very good methodology to access teachers' and learners' perceptions, meanings, definitions of situations and constructions of reality (Punch, 2005:168). Unstructured interviews can be employed to put emphasis on participant teachers' and learners' perceptions and understandings of concepts (Mukherji & Albon, 2010). Unstructured interviews were therefore employed in the implementation phase of the study when the CLOCKWISE mathematical programme was implemented (see Table 3.2). Learners' perceptions, understandings and ideas were captured whilst they were playing games, utilising manipulatives such as number lines, making drawings and discussing the physical objects of photographs they brought from home to depict a certain aspect of time. McMillan and Schumacher (2006) suggest that words reveal research participants' views, understandings and perceptions. Therefore, video recordings and photographs which captured classroom discussions and visual representations were also discussed with the participant learners involved. It constituted the shared construction of knowledge with the Grade 2 learners so that their understandings came to the fore (Waller & Bitou, 2011).

Finally, a focus group interview was employed in Stage two of the post-implementation phase (see Table 3.2) with all the Grade 2 teachers at the research site to reflect on the learning processes and teaching strategies of the CLOCKWISE mathematical programme. Focus group interviews can be facilitated by a researcher (Petty *et al.*, 2012). In this study it was utilised to gain a better understanding of the teaching of the



mathematical concept of time and the effect of the CLOCKWISE mathematical programme's teaching strategies on learners' understanding of the mathematical concept of time (Waller & Bitou, 2011).

### **3.4.1.3 Participant observation**

Henning *et al.* (2004) suggest that participant observation is a way to observe the actions of research participants. Thus, observations in this study were undertaken in the natural setting of the research participants' own classrooms whilst the CLOCKWISE mathematical programme was implemented (Petty *et al.*, 2012; TerreBlanche & Durrheim, 1999). Participant observation enabled me as practitioner researcher to assess learners' understanding of concepts and processes through observation during Stage three of the pre-implementation phase, Stages one and three of the implementation phase, as well as Stage one of the post-implementation phase (see Table 3.2). One could gauge their level of understanding from what they did and what they said (McMillan and Schumacher, 2006). Although participant observation was time-consuming, non-verbal cues, tacit knowledge demonstrated by actions or created objects and the language used by participants could also be taken into account when data was analysed. Member checking also enabled the research team to validate the information and data they gathered from the participant learners' actions and expressions.

Participant observation was utilised to capture learner participants' actions through which their growth of mathematical understanding was sometimes revealed (Walliman, 2005). This was feasible as the learner participants of the three Grade 2 classes were familiar with their own classrooms in which the research was conducted. They knew their peers and their own teachers conducting the research.

Learners' verbal and visual representations and the games they played were captured utilising photographs, video recordings and field notes in order to present authentic and descriptive data (McMillan & Schumacher, 2006). Coltman (2006) noted that by means of photographs and video recordings, one can record the actual behaviour of the learners while they are involved in activities. McNiff *et al.* (1996) and Macintyre (2000) suggest that these photographs and video recordings illustrate how well the participant

learners were involved in classroom discussions and activities. Copies of these photographs and video recordings were also employed in the focus group discussion with my six Grade 2 colleagues on the effect of the CLOCKWISE mathematical programme.

Games, such as *Time Bingo*, the *CLOCKWISE game* and *Time Snakes and Ladders*, revealed learners' understanding of time concepts and strengthened their learning and understanding of mathematical time (Burns, 2008). Learners' growth of mathematical understanding was also revealed whilst engaging with manipulatives such as clocks, number lines, whiteboards and printed worksheets. Van de Walle and Lovin (2006) describe manipulatives as tools which are used to represent concepts visually in order to influence learning positively. When learners are having fun, they will be actively involved in the learning process (Schminke *et al.*, 1978). Although literature suggests that approaching telling time through the use of modelling with clock faces will give the best possible chance for all learners to develop skills, this study employed the learners' own one-handed clocks, printed sunglasses, number lines, printed activity sheets and whiteboards to deepen their mathematical understanding (Bell, 1980; Holmes, 1985; Scholastic Research & Results, 2008). These manipulatives were used in informal classroom activities and discussions and provided opportunities to observe learners' attainment of the concept of time unobtrusively. Learners' explanations whilst manipulating the afore-mentioned tools were video recorded and descriptive field notes were made thereof. It provided a thick description of the learning processes of the participant learners.

#### **3.4.1.4 Document analysis**

Document analysis includes written work, drawings and pictures (Petty *et al.*, 2012). Documents which were consulted during the pre-implementation phase of this study included educational policy documents of South Africa as well as England, the United States of America and Singapore (as outlined in Chapter 2 Table 2.1 and discussed in Section 2.3.1.1). These documents propose concepts and standards for the teaching of mathematical time in the second grade or year of formal schooling (see Table 3.3).

**Table 3.3: Policy documents: Concepts and standards for the teaching of mathematical time in Grade 2**

|         | England   | United States of America  | Singapore   | South Africa   |
|---------|---|---|---|--|
| Grade 2 | Compare and sequence intervals of time (Department for Education, 2013a).                                       |   |   | "Identifies important dates on calendars including learners' birthdays, religious festivals" (Department of Basic Education, 2010:15). |
|         |   |   |   | Name in order and sequences events according to days, weeks, months and years.   |
|         | Tell and write the time to five minutes, including quarter past/to the hour and draw the hands on a clock face. | "Tell and write time from analogue and digital clocks to the nearest five minutes using am and pm" (Common Core State Standards Initiative, 2010:20). | Telling time to 5 minutes.<br>Use of am and pm.<br>Drawing hand on the clock face to show time (Ministry of Education, 2012). | Read analogue time in hours and minutes.   |
|         | Know the number of minutes in an hour and number of hours in a day.   |   | Duration of 1 hour/half hour (Ministry of Education, 2012).   | Calculates elapsed time in hours and minutes using clocks, as well as days, weeks and months using calendars.                          |

This table is adapted from Common Core State Standards Initiative (2010:20); Department for Education (2013a); Department of Basic Education (2011:15); Ministry of Education (2012:40)

Literature was also reviewed to determine which strategies are recommended for the teaching and learning of mathematical time. The research team's ideas regarding the teaching and learning of time and the proposed strategies could then be compared to develop the CLOCKWISE mathematical programme. Document analysis formed part of this study and served to triangulate evidence from different sources.

My personal reflections on participants' actions, difficulties and understandings were recorded in a personal research diary and in field notes during all three phases of the study and reflected upon when data was analysed (Thomas, 2009:166). According to McMillan and Schumacher (2006:359), field notes are "detailed, descriptive recordings of events, actions and objects in settings". Descriptive field notes were made of task-based

interviews and semi-structured interviews since the Grade 2 teachers and my co-researchers found the video camera to be intrusive in the interview setting. These field notes were transcribed to evaluate the development of the teachers' and learners' understanding of the mathematical concept of time. The participant learners did not find the video camera to be intrusive as they were familiar with audiovisual material utilised in preceding lessons.

Learners' drawings, written data, visual as well as verbal representations are all presented and analysed in the study. Mukherji and Albon (2010) assert that learners can communicate their understanding of concepts in their drawings. Carruthers and Worthington (2006) mention that learners should be encouraged to discuss their drawings and written work, since it could clarify their perceptions and understandings. Therefore, participant learners had to explain their visual representations verbally or by means of writing a sentence which explained their representation. These explanations validated teacher observations (McMillan & Schumacher, 2006). I also reduced researcher bias by giving my co-researchers samples of all the data we collected within our three classrooms to verify the analysis and conclusions drawn by me (Burton & Bartlett, 2009).

### **3.4.2 Data and thematic analysis process**

A key principle of interpretive analysis is to be faithful to the data, seeking to understand with empathy what is beginning to be revealed (TerreBlanche & Durrheim, 1999). Therefore all data collected was analysed, in order for me to integrate all the information available. The data had to be translated into English since the programme was implemented in Afrikaans.

In congruence with Lim (2007:3), I believe that "practitioner research cannot and should not be used to generate educational theories or test educational theories". Therefore, I employed thematic analysis to identify, analyse and report patterns or themes within the data I collected (Anderson, 2011; Braun & Clarke, 2006). According to Braun and Clarke (2006) a theme identifies a relevant and meaningful connection between the data and

the research question. Thus, thematic analysis aims to end up with key themes that describe the essence of the study and provide rich and insightful information.

Data was collected from the learners as well as us the teachers during the pre-implementation, implementation and post-implementation phases of the practitioner research project (see Table 3.2). As practitioner researcher, I, like Ferreira (2006:135), was “involved during the entire research process which enabled me to start with data analysis whilst still collecting data”. During the pre-implementation phase of the study I could reflect upon the Grade 2 teacher and learner participants’ understanding of the mathematical concept of time. It generated data which was utilised to design the CLOCKWISE mathematical programme. During the implementation phase of the CLOCKWISE mathematical programme, data provided insights into the learners’ growth of mathematical understanding and the effect of the employed teaching strategies. In the post-implementation phase, learners’ understanding as well as teachers’ teaching strategies could be focused upon. As practitioner researcher I was familiar with the data. I therefore constantly reminded myself not to come to any conclusions before the data collection process was completed. To initialise the thematic analysis process, the raw data obtained from the data collection instruments was transcribed, translated and interpreted in each of the three phases.

As suggested by Ryan and Bernard (2003), I perused the raw data provided by interviews, classroom discussions, document analysis, field notes as well as inscriptions in my personal research diary to initialise the thematic analysis process. The themes were not predetermined but rather emerged as I reviewed the data collected in the three phases (Anderson, 2011). I searched for recurring vocabulary and phrases or meanings and I colour-coded similarities and differences within the data presented (Ryan & Bernard, 2003; TerreBlanche & Durrheim, 1999). The colour-coded items were then examined and quotes or expressions which seemed important were written down on small index cards. I subsequently identified relationships between the colour-coded data and organised them into piles which I categorised. Lankshear and Knobel (2004:270,271) define the coding process as “categorical analysis”. In the pre- as well

as post-implementation phases, I categorised the piles as ‘strengths’ and ‘limitations’ of teaching strategies. In Phase 2, the learners’ understandings as well as recurring vocabulary or phrases were categorised as ‘change’ and ‘experience’. Thereafter, I read through my transcribed video recorded data and started making brief notes in the margins, serving as an initial sorting process. Recurring data was then colour-coded. I utilised small index cards to write down recurring ideas or phrases and I organised them into piles which I categorised as ‘teachers’ understandings’ and ‘learners’ understandings’.

Then I started with the formal coding process. I followed a bottom-up (inductive) approach in order to identify the underlying principles of the collected data (Terreblanche & Durrheim, 1999). I re-read all my index cards, sorted them and grouped them under appropriate code headings which were ‘understandings’, ‘experiences’ and ‘exploration’. I noted that some ideas were used in more than one way, which resulted in the refinement of three potential theme headings.

I looked for connections between the categories, and used my notes to help me identify phrases that would best describe the basic elements (Ferreira, 2006). The thematic analysis process provided evidence in terms of three themes (see Section 5.2.2) which provided insights for me to answer the research questions of the study.

### **3.5 Ethical considerations**

Mouton (2001) posits that interactions, whether with people or with the environment, can give rise to ethical issues, and particularly when there is the possibility of conflict of interests. Therefore, I applied for ethical approval prior to data collection. Ethical approval was granted by the Gauteng Department of Education (see Appendix B) and the University of Pretoria ethics committee (see Appendix A). No secret research was conducted and my research and results were accessible to be evaluated and assessed, as suggested by Mouton (2001). I was prepared to disclose my methodology and techniques of data analysis at all times and my study contains references to all participants’ contributions.

The following ethical principles guided the research project:

- informed consent
- voluntary participation
- safety in participation (confidentiality, anonymity and privacy)
- trust

### 3.5.1 Informed consent

I have been encouraged to abide by the ethical norms of the basic rights of participants, especially as I was working with young children. Participants were informed about their role in the research project, the aim of the research and the research procedures.

The informed consent of participants' parents or guardians (Appendix E) and the two Grade 2 teachers who voluntarily became my co-researchers (Appendix G) were obtained. In addition the permission of the ethics committee of the University of Pretoria (Appendix A), the Gauteng Department of Education (Appendix B) and the principal and governing body (Appendices D and C) at the school where I teach (Mouton, 2001) were requested. As participant learners were between the ages of seven and nine years, their informed assent was obtained (Appendix F).

### 3.5.2 Voluntary participation

Participants were assured that participation was voluntary and that they could withdraw at any time. Anticipated limitations are discussed in Section 1.8. Learner participants did not receive incentives since incentives could not be withheld from learners not taking part in the research project.

### 3.5.3 Safety in participation (confidentiality, anonymity and privacy)

Participants had the right to privacy; they could withhold answers or could even choose not to be interviewed (McNiff *et al.*, 1996; Mouton, 2001). Participants were assured that participation was voluntary and that they could withdraw at any time. Teachers (all six) were not interviewed when they had tea breaks. The participant teachers and learners also had the right to anonymity and confidentiality.

As suggested by Mouton (2001:243), the results obtained are also in harmony with their “privacy and dignity”. The privacy of the participants was respected and their identity was not revealed in my thesis. Pseudonyms were used to identify the two co-researchers, whilst each learner drew a number to which their data was linked. Visual images portrayed in the thesis do not reveal the learners’ identities.

### **3.5.4 Trust**

Respect and trust were upheld at all times (Viviers, 2010). This was feasible as the learners were not unfamiliar with their teacher and the classroom in which the research was conducted.

## **3.6 Trustworthiness of the study**

As practitioner researcher, I accepted my subjectivity which might have “affected the nature of my observations and interpretations” of learners’ actions in my own class (Thomas, 2009:110). My main objective was to enhance the validity and trustworthiness of my research.

The informed consent of the participant learners’ parents or guardians was attained (see Appendix E). Parents and guardians were assured that instructional time would not be compromised and that they would not be denied access to outcomes and results. Participant learners’ assent was also attained (see Appendix F). Although precautions were taken to minimise intrusion, parents or guardians and learners’ withdrawal or refusal to consent and assent respectively did not go unnoticed. As suggested by Cohen *et al.* (2001:52), where learners refused to participate, they were not questioned, their actions were not recorded and these learners will not be included in any article published or thesis, even with the use of a pseudonym.

The rapport I have with the learners in my own class enabled me to observe them and their actions unobtrusively without them trying to impress me (Mouton, 2001). To further enhance the trustworthiness of my study, participant observations and interviews with all six teachers as well as learner participants were also conducted in natural settings; their



own classrooms with which they were familiar “to reflect lived experiences” (McMillan & Schumacher, 2006:325). In addition, the programme was also developed in Afrikaans to be implemented in the school’s language of learning and teaching (LoLT).

Member checking (see Sections 3.4.1.2 and 3.4.1.3) was employed to ensure the authenticity and trustworthiness of the collected and analysed data (McMillan & Schumacher, 2006). I shared my findings with my co-researchers to enhance and substantiate the validity and trustworthiness thereof. As suggested by McNiff *et al.* (1996), all the Grade 2 teachers at the research site were kept informed as my co-researchers and I discussed the implementation and findings of the programme with them at the weekly Grade 2 planning session which was scheduled on their daily timetables. Their contributions were taken into account when the next stage of the CLOCKWISE mathematical programme was planned.

Data was utilised for these discussions which provided a deeper analysis and further insights into the effect of the teaching strategies employed in the CLOCKWISE mathematical programme on learners’ understanding of the mathematical concept of time (Waller & Bitou, 2011).

Mouton (2001:151) describes the main sources of error when employing practitioner research. He asserts that the researcher may “possibly manipulate research participants and the research process to serve their own interest”. I therefore acknowledged this as a limitation, but I trust that the voluntary participation and involvement of Grade 2 learners and my co-researchers enhanced the trustworthiness of the study. I furthermore believe that the different learning styles and teaching methods which are incorporated into the CLOCKWISE programme as well as the learners’ explanations (verbally and in writing) of their visual representations (Carruthers & Worthington, 2006) will enhance the trustworthiness of the research data. Triangulation of different data collection instruments “enhanced the chances of high construct validity, ownership of findings” and the trustworthiness thereof (Mouton, 2001:151).

Dadds (2004:3) states that “the traditional research concept of generalisability becomes less appropriate in practitioner research”. Therefore the notion of transferability became more appropriate. In order to enhance transferability, my co-researchers and I sought to encourage mathematics teachers at our school to employ different teaching strategies to enhance their Grade 2 learners’ understanding of the mathematical concept of time (Dadds, 2004). Hence, the CLOCKWISE mathematical programme’s activities and manipulatives are described in detail. The study also describes the teacher and learner participants in detail to enable teachers at other schools to implement the programme as it is or to adapt it accordingly. A PowerPoint presentation of the CLOCKWISE mathematical programme as well as templates of the manipulatives and worksheets are available on compact disc (CD 1, CLOCKWISE) which could be useful for Grade 2 mathematics teachers.

The data collection methods and means of documentation which were utilised in the study are indicated in Table 3.4 along with the measures taken to enrich the trustworthiness of the data. To conclude the data collection stage, the collected data was organised and compared (Mouton, 2001).

**Table 3.4: Data collection and enrichment of trustworthiness**

| Data collection instrument       | Means of documentation of textual data  | Limitations   | Enrichment of trustworthiness   |
|----------------------------------|---|---|---|
| CLOCKWISE mathematical programme | <ul style="list-style-type: none"> <li>➤ Field notes of classroom discussions</li> <li>➤ Transcribed video recordings</li> <li>➤ Photographs</li> <li>➤ Learners’ work:               <ul style="list-style-type: none"> <li>- Drawings</li> <li>- Writing</li> <li>- Worksheets</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>➤ The programme was implemented in Afrikaans, which is the language of learning and teaching at the research site</li> <li>➤ Learners’ verbal representations, the co-researchers interview data, informal discussions and field notes were translated into English</li> </ul> | <ul style="list-style-type: none"> <li>➤ The participant learners and teachers are described in detail</li> <li>➤ The CLOCKWISE mathematical programme is available on CD</li> <li>➤ Templates of the manipulatives and worksheets employed in the CLOCKWISE mathematical programme are available on CD</li> <li>➤ Member checking was employed to validate learner and teacher participants’ data</li> </ul> |

|  |   |   |  |
|--|---|---|--|
| Participant observation  | <ul style="list-style-type: none"> <li>➤ Field notes of classroom discussions</li> <li>➤ Transcribed video recordings</li> <li>➤ Research diary</li> <li>➤ Photographs</li> </ul>   | <ul style="list-style-type: none"> <li>➤ Researcher's own view could hinder participants' expressions</li> <li>➤ The possibility that they would try to produce responses that they thought would impress the researcher</li> </ul>               | <ul style="list-style-type: none"> <li>➤ The rapport the researchers had with the learners in their own classes enabled them to observe the learners and their actions unobtrusively</li> <li>➤ A relationship of trust between learner and own teacher existed</li> </ul> |
| Semi-structured interviews with:<br>- each of the Grade 2 teachers at the research site<br>- my co-researchers<br>- learner participants | <ul style="list-style-type: none"> <li>➤ Field notes of interviews, since they perceived the video camera as intrusive</li> <li>➤ Transcribed video recordings</li> </ul>   | <ul style="list-style-type: none"> <li>➤ Power relationship because researcher is the HOD.</li> <li>➤ Practitioner-researcher role meant that I had to guard against guiding them</li> </ul>  | <ul style="list-style-type: none"> <li>➤ Made use of a variety of data collection methods</li> <li>➤ Participants volunteered to take part in the research</li> </ul>  |
| Focus group interview with the six Grade 2 teachers at the research site (my co-researchers included)                                    | <ul style="list-style-type: none"> <li>➤ Transcribed video recordings</li> </ul>  | <ul style="list-style-type: none"> <li>➤ Practitioner-researcher role meant that I had to guard against guiding them</li> <li>➤ Researcher bias could influence the conclusions drawn by the researcher</li> </ul>                                | <ul style="list-style-type: none"> <li>➤ Open-ended questions were asked</li> <li>➤ PowerPoint of visual data provided key for conversation</li> <li>➤ Co-researchers were asked to verify the analysis</li> </ul>   |
| Unstructured interviews with learners during classroom discussions   | <ul style="list-style-type: none"> <li>➤ Transcribed video recordings</li> <li>➤ Field notes of classroom discussions</li> </ul>  | <ul style="list-style-type: none"> <li>➤ Learners afraid to give incorrect answers or use the wrong terminology.</li> <li>➤ The possibility that they would try to produce responses that they thought would impress the researcher</li> </ul>    | <ul style="list-style-type: none"> <li>➤ Learners were allowed to use everyday language to describe their thoughts</li> <li>➤ Informal conversations during the day were conducted with individual learners</li> </ul>   |
| Document analysis  | <ul style="list-style-type: none"> <li>➤ Field notes of classroom discussions of textual data</li> <li>➤ Transcribed video recordings</li> <li>➤ Photographs</li> <li>➤ Learners' work:           <ul style="list-style-type: none"> <li>- Drawings</li> <li>- Writing</li> <li>- Worksheets</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>➤ Time constraints to finish drawings</li> <li>➤ Misunderstanding of meaning (Carruthers &amp; Worthington, 2006)</li> <li>➤ Incorrect language structure or spelling could blur interpretation</li> </ul> | <ul style="list-style-type: none"> <li>➤ Learners were allowed to finish during the day</li> <li>➤ Explaining their meaning reinforced their own ideas</li> <li>➤ Learners were asked to give a verbal account of their text too</li> </ul>                                |

### **3.7 Conclusion**

Chapter 3 provided insights into the methodological as well as ethical considerations of the research project. The chosen research methods were justified in line with the purpose of the research. The methodological as well as conceptual framework (Chapter 2, Section 2.5) of the research influenced the design, facilitation and evaluation of the CLOCKWISE mathematical programme. The CLOCKWISE mathematical programme is presented in Chapter 4.

## CHAPTER FOUR: THE CLOCKWISE MATHEMATICAL PROGRAMME



### 4.1 Introduction

As an integral part of the study, attention focused on the design, implementation and evaluation of a mathematical programme entitled CLOCKWISE. This chapter focuses firstly on the rationale for the development of the programme. Secondly, the design of the programme is discussed. The chapter further explores suppositions in which the programme is grounded. The essence of the CLOCKWISE mathematical programme is discussed in the next sections. The implementation challenges and recommendations of the research team, as practitioner researchers, are discussed in the last section.

### 4.2 Rationale for the development of the programme

In other countries, and in a South African context, foundation phase learners are expected to describe the time of day, compare activities, sequence and identify events and read and write analogue and digital time (Common Core State Standards Initiative, 2010; Department for Basic Education, 2013; Department of Basic Education, 2011; Ministry of Education, 2012). Literature affirms however, that the mathematical concept of time is challenging for both the teachers and learners in the foundation phase (Charlesworth & Lind, 2013; Cockburn, 1999; Dunphy, 2009).

The decision to design the CLOCKWISE mathematical programme was based on the ANA results (Department of Basic Education, 2012) described in Chapter one (see Section 1.2), my own teaching experience and foundation phase teachers' assertion (see CD 2, Teachers' understandings) that learners struggle to acquire the mathematical concept of time in a South African context. Therefore, the CLOCKWISE mathematical programme aims to address the teaching of, and learners' understanding of, the concept of time in a sequential way.

### 4.3 Design of the programme

The major objective of the CLOCKWISE mathematical programme is to teach the mathematical concept of time in “such a way that it would give learners a real sense of the practicality and applicability of mathematics’ (Kwon, 2004:151). Designed in collaboration with two Grade 2 teachers (who acted as my co-researchers) at the school where I teach, the CLOCKWISE programme pertains specifically to the facilitation of analogue and digital time in Grade 2.

The CLOCKWISE mathematical programme’s instructional design incorporates pedagogical principles (see Section 2.4.2) derived from existing literature. Literature suggests that although it still is a surprisingly challenging concept to teach and to understand, learning to tell time can be acquired in the early primary Grades (Lind, 2011). Hence, my own as well as the teaching experiences of my co-researchers were considered when the programme was designed. Teaching strategies such as direct instruction, games, classroom discussion, task-based activities as well as the medium of oral storytelling are utilised in the study. Sustained feedback by teachers are utilised to support learning and instruction.

The programme’s title is derived from the pedagogical principles embedded in the programme and in each lesson, which are discussed in detail in Section 2.4.2:

- C**onceptual analysis
- L**earners’ prior knowledge
- O**riginate discussion
- C**oncept development
- K**ey strategies
- W**orking cooperatively
- I**ndependent work
- S**ustained feedback
- E**nrich and encourage

## 4.4 Suppositions of the programme

Fundamentally, the programme is grounded in the following suppositions:

- that oral storytelling will get learners mentally engaged
- that learners' representations will promote reflective thinking, and
- that the sequence of instruction will facilitate growth of mathematical understanding.

Each of these suppositions are discussed in the following section.

### 4.4.1 Oral storytelling will get learners mentally engaged

The social constructivist theory emphasises learners' active involvement in the learning process whilst interacting with peers and the teacher (Cobb & Yackel, 1996; Ernest, 2011; Kim, 2009). The CLOCKWISE mathematical programme utilises oral storytelling as a pedagogical principle with the purpose of encouraging learners to actively participate in their own meaning-making (Schiro, 2004). It enables the teacher to “use constant eye contact and make adjustments to enhance understanding” (Goral & Gnadinger, 2006:6). Oral storytelling also allows the storytellers (teachers) and the learners to discuss the story and to learn from each other (Casey *et al.*, 2003).

Oral storytelling will most likely facilitate classroom discussion amongst learners and with the teacher which will enable the teacher to evaluate learners' understanding unobtrusively, to make timely adjustments to instruction and to improve learners' mathematical vocabulary (Backhouse *et al.*, 1992; Ball & Lakatos Primary Mathematics Group, 1990). *CLOCKWISE IN AFRICA* (see pp. 74-80) is the story in the CLOCKWISE mathematical programme and a core component of the programme. It is an adventure story in the form of sagas, allowing the concepts of time to be taught in a systematic, coherent way over a period of eight weeks (Casey *et al.*, 2003). The story is told in the learners' vernacular, which will enable the storyteller to use the learners' “familiar everyday language, whilst at the same time extending their mathematical vocabulary” (Orton & Wain, 1994:112).

Storytelling only commences in Week 2 of the implementation period, since the Grade 2 learners' perceptions and understanding of mathematical time is focused upon in Week 1.

## **CLOCKWISE IN AFRICA**

Author: Maretha Steyn

### **Week 2**

★ Lionel Lion is the king of all the animals living in die CLOCKWISE game reserve in Africa. As we all know, Africa is known for its wildlife, rivers and sunshine. Early one morning in the month of September, Lionel Lion summons his messenger to his castle in the reserve. Pete Parrot leaves his nest immediately and flies to the castle. Upon arrival he receives an urgent message from the king to deliver to all the animals in the CLOCKWISE game reserve. All of the animals have to gather at the king's castle at nine o'clock! Pete Parrot flies as fast as he can to inform all of them.

Then the clock in Lionel's castle strikes nine times (dong, dong, dong, dong, dong, dong, dong, dong, dong). He gets up from his throne and looks out of the window, but there is nobody in sight! Lionel Lion gives a sharp roar! It sounds like thunder striking an oak tree, like glass breaking into a thousand pieces, like a dragon with a tooth ache! Lionel is furious and sends Pete Parrot to summon all the animals to the castle – immediately!

Pete finds George Giraffe reaching for a leaf at the top of the old fig tree. Hidro Hippo and Ally Alligator are both lying in the water, bathing in the hot summer sun. Ronnie Rhinoceros and Eddie Elephant are lazily grazing along the banks of the river, whilst Lyla Leopard and Barry Baboon are lying on a tree branch.

Pete Parrot flaps his wings and twitters as loudly as he can: 'Do you know what time it is?'

The animals all lift their heads in amazement and stare at the bewildered Pete Parrot. George Giraffe clears his throat and says: 'Pete, what is your problem? It is still very early in the morning.' Pete almost loses one of his wings and shrieks:

'Where were you this morning? The king is furious and he wants you to come with me immediately!'

The animals realise that they are all in big trouble, but they still don't know why Lionel Lion is so furious! George Giraffe thinks that it is only eight o'clock. Hidro Hippo and Ally Alligator thought that Lionel wanted to see them at nine o'clock that evening. Oh my, Ronnie Rhinoceros and Eddie Elephant are confused. They cannot even remember what nine o'clock is supposed to look like on an analogue or digital clock. Lyla Leopard and Barry Baboon mumble between themselves that Pete Parrot could have told them that they had to be at the castle at nine a.m.

Arriving at the castle they come face to face with King Lionel Lion. They wait patiently for him to speak. Lionel stands up slowly and walks towards them with long, urgent strides. He gives a brutally loud roar. Above the sharp roar, the animals hear the sound of birds flying away and insects scurrying into their holes.

Lionel stamps his paw and shouts: 'TIME, yes time is a precious thing! Time is a thing you do not ignore! Time is a thing you spend wisely – every month, week, day, hour and minute! But you, yes all of you, believe that time does not go by. Therefore, I have decided that all of you are banished from the CLOCKWISE game reserve. You must stay in the bushes beyond the borders of the reserve, until you learn to spend and read time wisely.'

King Lionel Lion twirls around and walks away, leaving the stunned animals standing there all by themselves. Whilst walking towards the main gate of the CLOCKWISE game reserve, tears are falling from their eyes. The gate is closed and locked behind them.

George, Hidro, Ally, Ronnie, Eddie, Lyla and Barry sit under the nearest tree and all of them are crying. Then ... they hear a familiar voice ... It is Pete Parrot!

### **Week 3**

★ Pete Parrot holds a big bag between his two paws. He flies down and drops the bag in front of the animals. The animals are excited to see Pete Parrot because they all know that he is a very clever parrot.



Pete Parrot says: 'I know a few things about time and I am willing to help you figure out what time is all about.' George and Hidro grab the bag and take everything out – one by one. There are numbers, hands, weird but wonderful sunglasses, paper plates, circles and number lines. The animals are all amazed but rather confused since none of them can figure out what to do with the objects.

Pete Parrot takes a number line and puts it down for all to see. He then asks: 'Do you know what the word 'day' means?' Ronnie frowns and asks hesitantly: 'Isn't Monday a day?' Lyla interrupts him excitedly and exclaims: 'A day has 24 hours!'

Pete compliments them and asks Ally and Lyla to collect all the numbers they can find. Pete then asks the animals to sequence the numbers from 1 to 24 onto the number line.

Can you do it too?

★ 'Well', says Pete, 'Now you all know that the numbers 1-24 represent the 24 hours of a day. We use these numbers on a digital clock'. 'Oh no', exclaims Betty, 'I thought we were getting smarter but you are using words which we do not understand. What is a di...gi...ta... that strange thing you are talking about, Pete?'

Pete laughs and explains to Betty that a digital clock is a clock which uses numbers to show the time and that everything on a digital clock is written in pairs. Pete grabs a stick and writes something in the sand whilst explaining: 'There are two numbers in front, followed by dots and then there are two numbers at the end. (Write a digital time on the whiteboard). Pete then explains to them that the first two numbers on a digital clock represent the **hours** of the day.

All the animals, except Barry Baboon, are very excited and they all grab a number card (01-24/00) to play with. Eddie holds up a 08 and Ronnie screams excitedly: 'It is eight o'clock!' Hidro sees the 22 which George holds up and he calls out: 'It is 22 hours!' The animals play *What time is it?* until it gets too hot for them to stay in the sun.

★ Barry Baboon still looks confused and Pete wants to know why he looks so sad. Barry is annoyed and answers angrily: 'I have never had an appointment which started at 22 o'clock. It sounds silly!'

Therefore, Pete asks the animals to gather all the coloured number cards and two pictures of the. On the ground, Pete draws a chart with 4 sections. Then he asks Lyla to pass the card with a 01 on it.

Pete puts the card in the first section and reminds the animals that the 01 represents the first hour of a new day. Barry immediately asks: 'Why is the card white?' Therefore Pete explains to them that the white card represents the moonlight when a new day begins. 'Eish!' shouts George, 'I thought the term 'day' is represented by sunshine'. 'You are not mistaken, George,' says Pete. 'When the sun shines we say it is day, but a new day starts when it is still dark outside.'

Pete puts all the white numbers in the top, left hand corner of the chart. It is represented by the numbers 01-05. Next, he takes the 06, which looks like a sun. 'Do you see the sun?' asks Pete. 'The sun represents the time of day when the sun rises.'

Then he takes the yellow cards and puts them all in the top, right-hand corner of the chart. 'Listen carefully,' he says. 'All these hours of the day represent morning, but if you really want to impress Leo you must remember that it is also known as a.m.-time which means the hours between midnight and midday. The animals are satisfied and they all go to sleep.

★ The next morning, Pete flies down from his nest and wakes all the animals to see the sun rising in the east. He flaps his wings and encourages all the animals to sing and dance along:

*One o'clock, two o'clock, three o'clock clap*  
*Four o'clock, five o'clock, six o'clock flap*  
*Seven o'clock, eight o'clock, nine o'clock stamp*  
*We gonna hop at ten, eleven and twelve*  
*Oh, this is one... bright new day*  
*Tomorrow will start in the same old way*  
*Let's clap and flap and stamp our feet*  
*And turn around, don't miss a beat*  
*One, two, three, four, five,*  
*six, seven, eight, nine, ten,*  
*eleven, twelve all over again!*  
*This is a bright, new sunshine day again!*

All excited, the animals sit down to listen to Pete's lesson for the day. He points out that the moon did not bother them while they were fast asleep and that the animals in Africa are all thankful for a bright new day when they feel the soft sunrays on their bodies. Therefore, we do not need to put our sunglasses on until midday. "Which is...?" asks Pete. (Ask the learners if they know the answer). All the animals answer in unison that it is 12 o'clock!

'Yes', says Pete. 'Until midday everything stays just as it is in Africa. As a result the hours preceding midday stay the same as well. Do you think you will be able to tell me which time of day this number represents?' Pete holds up a 03 and Lyla shouts excitedly that it represents 3 o'clock in the morning. 'That is correct', says Pete. He goes on showing them a few other numbers. He informs them that the hours before midday can also be represented by the letters a.m. which means 'after midnight'.

★ Early the next morning Pete wakes Barry and asks him to find the weird but wonderful pair of number 12 sunglasses in the bag. At first Barry is reluctant to go, because he still wants to know what 15 or 20 on a digital clock means. Pete promises Barry that the sunglasses will help him to determine which time of day the 15 and 20 represent.

★ Barry feels just like a tourist wearing sunglasses whilst visiting the game reserve. The other animals also grab a pair of weird and wonderful number twelve sunglasses. Eish! They look funny!

'As you all know', Pete says, as he flies down from the tree branch, 'the sun gets hotter during the day. Therefore, moms all over the world and especially in Africa tell their kids to get out of the sun when the clock strikes 12. Beyond the borders of the CLOCKWISE game reserve the animals also put weird but wonderful sunglasses on to keep the dangerous sunrays and moonlight away from their eyes. They keep these number 12 sunglasses on until midnight – when they fall asleep and the moonlight does not bother them anymore'. Pete sends Hidro to collect all the remaining white and yellow numbers as well as the sun from the bag. He puts all the yellow ones in the bottom, right-hand quarter of the time chart. Only the white numbers are left. He then asks Barry to sequence them in the bottom, left-hand quarter of the time chart.

Now the animals can all see that numbers 13, 14, 15, 16 and 17 represent hours in the afternoon. The 19, 20, 21, 22, 23 and 24/00 clearly represent hours at night. Then the animals realise that number 18 has been omitted. Pete explains that the 18 is written on the sun, since it represents 6 o'clock in the afternoon when the sun sets. He informs them that afternoon and night times are also referred to as p.m. times.

★ Our number twelve sunglasses will help us to determine what time it is. Our sunglasses already tell us that it is past midday or past 12. All we need to do is to lie on our backs and to count the rays of the sun or moon which filter through the leaves. Do you want to try it?

All the animals lie on their backs. They all have their weird and wonderful number twelve sunglasses on. They all count the rays filtering through the leaves: 'One, two, three, four, five, six.' 'How many rays are bothering us?' Pete asks. Hidro jumps up and shouts: 'Six rays are bothering me!' Barry jumps on Hidro's back and exclaims: 'Therefore it is 6 o'clock in the afternoon, or 6 p.m.!'

'Wow, you are very clever,' says Pete, 'but can you represent 6 o'clock in the afternoon on a digital clock?' The animals discuss it amongst themselves and come to the conclusion that they cannot write 06 hours, because it represents six o'clock in the morning. Pete helps them. He reminds them that their sunglasses represent 12 hours; therefore they must just start at 12 and count on. The animals and Pete all count the rays together again: '13, 14, 15, 16, 17, 18! Eighteen!', they all exclaim. 'Six o'clock at night is 18 hours!' 'Or,' says Lyla, '... 6 o'clock at night!' 'Or,' interrupts Barry, '... 6 p.m.!'

'You are very clever,' says Pete. 'I would also like to tell you a secret. You all know that the p in p.m. suggests that it is a time past midday, but it also stands for 'perform'. It reminds us to 'perform an action' – to start counting! Isn't this a clever plan?'

★ Pete reminds the animals that everything that is written on a digital clock is written in pairs. He reminds them that there are also two numbers at the end. Pete points out that minutes are represented by the last two digits. Since the animals know that there are 60 minutes in an hour, they suggest that Pete writes 60 next to the two dots. But Eddie trumpets excitedly because he has something in mind. He points out that they should rather write two 00's to illustrate that a new hour has just begun. 'Yes,' says Lyla. 'I shall always remember this, since the two 'o's' in 'o'clock' look just like two 00's'.

## O'clock

'Wow!' whistles Pete. 'Lionel Lion will be impressed!' He then sends the animals to practise their newly acquired skills.

### Week 4

★ Whilst grazing on the banks of the river, Ronnie Rhinoceros and Hidro Hippo stumble upon a big iron ring lying in the grass. Hidro states that it looks like a part of a car's wheel but Ronnie suggests that they must take it to Pete to confirm Hidro's notion. While walking along they sing a song they heard some school kids who visited the CLOCKWISE game reserve sang:

*The wheels on the bus go round and round  
 round and round  
 round and round.  
 The wheels on the bus go round and round  
 all around town.*

Pete sees them coming and calls the other animals to come closer. He confirms that the ring is part of a car's wheel and asks them to put it down on the ground. He then realises that the ring could be used to teach the animals something about an analogue clock. He asks them to sequence the numbers 1-24 all around the ring to signify the 24 hours of a day. They try to do that but the numbers are so close together, they cannot identify one from another. Pete then leads them into song whilst removing the numbers 13-24.

*The hand on the clock goes round and round  
 Round and round  
 Round and round  
 The hand on the clock goes round and round  
 Twice in one day. (The learners can sing along)*

Only the numbers 1-12 are left around the ring. Pete informs them that every analogue clock has a hand which has to go round the clock twice in one day, once in the morning and once in the afternoon or night. Whilst singing the song again, they take turns to move around the circle twice.

★ Whilst the animals are still singing, Pete picks up a short stick to demonstrate that the short dial on an analogue clock shows us which hour of the day it is. He also emphasises that the hour dial must be EXACTLY on a number on the clock. Pete looks every animal in the eye to make sure that they all hear that this dial is called an hour dial. Then they take turns to display a certain hour of a day, using the short stick as an hour dial.

★ Pete explains to the animals that an analogue clock cannot illustrate the time zones of the day, such as morning, afternoon or night. Therefore, it is imperative that the reader of the clock should know if it is an a.m. or p.m. time depicted on the clock. 'Well,' says Ally, 'fortunately, we know that a.m. times are in the morning and p.m. times are in the afternoon and at night'. 'Yes,' says Betty, 'but we must not forget that it is dark outside when a.m. times begin very, very, very early in the morning'.

★ Barry Baboon climbs into the tree and jumps from branch to branch whilst the other animals sit around the analogue ring they found. Suddenly a long stick falls from the tree and hits Eddie Elephant on his head. He jumps up and reaches into the tree with his trunk to pull Barry closer. Barry scuttles away!

Pete gives a long and high-pitched whistle, which stops Eddie and Barry in their tracks. Pete seems to be more than excited because he flaps his wings in excitement and clutches the long stick in his two paws. He thanks Barry for kicking the long stick from the tree. Annoyed, Eddie walks away from his circle of friends, but Pete stops him. He ensures Eddie that if Barry did not accidentally kick the long stick from the tree; he would have forgotten that an analogue clock has two dials – a short dial representing the hours and a longer dial which represents the minutes passing during the day.

Pete tells the animals that the minute dial likes to MOVE! It only needs 60 minutes to run round the clock ones, whilst it takes the hour dial 12 hours to go around once!!!

Pete gives the longer stick to Eddie and asks him to put it exactly on the 12 to indicate that it is EXACTLY an hour. Not a second before or a second past. The short stick still represents the hours of the day and it is exactly on a specific number such as on the one when it is exactly one o'clock. The animals are all excited, because they can now identify hours on an analogue clock too.

### Week 5

★ Since Lionel Lion banished the animals from the CLOCKWISE game reserve Barry Baboon had little to eat given that he cannot eat grass, leaves or meat like the others. He has a headache, his stomach pains and he is coughing. Therefore, his friends decide to find something for him to eat.

Ally gets into the river, but she only finds a fish. Do you think Barry will be able to eat a fish? Hidro and Ronnie search along the banks of the river, but they cannot find anything for Ally to eat. Lyla and Eddie search between the grass and leaves but even they cannot find anything. Only George Giraffe finds one fig perched high up in a tree. They decide to give one half of the fig to Barry. They will keep the other half for him to eat that evening.

As Ally Alligator prepares to bite the fig in half, she remembers something she saw in Lionel Lions' castle. She tells Pete and the others that the analogue clock in the castle had an hour dial which was positioned between the four and five. 'Yes! Yes!' Pete yells. 'Now I remember. The hour dial is halfway between to numbers and it is called half past!'

Whilst Barry eats half of the fig, the other animals all grab their analogue clocks to practice with the hour dials.

★ 'Wow, the learners are clever!' says Ally. 'Can you please help us to represent half-hours on digital clocks too, Pete?'

'Oh yes,' says Pete. 'This is going to be a very easy task. You already know that a half-hour represents 30 minutes. Therefore, we write a 30 after the two dots to illustrate that 30 minutes has past. Always remember, minutes are represented by the last two digits on a digital clock. Thus, the :30 in 10:30 illustrates that it is half past the hour.

To know which hour we are talking about, we only look at the first two digits on a digital clock. 'Wait, wait! I would like to try,' says Ally. 'Isn't it half past ... mmm ... ten in the morning?' 'That's right,' says Pete. 'You are a clever alligator!'

### Week 6

★ One morning, Pete Parrot is nowhere to be seen. The animals look everywhere, but they cannot find him. Late that afternoon they all hear a familiar voice ... It is Pete Parrot! He is out of breath but very excited. He tells the animals that he visited Lionel Lion that morning.

Pete starts by telling them that Lionel Lion summoned him to the palace. He wanted Pete to fly to the border of the CLOCKWISE game reserve to see if the animals now know anything about time. Pete says he did not tell Lionel Lion that he has been helping the animals. Pete then informs them that Lionel Lion said they could come back to the CLOCKWISE game reserve if they can recognise analogue and digital times. Eddie Elephant instantaneously jumps up and exclaims: 'Let's go!' 'Yes!' says George. 'I think Lionel Lion is going to be impressed.'

Pete stops them before they get too excited. 'Wait a minute,' he says. 'You will have to be patient. You can only recognize hours and half-hours on clocks. What about minutes past and minutes to the hour?' 'Oh no,' sighs Lyla. 'Then we should make a conscious effort to learn those concepts as fast as possible.'

★ George Giraffe is very sad today. He misses his family dearly, because they live in the CLOCKWISE game reserve. Ally calls all the animals together. Then he asks George to tell them about his family, because he believes that George will feel much better if he talks about them.

### Week 7

★ All the animals are overly excited today, because Pete Parrot said they can start walking to the gate of the CLOCKWISE game reserve. They will have to wait there until King Lionel Lion summonses them to the palace, but they do not mind.

They are talking excitedly amongst themselves. They do not even realise that they are going in the wrong direction. A half-hour passes before they realise their mistake. None of them know where they are. Fortunately, George Giraffe has a looooooong neck.

George stretches his neck to see if he can see anything above the highest trees. 'You will not believe me,' he says excitedly, 'the main gate of the CLOCKWISE game reserve is just behind those trees.' 'Wow!' we must start walking immediately,' says Eddie. George stops them and says: 'Before any of us can walk one step, we should first make a plan. The main gate IS on the other side of those trees, but to get to the gate we must cross the river!'

Barry Baboon starts crying uncontrollably and stutters: 'I do not like water, and I ... do not think I ... can ... swim!' Poor Barry, he really is afraid and very sad. Hidro and Ally smile and wink whilst they both walk towards Barry to comfort him. 'Come on, Barry,' Ally says. 'Did you forget what a great swimmer I am?' Barry looks up hopefully, but then he realises that alligators swim under water and starts crying again. 'We know,' says Hidro, 'but I can stand up straight in the water. Listen Barry, Ally and I have a plan. You are going to get onto my back. I will walk through the water and if it gets too deep, Ally will float to the other side with you on her back.'

Barry stops crying and hugs both of them.

The animals walk towards the river, whilst standing on the bank of the river they see Pete Parrot on the other side. He shouts: 'I am glad to see you, but before you all cross the river I would like to know where you are all standing.' 'Pete! Can't you see that we are all standing in front of a BIG river which we would like to cross now?' Lyla shouts anxiously.

Pete laughs and says that he would like to remind them that they have not yet practised minutes to the hour. 'That's easy,' the animals proclaim. 'We are only going to put the hour dial in front of the number and then we are going to count in multiples of five on the left hand side of the clock to position the minute dial.' 'That is a clever plan. You must all practise it for a while. I will be back soon. Maybe King Lionel Lion will allow me to come and get you!' says Pete.

Off he goes!

★ Whilst waiting for Pete to return the animals all fall asleep. Suddenly Lyla jumps up and exclaims: 'I've got it, I've got it!' All the animals are wide awake and they all look bewildered. 'My heart almost stopped!,' Ronnie says angrily. 'What is wrong with you?'

Lyla climbs down from the tree branch she's been sitting on and asks the animals to sit down in front of her. Then she explains to them that she realised that there is an easy way to remember what 'minutes to' the hour looks like on a digital clock. She writes the word 'to' in the sand. Then she starts explaining: 'Do you see this letter?' she asks whilst pointing to the letter 't'. 'I think the little stripe resembles a subtraction symbol. Don't you think so too?' The animals all look carefully and then they all agree with her. 'Well,' Lyla says, all we have to do is to subtract one hour. Let's say we want to show King Lionel what ten minutes to 4 will look like on a digital clock. All of us already know that it is not 4 o'clock yet. Therefore, we cannot write 04. That is why we should subtract one hour and then we write 03.' 'Wow, you are a clever girl!' the animals all shout out loud.

'But what should we do about the minutes?' Ronnie asks. 'I think we should subtract it from 60, since it is not the next hour yet. So ten minutes to four should be ...' Scratching her head she tries to calculate the answer (Ask the learners to help). 'It is 50!' shouts Barry excitedly. 'That's right. So, ten minutes to four in the morning should be ... mmm ... 03:50 on a digital clock.'

'Now we can all go back to sleep.'

★ Early the next morning, Pete Parrot arrives with a letter clasped in his paw. The animals can't wait to read the letter, because they are sure that King Lionel wrote it.

Pete sits down and says: 'It is a beautiful day. Don't you think so too?' 'Yes, it is,' answers Ronnie irritably, 'but won't you please read that letter to us first. Then we can talk about the weather again.' Pete opens the letter immediately and reads:

'Dear animal friends,

If not for you, we would still not know anything about analogue and digital times. Therefore, I would like to help you today. Pete told us that although you know a lot about time, you still need to practise minutes to on digital clocks. We would like to help you. Just send Pete to fetch an instruction video. The learners and I recorded two of our lessons for you.

*We love you all!*

Miss \_\_\_\_\_'

'That is a nice gesture,' say Barry and Lyla simultaneously. Pete, won't you please fetch the video for us?' Pete flies away to fetch the video

### Week 8

★ Pete Parrot is very excited this morning. He just came back from King Lionel Lions' castle in the CLOCKWISE game reserve and he has good news for all the animals.

Pete finds George Giraffe reaching for a leaf at the top of the old fig tree. Hidro Hippo and Ally Alligator are both lying in the water, bathing in the hot summer sun. Ronnie Rhinoceros and Eddie Elephant are lazily grazing along the banks of the river, whilst Lyla Leopard and Barry Baboon are lying on a tree branch.

Pete Parrot flaps his wings and twitters as loudly as he can: 'I have good news this morning!' The animals all lift their heads in amazement and stare at the excited Pete Parrot. They immediately gather around Pete to hear what he has to say. Pete tells them that King Lionel Lion summoned him to his castle that morning and sent a message to all of them. He wants them to come to the castle in pairs that afternoon. He will then test their knowledge of analogue and digital time. Those who answer correctly will be allowed to enter the CLOCKWISE game reserve again. The animals look at each other with worried eyes, but Pete assures them that they will all pass the tests.

The animals quickly choose partners. Hidro Hippo chooses Ally Alligator, Eddie Elephant chooses Ronnie Rhinoceros and Barry Baboon chooses Lyla Leopard as a partner. Only George Giraffe does not have a partner. Big tears fall from his eyes because he realises that he won't be able to go to King Lionel, which means that he won't be able to go back to his family in the CLOCKWISE game reserve. 'Will I have to stay in the bushes outside the game reserve forever?' George asks bewildered. Pete immediately goes to George and dries his eyes with a leaf. 'George,' he says 'I will never leave you here, I will be your partner.' All the animals clap their hands. They all make sure that they are clean and then they walk through the gate of the CLOCKWISE game reserve – straight to King Lionel's castle.

★ Kids, I am very excited today. Pete Parrot sent this letter to me and he asked me to read it to you.

*Learners,*

*I am writing this letter to thank you all. If you did not help us we would never be able to learn anything about analogue and digital time.*

*I have great news ... all the animals answered King Lionel's questions correctly! All of them slept in the CLOCKWISE game reserve last night. I wish you were*

*here to see King Lionel Lion's face when the animals did not even have to think about an answer!*

*George, Ally, Ronnie, Eddie, Lyla, Barry and Hidro send their love and a hug for each of you. You are great!*

*Love*

*Pete*



Although the story is presented in writing in the programme, it was fundamental that my co-researchers and I familiarised ourselves with the story, since our role was that of storyteller.

#### 4.4.2 Learners' representations will promote reflective thinking

Van de Walle and Lovin (2006) as well as Ball *et al.* (1990) assert that learners will most likely understand the underlying principles of a mathematical concept better, if they are encouraged to initially reflect upon their own ideas and understandings related to the concept. Both the Pirie-Kieren model and the social constructivist theory "refer to the knowledge that a learner brings to the classroom" as a starting place for learning (Lawan, 2011:70; Tolman & Hardy, 1995).

Literature also suggests that the more ways learners are given to think about a mathematical concept, the better chance they will have to understand the underlying properties of the concept (Van de Walle *et al.*, 2010). According to Charlesworth (2005), there are many different ways in which learners can reveal their grasp of mathematical ideas. They can speak, write, draw, do actions, make use of conventional symbols or even make up their own. The CLOCKWISE mathematical programme employs activities which will encourage learners to represent and communicate their ideas and own understanding of the mathematical concept of time in various ways (Becker & Selter, 1996).

The CLOCKWISE mathematical programme focuses on learners' verbal and visual representations. Learners are also required to explain their thinking to reinforce their own understanding of the mathematical concept of time (Carruthers & Worthington, 2006). Olsson (2009:20) states that each learner and each teacher "has their own unique way of thinking, speaking, acting and feeling". Verbal and visual representations of the learners' individual understandings and ideas on the mathematical concept of time, will encourage active participation of both teachers and learners in the meaning-making process (Olsson, 2009).

#### **4.4.3 The sequence of instruction will facilitate growth of mathematical understanding**

Although the literature suggests a sequence of instruction (Grinstein & Lipsey, 2001; Holmes, 1985; Louw & Louw, 2007:217; Van de Walle, 2004), clock reading still appears to be a difficult skill to teach and attain in the early years (Cockburn, 1999). Since both digital and analogue clocks are used in the learners' daily lives, the CLOCKWISE mathematical programme employs a unique sequence of instruction (Grinstein & Lipsey, 2001). The programme introduces digital and analogue clocks simultaneously.

Acknowledging that there are twenty-four hours in a day which are divided into periods called morning, afternoon and night is prerequisite for the conceptualisation of mathematical time (Thyer & Maggs, 1971). The CLOCKWISE mathematical programme

initially focuses on the identification of time periods which culminates in the identification of hours on a digital clock. Subsequently, learners will most likely be able to identify the hours on an analogue clock since they are clearly marked (Cockburn, 1999). This aspect is followed by the distance the minute dial has gone or has yet to go. The next step is to describe the position of the hour dial when it is halfway between two hours. Since the minute dial registers half a turn, the clock face will also be cut in half to demonstrate that a half-hour represents 30 minutes (Cockburn, 1999). Learners will most likely then be able to visualise the position of the minute dial when half past times have to be represented on an analogue clock.

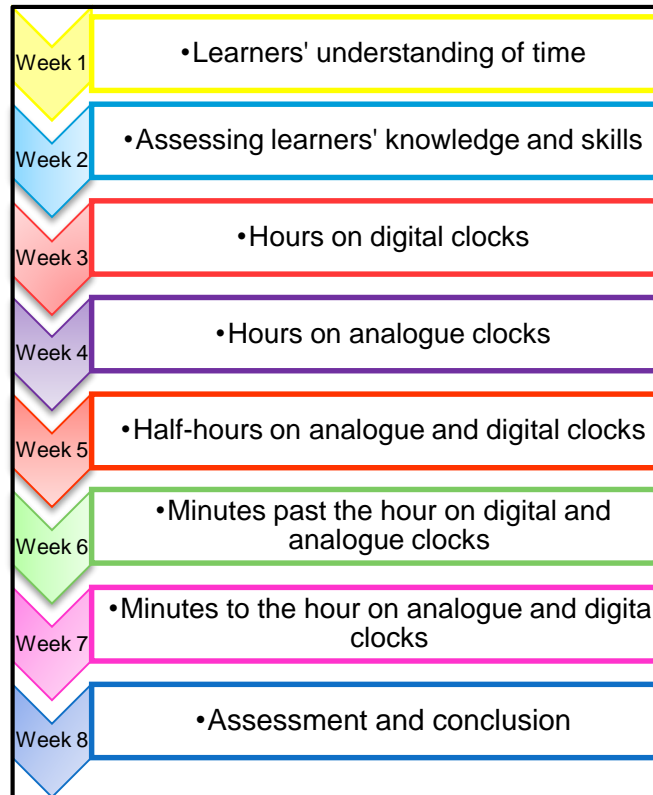
Since learners will probably be able to identify hours on digital clocks and 30 minutes as a half-hour, they will most likely not have any problems with half-hours on digital clocks. It is important to note however, that language affects the teaching of half-hours on digital clocks. In English 03:30 will be identified as half *past* three, but in Afrikaans it is identified as [half 4] which translated will mean that 'the minute dial is halfway on its way to four o'clock'. Therefore, the CLOCKWISE mathematical programme utilises manipulatives such as number lines to visually represent the passing of time. Subsequently minutes past the hour follow, since the digital clock clearly displays the minutes which have gone by. This is followed by 'minutes past' on analogue clocks. Although Van de Walle *et al.* (2010) suggest that 'minute to' the hour can be focused upon later, it is part of the CLOCKWISE mathematical programme as well as national curricula in other countries (as described in Chapter 2, Table 2.1). Learners might recognise that if it is a few minutes to three, it means that it is not yet 3 o'clock or it is a few minutes before 3 o'clock. Minutes to the hour on digital clocks are also discussed, but it is not expected that learners should acquire the concept.

Since the programme is grounded in the Pirie-Kieren model for growth of mathematical understanding, 'folding back' is integral to the implementation process (Meel, 2003). It implies that "ideas in one lesson may often reappear in subsequent lessons" to facilitate growth of mathematical understanding (Gabbard, 2008:2).



## 4.5 The essence of the CLOCKWISE mathematical programme

The programme assists the teacher to scaffold the concept of time over a period of eight weeks (see Figure 4.1).



**Figure 4.1: Implementation of the CLOCKWISE mathematical programme**

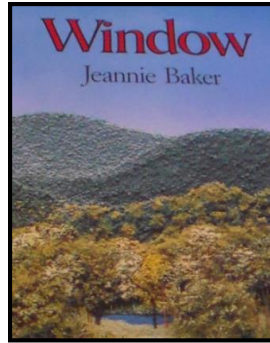
In South Africa, the national curriculum (Department of Basic Education, 2011) guides mathematics teachers regarding the amount of time they should spend on the different content areas. An average of four hours a week must be spent on numbers, operations and relationships, whilst three hours should be spent on the remaining content areas. The CLOCKWISE mathematical programme was introduced without compromising the teaching of other concepts. During its implementation, twenty minutes per day were allocated for the programme whilst sixty-four minutes were spent on other content areas prescribed by the national curriculum. Activities such as the *CLOCKWISE game*, storytelling of *CLOCKWISE IN AFRICA* and the drawings learners were required to do throughout the study, could also be integrated with home language and the creative arts

component of life skills lessons (Department of Basic Education, 2011). In the following section the essence of each of the eight weeks is discussed. A comprehensive description of the programme is offered as a PowerPoint representation on a compact disc.

#### **4.5.1 Week 1: Learners' understanding of time**

According to Kastberg (2002), learners' understandings and ideas might influence their learning of mathematical concepts. In accordance, I anticipated that the Grade 2 learners' own understandings will most likely influence and encourage their growth of mathematical understanding of the concept of time (Mason & Johnston-Wilder, 2004). Consequently, the CLOCKWISE mathematical programme focuses on learners' understandings of time during the first week of implementation. Classroom discourse is also exploited to draw attention to possible relationships between mathematical concepts (Hiebert & Carpenter, 1992). Thereafter, the assessment of learners' knowledge and skills can commence.

Literature suggests that books can be used to enhance learners' understanding of mathematical concepts (Peters & Young-Loveridge, 1994; Young-Loveridge, 2004). The CLOCKWISE mathematical programme utilises Jeannie Baker's book *Window* (Baker, 2002) which focuses on urbanisation. The author presents urbanisation over a period of 24 years by means of collages. Although the book focuses on urbanisation, it is exploited in the CLOCKWISE mathematical programme to explore the concept of time and the influence thereof on one's life. To initiate discussion, visualisation is employed, which Olsson (2009:12) believes "serves as a meeting place for all participants and plays a crucial role in learning processes". The teacher and learners browse through the pages of the book (shown in Representation 4.1).



**Representation 4.1: The book *Window***

Concepts of time, which they feel are exemplified in the book are discussed. These informal discussions are important since they might reveal the learners' mathematical ideas to the teacher (Wilson & Stein, 2013). The following day, learners are asked to draw a series of pictures which illustrate one of the concepts of time they identified in the book (see Representation 4.2). Subsequently they have to explain the development in their representations in writing. The utilisation of oral, pictorial and written language provide the means for the researcher or teacher to investigate the influence of learners' learning processes on their conceptualisation of mathematical time (Slaten, 2006).



**Representation 4.2: Learners' representation of a time concept which they identified in the book *Window***

In a South African context (Department of Basic Education, 2010) learners in Grade 1 should be able to “compare events in terms of the length they take, describe the time of

day using vocabulary such as ‘early’ and ‘night’, sequence events using language such as ‘yesterday’, ‘today’ and ‘tomorrow’ and to identify birthdays on calendars”. Since these concepts had previously been introduced to the learners, they are only reviewed on day four.

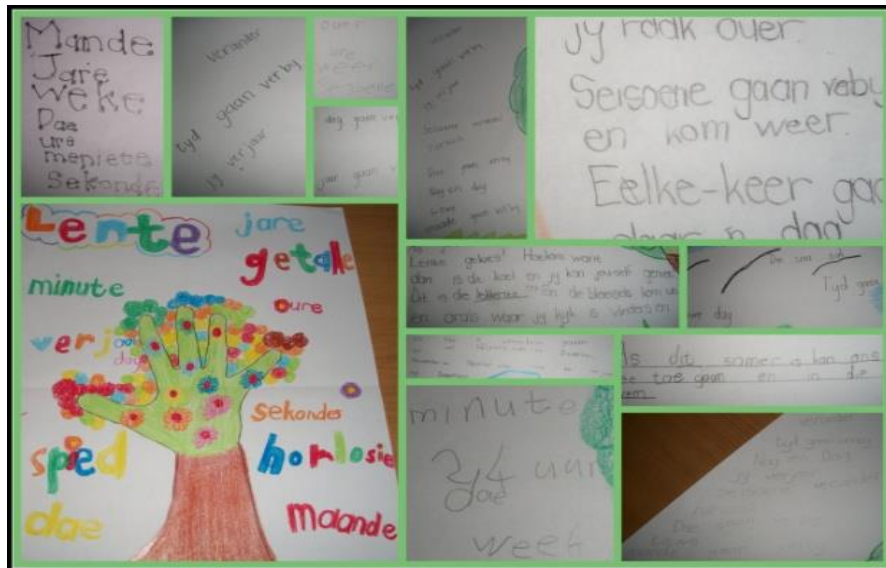
Learners are divided into groups and each group is presented with four photographs which will most likely draw their attention to concepts of time such as seasons, months, years, day, night and specific events. The group members have to discuss concepts of time they believe are represented by the photographs (see Representation 4.3). The teacher listens to the vocabulary the learners use to verbalise their understandings since informal classroom discussion in the learners’ vernacular will encourage the learning and understanding of mathematics. Questions can direct the learners’ thoughts.



**Representation 4.3: Photographs which represent concepts of time**

Carruthers and Worthington (2006:194) assert that learners are able to “devise their own ways of recording their knowledge and understanding”. Therefore, the first weeks’ programme concludes with a task-based activity. Learners are required to represent their understandings on the concept of mathematical time in writing and through drawings (see Representation 4.4). The teacher is also required to listen to what learners say about their representations to ensure that what they are intending to

communicate has been accurately understood (Carruthers & Worthington, 2006). Discussing their visual representations also helps the learners bring clarity to their own understanding of basic concepts of time (Ball *et al.*, 1990; Carruthers & Worthington, 2006; Wilson & Stein, 2013).



**Representation 4.4: Learners' representations of concepts which they associate with mathematical time**

#### 4.5.2 Week 2: Assessing learners' knowledge and skills

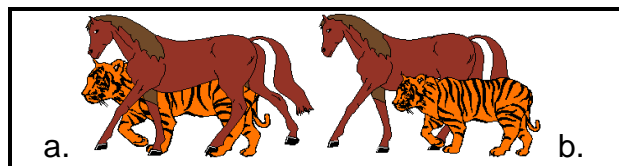
Ausubel (1968) argued that young learners' pre-existing knowledge will influence their learning. In accordance, Van de Walle (2004) affirms that from the basis of known ideas, connections are made with other ideas, leading ultimately to the construction of new ideas. Therefore, it is imperative to build upon the Grade 2 learners' pre-existing knowledge which can influence their acquisition of the mathematical concept of time.

Piaget considered the attainment of conservation, reversibility, transitivity, classification and seriation as prerequisites for the conceptualisation of analogue and digital time (Holmes, 1985). Since Grade 2 learners are most likely in the concrete operational stage of their cognitive development, they would most likely have attained the aforementioned skills (Cockburn, 1999). It will enable them to identify and compare events when the teaching of the concept of time commences. Carruthers and

Worthington (2006:390) assert that “as learners make these types of comparisons, not only are they gaining an understanding of the particular attribute and the associated vocabulary, they are also learning procedures that will help them in assigning a number to measurement”. The CLOCKWISE mathematical programme therefore employs task-based activities to assess the Grade 2 learners’ current knowledge and skills. In addition it provides information which can be analysed to determine their growth of mathematical understanding. The task-based activities are explained in the next sections.

#### 4.5.2.1 Conservation

Vrey (1979) states that conservation is the understanding that matter can change in appearance without changing in quantity (three a.m. on an analogue clock is equivalent to 03:00 on a digital clock). Therefore, the Grade 2 learners will most likely be able to comprehend that the type of clock does not influence the time measured. As suggested by Cathcart *et al.* (2003), the following conservation activities are therefore employed to test the Grade 2 learners’ conceptualisation of the conservation of time (see Representation 4.5).

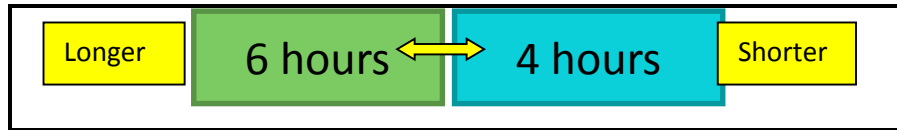


**Representation 4.5: Conservation task**

Two stuffed or plastic animals are used to determine if the learners attained the conservation of time (see Representation 4.5). The two animals are lined up next to each other. The learner then instructs the teacher when to move the animals forwards and when to stop. First of all the two animals are moved forwards but remain side-by-side. Then one animal is moved forwards with longer strides than the other until the learner says ‘Stop’. Therefore, the one animal will be further ahead. The teacher then asks the learners if the animals started and stopped at the same time in both cases. An affirmative answer on both of the questions asked would indicate that the learner most probably has attained the conservation of time.

#### 4.5.2.2 Reversibility

Copeland (1984) asserts that a learner who has mastered reversibility would realise that if 6 hours is longer than 4 hours, 4 hours would be shorter than 6 hours (see Representation 4.6).

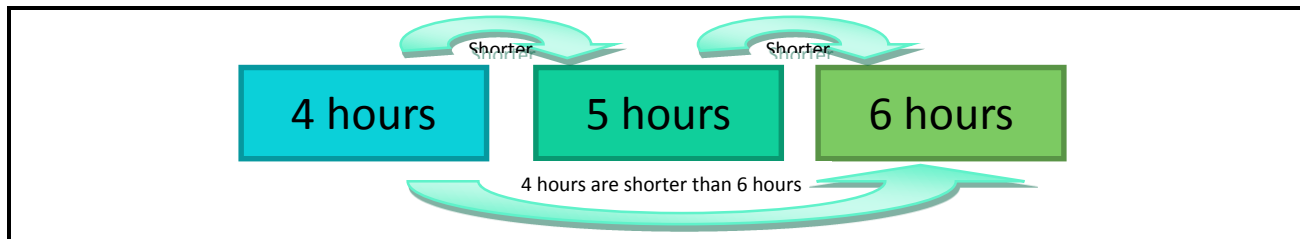


**Representation 4.6: Reversibility task**

The same animals as in paragraph 4.4.2.1 can be used to assess learners' attainment of reversibility too. Learners are asked to answer questions such as: This tiger is a cat, is this cat a tiger?

#### 4.5.2.3 Transitivity

From Sarama and DiBaise (2004) as well as Kamii and Clark (1997) we learn that with transitivity, one is able to consider two or more relationships that are equal or unequal, and then draw a conclusion regarding a further relationship.

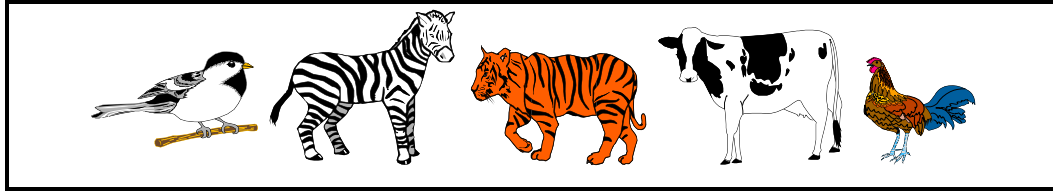


**Representation 4.7: Transitivity task**

It suggests that the learner will be able to comprehend that if 5 hours is shorter than 6 hours and 4 hours is shorter than 5 hours, then 4 hours is shorter than 6 hours (see Representation 4.7).

#### 4.5.2.4 Classification

The ability to understand hierarchies of classes (time = morning, a.m., 03:00) rests on the “ability to move both ways when thinking about relationships” (Louw & Louw, 2007:217). Ojose (2008) points out that in classification, common characteristics are identified in order to sort objects into groups.

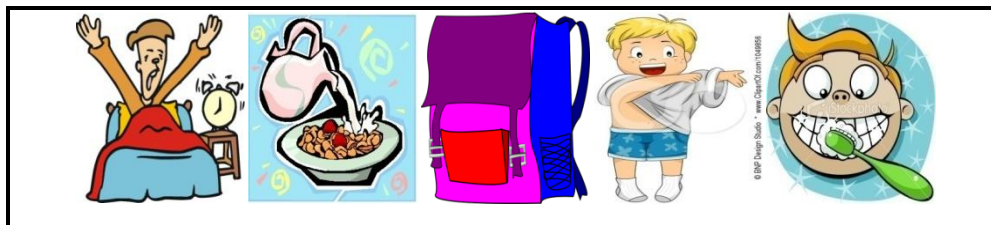


**Representation 4.8: Classification task**

Each learner receives five animals or pictures which he or she has to sort individually (see Representation 4.8). The learners must be allowed to use attributes of their choice. The animals or pictures must be sorted into two groups. The learners also have to explain the reason for the classification.

#### **4.5.2.5 Seriation**

The young child in the concrete operational stage will most likely also be able to order (seriate) events in the order in which they happened (Copeland, 1984), thus developing a mental image of time concepts (see Representation 4.9).



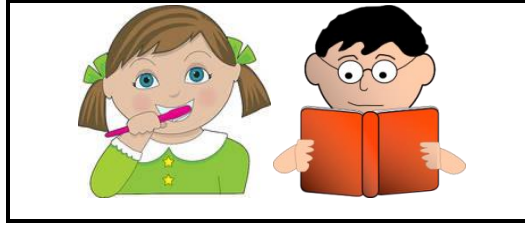
**Representation 4.9: Seriation task**

An arrangement which can be explained justifiably will indicate attainment of seriation. The Department of Basic Education (2011) states that learners should be able to compare events in terms of the length of time they take (longer, shorter, faster, slower). Thus, events are also compared perceptually, directly and indirectly in the intervention programme, which will most likely constitute the development of a mental image of time.

#### **4.5.2.6 Comparing events perceptually**

The duration of two events, such as brushing your teeth and reading a story, could be compared and described as being the same length or different (Carruthers & Worthington, 2006). Therefore, pictures of events are chosen with learners' experience and background in mind (see Representation 4.10).



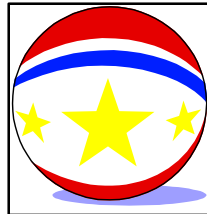


**Representation 4.10: Comparing events perceptually**

Learners are instructed to indicate which event will take the longest or shortest time to complete. Learners are also required to justify their answers verbally, because the teacher has to make sense of their thinking (Carruthers & Worthington, 2006).

#### **4.5.2.7 Comparing events directly**

As suggested by Carruthers and Worthington (2006) learners are also required to compare events directly with vocabulary such as longer and shorter (see Representation 4.11).



**Representation 4.11: Comparing events directly**

Learners are required to bounce a ball 10 times. They all start at the same time and sit down when they have finished. The group members then discuss and decide which member took the longest and shortest time to complete the activity, whilst the teacher listens to their discussions.

#### **4.5.2.8 Comparing events indirectly**

Events are also “compared indirectly through a reference or third event” (Carruthers & Worthington, 2006:390). Learners are required to discuss statements such as: if combing your hair takes about 2 minutes, what about brushing your teeth or washing the dishes. Carruthers and Worthington (2006) assert that sometimes what is said can be misunderstood, therefore, learners must also justify their answers.

#### **4.5.2.9 Pre-testing of all the learners in Grade 2**

In order to determine whether or not Grade 2 learners' conceptual understanding of time improves as a result of their participation in the CLOCKWISE mathematical programme, it is imperative to determine what all Grade 2 learners' level of understanding of mathematical time is before the programme commences.

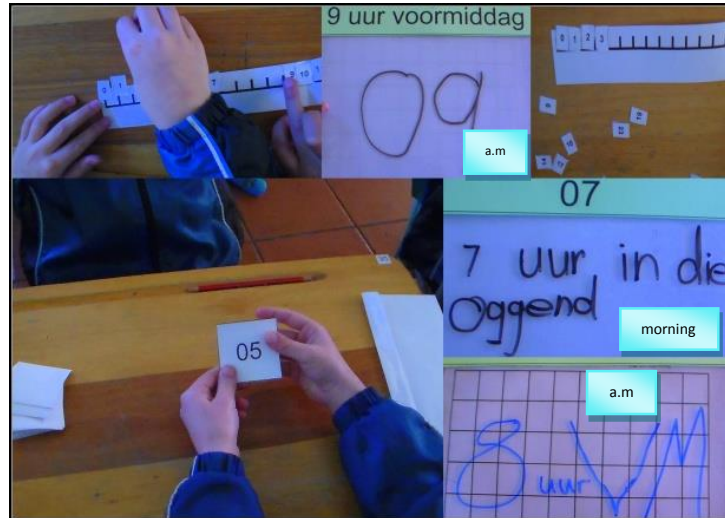
Each learner therefore receives an analogue clock. They are instructed to represent certain times given on their clocks (see CD 1, CLOCKWISE). Their attainment of the mathematical concepts of time can therefore be assessed by the teacher. Thereafter, the oral storytelling of *CLOCKWISE IN AFRICA*, a story specifically developed for the programme, commences. Oral storytelling might encourage the "creation of mental images that belong to" the learners (Goral & Gnadinger, 2006:5).

#### **4.5.3 Week 3: Hours on digital clocks**

Cockburn (1999) contends that anyone who can read numbers as numerals would find it easier to read time on a digital clock. Thyer and Maggs (1971) point out the confusion that can arise from the use of language because the word 'day' is not limited to indicating the 24-hour day, but it is also used when describing the period of daylight. Nevertheless, learning that there are twenty-four hours in a day which are divided into periods called morning, afternoon and night probably comes best when we focus on digital clocks. Hence, the CLOCKWISE mathematical programme initially focuses on the identification of periods of the day and specifically hours on a digital clock.

Van De Walle and Lovin (2006:7) suggest that "manipulatives can help learners to learn important mathematical ideas". As suggested, learners are requested to sequence the numbers 0-24 on a number line. Thereafter they use flashcards to play *Identify the time* (see Representation 4.12). The story then introduces the learners to a.m.-times on a time chart, which implies that everything stays the same, as a.m. in the story indicates it is 'already answered'. Learners are required to represent the a.m.-times on their own time chart. Instruction of the 'morning' time period concludes with a task-based activity

which requires learners to identify the a.m.-times on word cards (see Representation 4.12).



**Representation 4.12: Digital a.m.-activities**

Then the instruction of p.m.-times on a digital clock commences. The specified hours are divided into ‘afternoon’ and ‘night’ time periods on their time charts. Afterwards learners make their own ‘nr.12 sunglasses’. They use their sunglasses to count the rays which hurt their eyes (see Representation 4.13). Whilst playing with their sunglasses, learners translate hours after midday to the 24-hour clock in a fun way (Lever, 2003). Subsequently, they play *What time is it?* and *Time Bingo* which are used by the teacher to unobtrusively determine the learners’ understanding of hours on digital clocks (see Representation 4.14). These cooperative learning activities will engage learners to talk about what they are doing “using their new vocabulary” (Greenes *et al*, 2004:163).



**Representation 4.13: Digital p.m.-activities**

*Time Bingo*

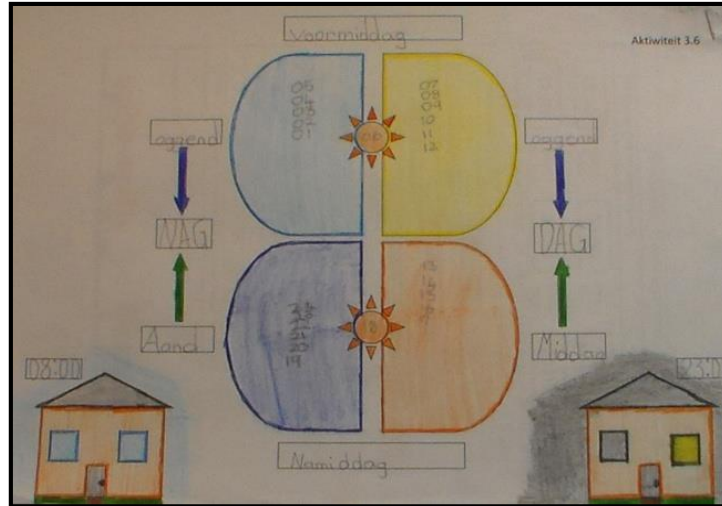
|       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|
|       | 07:00 | 19:00 | 05:00 |       | 16:00 |
| 14:00 | 21:00 |       | 17:00 | 15:00 | 02:00 |

*What time is it?*

**Representation 4.14: Digital hour games**

This weeks' programme concludes with a task-based activity and a worksheet which will most likely portray the learners' growth of mathematical understanding. Learners are required to choose an a.m.-time and a p.m.-time and to represent those times with a chosen colour in the windows of the two houses on their time charts. They should also explain their choice of colour (yellow=lights on, black=dark, blue=daylight). Learners should also determine the time of day as well as the time period on their worksheets (see Representation 4.15).

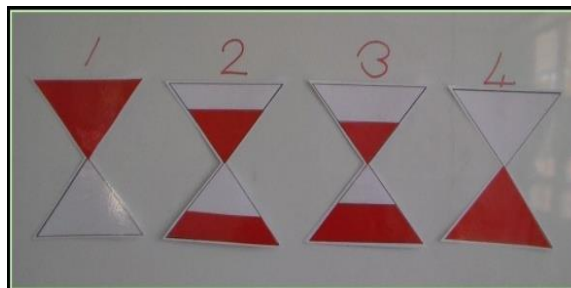
Thus, the CLOCKWISE mathematical programme gradually moves from guided practice and cooperative work to working independently. According to the Cockcroft Report (1982:139), this will most likely “allow learners to develop confidence in their own ability to do mathematics”.



**Representation 4.15: Time chart**

#### 4.5.4 Week 4: Hours on analogue clocks

Copeland (1984:185) states that the essence of an operational understanding of analogue time is “the coordination of at least two motions which he calls a co-seriation”. Reading an analogue clock requires that one should be able to focus simultaneously on both hands, and the difficulty of this must not be underestimated (Cockburn, 1999). Consequently a co-seriation task will be employed to focus learners’ attention on only one attribute at a time (see Representation 4.16).



**Representation 4.16: A co-seriation task**

Van de Walle *et al.* (2010) as well as Cockburn (1999) recommend that young learners should initially be introduced to one-handed analogue clocks. In that way the initial focus will be on the hours which are all clearly marked with appropriate numbers round the clock. The learners use paper plates and only an hour dial to create their own ‘one-handed clocks’ (see representations 4.17).



**Representation 4.17: Creating a ‘one-handed clock’**

Two learners each then throw a pair of dice; they calculate the total and then represent the hour on their own one-handed clocks (see representation 4.18).



**Representation 4.18: Hours on analogue clocks**

Thereafter, the focus of attention is on the position of the minute dial which is exactly on the twelve. Learners' attention is drawn to the fact that time periods cannot be illustrated on an analogue clock. Learners can experience time kinesthetically when they go outside to play the *CLOCKWISE game* (Grinstein & Lipsey, 2001). Twelve learners are expected to form an analogue clock, whilst three others represent a specific time and time period with a long skipping rope, short skipping rope and the appropriate word card (see Representation 4.19).



**Representation 4.19: *CLOCKWISE game***

The week concludes with two worksheets in order to assess the learners' understanding. "This will assist teachers in making timely instructional adjustments and it will enable teachers to give supportive feedback to learners" (Wolfe, 2005:178). Learners have to illustrate times and the time period on the first worksheet, and on the other, learners have to translate analogue times into digital times and vice versa.

#### **4.5.5 Week 5: Half-hours on analogue and digital clocks**

Cockburn (1999:85) suggests that "the next step would be to point the hour dial somewhere between two numbers on the clock face". It is also important to encourage learners to describe if the hour dial is just past, near to or halfway between two numbers. Thyer and Maggs (1971) and Cockburn (1999) contend that it might be important to fold

the analogue clock in half, since it will focus learners' attention on the position of the minute dial on the six.

The teaching of half-hours on analogue clocks is preceded by the oral storytelling of *CLOCKWISE IN AFRICA*. The animals in the story remember that the hour dial is exactly between two numbers when it is half past the hour. Therefore, the learners get the opportunity to use their one-handed clocks to represent half-hours and to describe the position of the hour dial in their own words. Since learners also have to know why the minute dial is on the 6 when it is half past the hour, they are presented with a printed analogue clock. Learners work in pairs and they are instructed to cut the clock in half (vertically). Thereafter they count the minutes on both halves of the clock. They will most likely come to the conclusion themselves that each half represents 30 minutes, which implies that an hour equals 60 minutes. Their attention will then be focused on the positioning of the minute dial on the 6, since it represents 30 minutes and a half-hour.

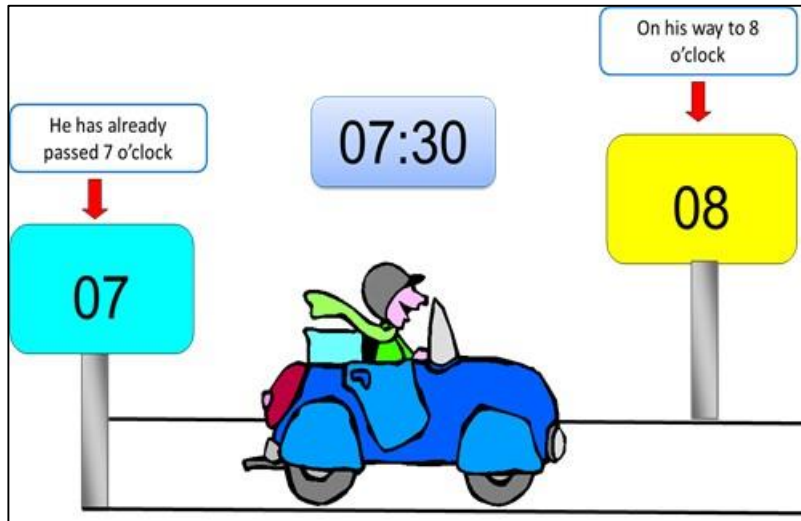


**Representation 4.20: Half-hours on analogue clocks**

Learners then use their own clocks to illustrate half-hours. The clock faces will provide “direct experience from which a mental model can be built” (Bell, 1980; Skemp, 1989:73). Each group also receives different hour and half-hour time-cards which they have to arrange in the correct order.

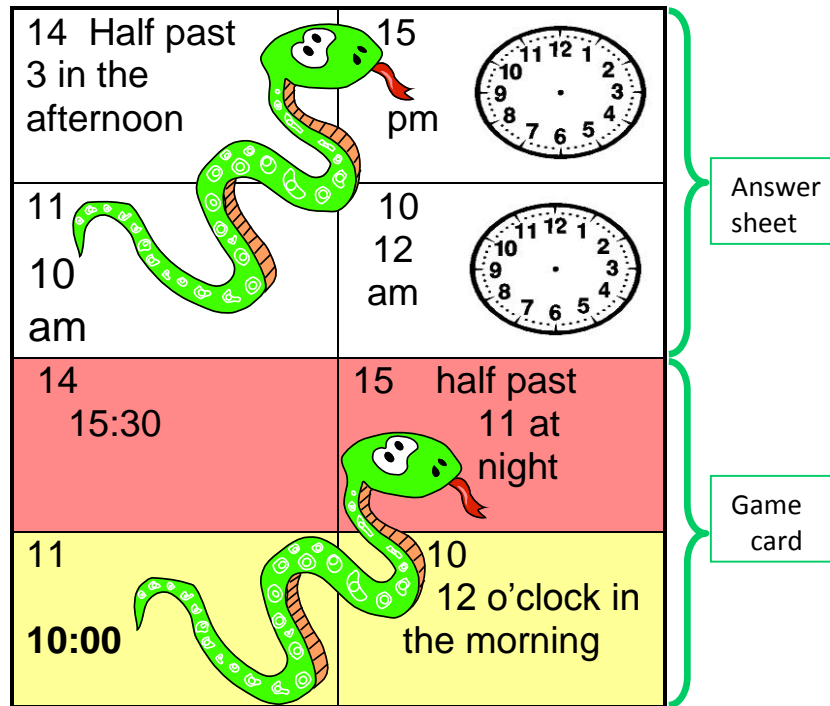


Subsequently, the teaching of half past on digital clocks commences. The story reminds the learners that a half-hour represents 30 minutes, therefore they already know that they have to write ':30'. The representations of a.m. and p.m.-times on digital clocks are then emphasised on subsequent days. Each learner receives a printed sheet which illustrates that a car is halfway between two hours. Learners are also reminded that a.m. implies that no action is needed, whilst p.m. suggests that you must 'perform an action'.



**Representation 4.21: Half-hours on digital clocks**

Learners then play the *Time Snakes and Ladders* game, which will assess their growth of understanding. Hours as well as half-hours are represented in the game (Grinstein & Lipsey, 2001).



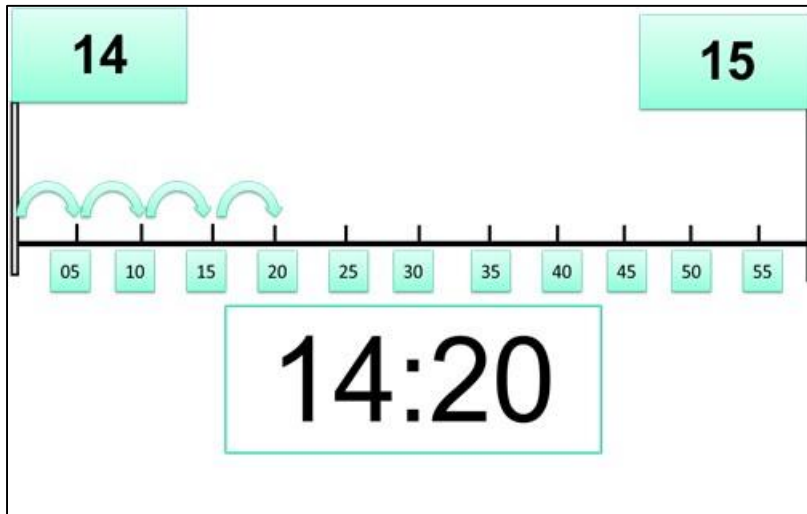
**Representation 4.22: A segment of *Time Snakes and Ladders***

The week's instruction comes to a close with the calculation of elapsed times as the focus of attention.

#### 4.5.6 Week 6: Minutes past the hour on digital and analogue clocks

Cockburn (1999) states that some learners are unable to recognise that the numbers of analogue clocks have different meanings depending on which hand points to them (five past or one o'clock). Some also find it difficult to remember which side of the clock is *to* (ten to five) and which is *past* (five past ten), therefore they will most likely find it difficult to conceptualise analogue time. Hence, the CLOCKWISE mathematical programme provides opportunities for learners to experiment with manipulatives and clocks to represent concepts of time. The CLOCKWISE mathematical programme's focus this week is first on 'minutes past' on digital clocks, since it clearly displays the minutes which have passed. Thereafter 'minutes past' on analogue clocks will be focused upon.

Number lines are utilised to indicate the minutes as well as hours which have passed. Learners need to jump along the number line whilst counting in multiples of five. Hence, elapsed times can also be calculated. They are also required to identify and describe the time which is represented on the number line (see Representation 4.23).



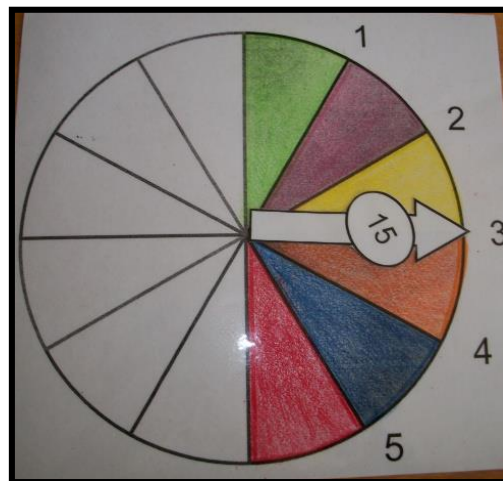
**Representation 4.23: Digital minutes past the hour**

Most foundation phase teachers assert that most learners find it difficult to distinguish between the two sides of the analogue clock. In the CLOCKWISE mathematical programme, learners are given the opportunity to experience it holistically (Grinstein & Lipsey, 2001). Learners use markers to represent an analogue clock outside. Whilst two learners sit at twelve o'clock and 6 o'clock respectively, they hold a skipping rope which divides the clock into two equal parts. Learners are required to jump from one side ('to') of the clock to the other side ('past') crossing the rope. Then they have to describe the action, for example: 'I jumped over or I passed the rope and landed on three o'clock' (see Representation 4.24). Hence, learners' attention is drawn to the fact that 'minutes past' implies that the hour dial has to jump over or pass the specific hour which has gone by.



**Representation 4.24: Experiencing both sides of the analogue clock**

Thereafter, learners are divided into groups of five and each group receives a printed analogue clock and 5 minute dials marked 5, 10, 15, 20 and 25 respectively. Each member has to count in multiples of five to individually find the position of their own minute dial on the 'past' side of the clock (see Representation 4.25).



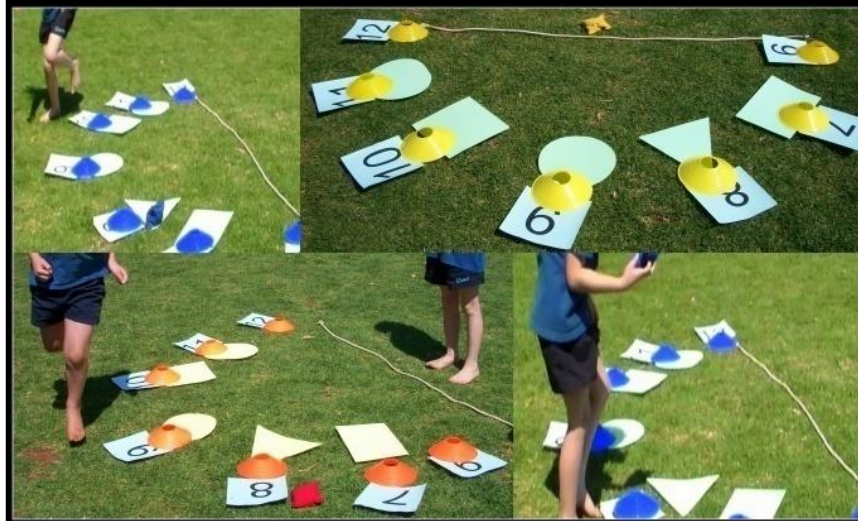
**Representation 4.25: Minute dial representing minutes past**

Subsequently, learners need to represent minutes past the hour on their one-handed clocks. Learners also have to distinguish between minute and hour dials and what each represents on analogue clocks.

#### 4.5.7 Week 7: Minutes to the hour on analogue and digital clocks

As indicated in Section 4.4.3, time before or till the hour is part of the CLOCKWISE mathematical programme although Van de Walle *et.al.* (2010) contend that this concept can come later. Learners will be encouraged to describe the position of the minute dial if it is a few minutes to a specific hour in their own words. Minutes to the hour on digital clocks will also be discussed.

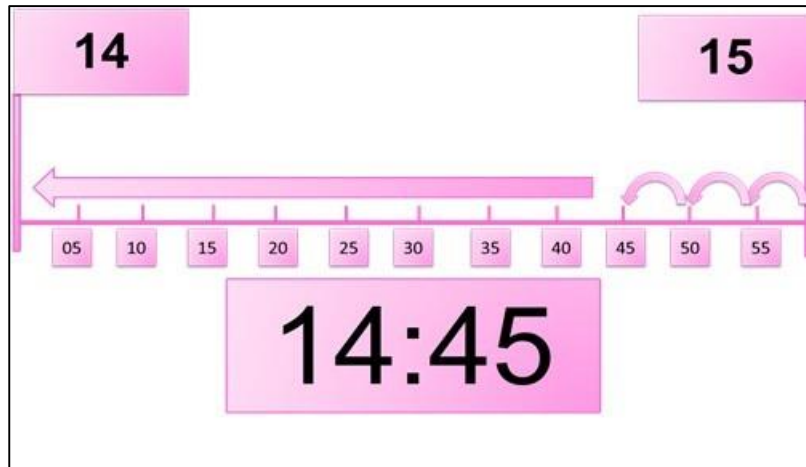
The teaching of minutes to the hour commences with the *Minutes to* game. The learners receive manipulatives with which they have to represent the 'to' side of an analogue clock. Thereafter, they are expected to throw the bean bag into one of the shapes and then jump towards the bag whilst counting in multiples of five. The learner must verbally describe the position of the bean bag: 'It is 20 minutes to'. Since they have to throw the bean bag towards a shape in the 'to'-side and count in multiples of five to determine the position of the bag, they will most likely be able to identify minutes to the hour (see Representation 4.26).



**Representation 4.26: Playing the *Minutes to* game**

Subsequently, learners need to represent minutes to the hour on their one-handed clocks (Van de Walle, 2004). They will have to be reminded that it is not yet a specific hour; therefore the hour dial will not be on a specific number yet.

Printed number lines and analogue clocks (Bell, 1980) will then be distributed to the learners. Their attention will be focused upon the term ‘to’ and specifically on the ‘-’ of the letter t. Since it resembles a subtraction symbol (-), subtraction is utilised to calculate ‘minutes to’ on digital clocks. Employing printed number lines, learners must identify the preceding hour and calculate the minutes whilst counting backwards. Thus, a quarter to three in the morning will be presented as 14:45 (see Representation 4.27).



**Representation 4.27: Calculation of 'minutes to' on a number line**

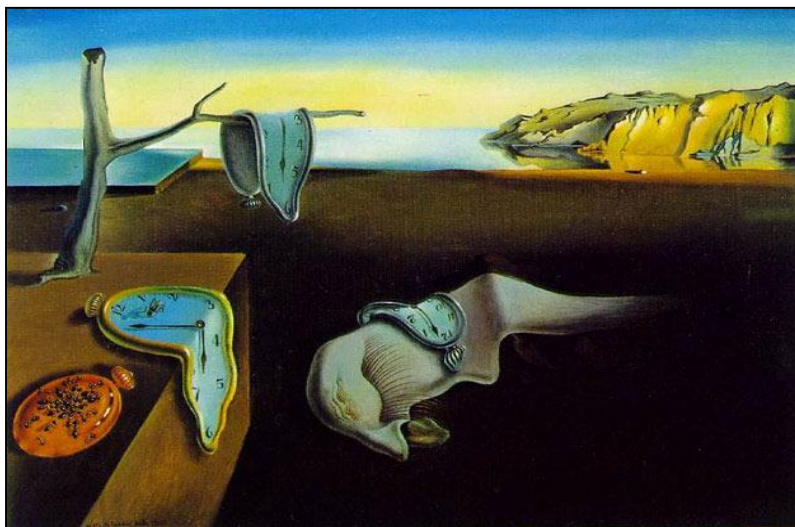
Analogue clocks can also be utilised to calculate minutes to the hour (Skemp, 1989). Learners will be requested to represent a certain time on their analogue clocks. To determine which digits will represent the hour on the digital clock, they must identify the hour which has just gone by. Subsequently, they must move round the clock whilst counting in multiples of five to determine which digits should represent the minutes on the digital clock. To establish if learners attained the concepts, they will be requested to identify times on a worksheet.

#### **4.5.8 Week 8: Assessment and conclusion**

Pirie and Kieren (Meel, 2003:169) contend that “a written instrument does not completely expose a learners’ understanding” and consider that interviews are useful assessment instruments. The mathematics teachers in this study, therefore, employ classroom dialogue and interviews to ascertain whether the learners are seeing how the concepts relate (Meel, 2003; Wolfe, 2005). As a result, the teachers are able to adjust their

instructional approach, if necessary, as well as give encouragement and direction to the learners (Wolfe, 2005). The CLOCKWISE mathematical programme also utilises learners' verbal and visual representations, as well as task-based activities and worksheets, to assess if they need instructional support (Crooks, 1988).

Each learner receives two worksheets to complete individually. Primarily, their attainment of the concepts of mathematical time and their ability to recognise analogue and digital times on clocks are assessed to determine the influence of the CLOCKWISE mathematical programme on their growth of understanding. The programme concludes with two task-based activities. First and foremost, a painting of Salvador Dali, *The Persistence of Memory*, is presented to the learners (see Representation 4.28). Visualisation is employed, which Olsson (2009:12) believes "plays a crucial role in learning processes".



**Representation 4.28: *The Persistence of Memory* by Salvador Dali**

Their attention is focused upon the melting clocks in the painting. Learners discuss their own ideas and understandings on what the clocks or painting represents. The following day learners are requested to create their own Salvador Dali drawing, which depicts something about the concept of time (see Representation 4.29). They also have to explain in writing which concept of time is illustrated by their drawing.



**Representation 4.29: Learners' own 'Time'-paintings**

Lastly, the development of a baby chicken is discussed. Their attention is drawn to the development and changes. The learners are then instructed to bring three objects from home to illustrate something which also changes over time. These items are photographed and discussed with peer members. This brings the facilitation of the CLOCKWISE mathematical programme to a close.

#### **4.6 Implementation challenges**

My co-researchers felt challenged by having to teach the programme on a consistent basis for at least eight consecutive weeks. The programme had been implemented at times allocated for mathematics on the daily time schedule, but the other content areas prescribed in the national curriculum (Department of Basic Education, 2011) had to be focused upon simultaneously. Therefore, it is recommended that the programme be implemented for two weeks per term during the school year.

#### **4.7 Recommendations**

Since concepts of mathematical time must be addressed throughout the Grade 2 school year according to the national curriculum (Department of Basic Education, 2011), it is recommended that the content of the CLOCKWISE mathematical programme should be distributed over a four-term period. After the implementation of the programme, it was



suggested that hours on analogue as well as digital clocks should be the focus of attention in term one of the school year. Half-hours on both the analogue and digital clock can then be focused upon in term two. Subsequently, minutes past the hour and minutes to the hour can be emphasised in term three and term four respectively.

## **4.8 Conclusion**

The CLOCKWISE mathematical programme was primarily designed and implemented to evaluate the effect the employed teaching strategies had on the Grade 2 learners' understanding of the mathematical concept of time (Grant, 2008). Therefore, I analyse and discuss the data obtained from the pre-implementation, implementation and post-implementation phases of the programme in the next chapter.

## CHAPTER FIVE: DATA ANALYSIS AND PRESENTATION OF FINDINGS

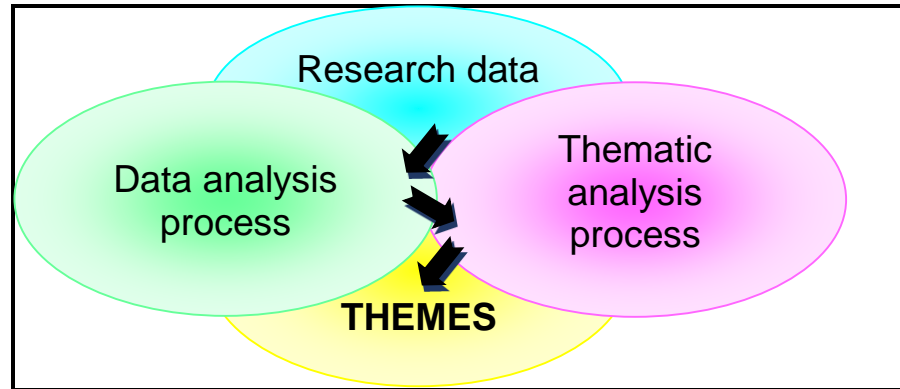


### 5.1 Introduction

In Chapter 3 I described the methodology of my study. In that chapter, I focused upon my selected research design and the methodological choices I made. Chapter 3 aligns with Chapter 4 where I described the teaching strategies and learning processes embedded in the CLOCKWISE mathematical programme. In Chapter 5, I describe the data analysis processes and report the results through the emerged themes. I commence this chapter by describing the analysis process through the phases of my research project. In order to determine how the CLOCKWISE mathematical programme enhanced Grade 2 teachers' teaching strategies and learners' understanding of the mathematical concept of time, the data was collected and analysed simultaneously. This process resulted in the thematic analysis process and it is explicated in the first section of this chapter.

Secondly, I provide evidence for the three themes which emerged during the thematic analysis. In the second section of this chapter, the themes are discussed and substantiated by my provision of verbatim responses and visual images from the participants.

## 5.2 The analysis process



**Figure 5.1: Visual representation of the analysis process**

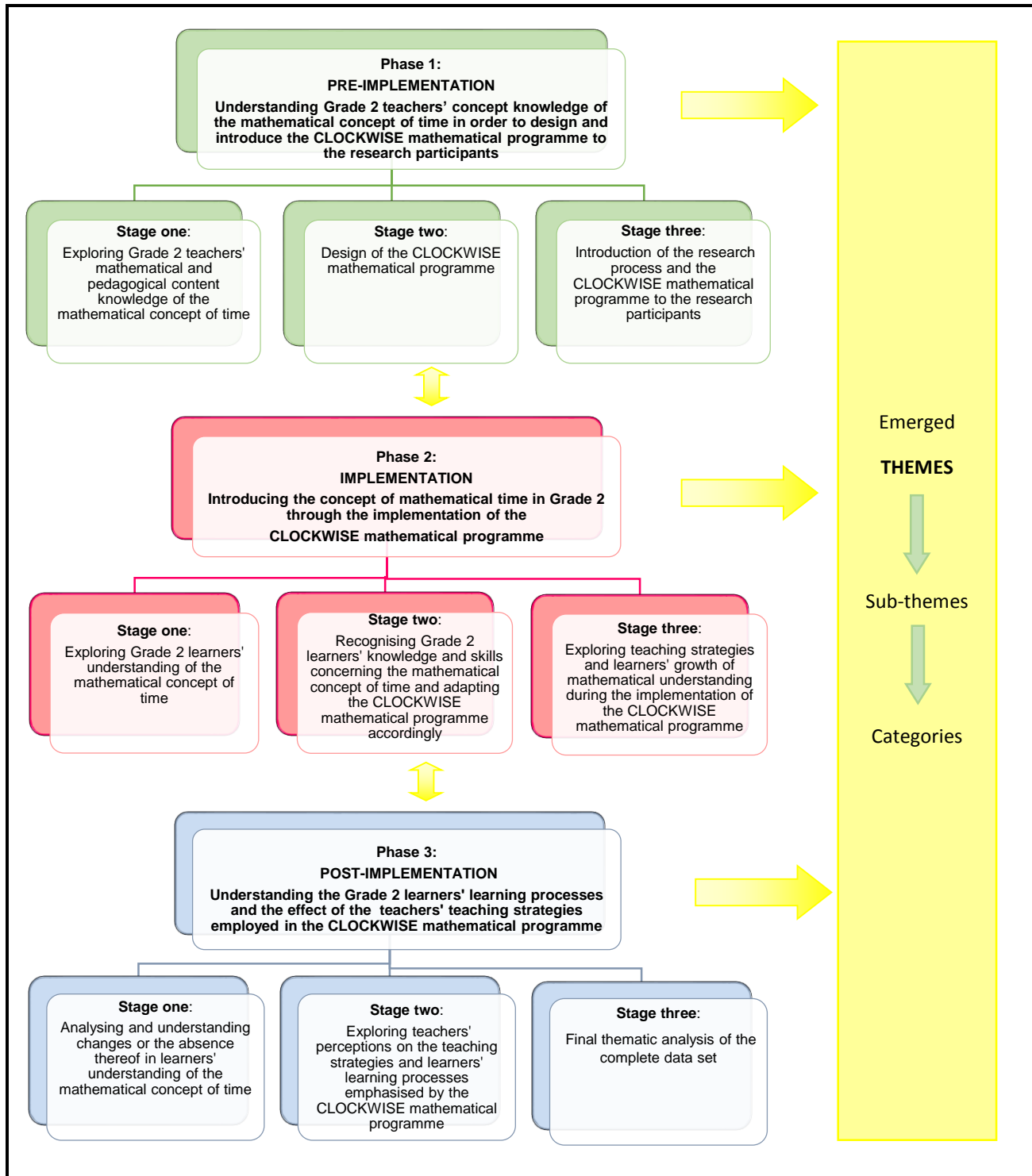
As practitioner researcher and interpretivist, I endeavoured to understand in-depth and “portray the teacher and learner participants’ perceptions and understandings” of the mathematical concept of time (Burton & Bartlett, 2009:22). As a result, the findings and themes of this study are grounded in the research data. In the following sections, I discuss the data analysis process and thematic analysis process which enabled me to present the final results as emerged themes in a two-fold manner. I commence with a discussion of the data analysis process which culminated in the thematic analysis process in stage three of the post-implementation phase of the study.

### 5.2.1 The data analysis process

I firstly focused on analysing the empirical research data generated by the data collection instruments (see Section 3.4.1). In order to describe the data analysis process, I summarise my data collection process. As practitioner researchers, my co-researchers (see Section 3.3) and I participated in the data collection process as a research team. We simultaneously collected and analysed the data (Cohen *et al.*, 2001) whilst we implemented the CLOCKWISE mathematical programme, as illustrated in Table 3.2 in Chapter 3. We were able to identify and discuss concerns and “issues of potential interest” at our weekly Grade 2 meeting (Braun & Clarke, 2006:86). It encouraged me to focus upon the perspectives and actions of the participating teachers (who acted as my co-researchers) and their learners; these were identified before, during and after the implementation of the CLOCKWISE mathematical programme.

Different data collection techniques were utilised to identify important data which could improve the Grade 2 mathematics teachers' teaching and Grade 2 learners' learning of the mathematical concept of time. Fieldwork included semi-structured interviews, focus group interviews, unstructured interviews and informal discussions with Grade 2 teachers at the research site (see Section 3.2.1). It also included observation, unstructured interviews as well as informal classroom discussions with learner participants whilst participating in task-based activities. I also made video-recordings of classroom interactions and learners' verbal representations which I transcribed. Furthermore, I took photographs of the Grade 2 learners' visual representations. I wrote field notes and supplemented my data with notes in my personal research diary.

Fieldwork was conducted in three phases (see Section 3.2.2.3), as suggested by Fox *et al.* (2008). The pre-implementation phase included the rationale for the implementation of the programme, the design of the CLOCKWISE mathematical programme as well as the introduction of the programme to research participants (Fox *et al.*, 2008). This was followed by the implementation phase which enabled each participant to engage with the CLOCKWISE mathematical programme. Thereafter the post-implementation phase commenced. This included reflection upon the teachers' understanding and teaching strategies as well as the learners' learning and mathematical understanding of the concept of time. Figure 5.2 illustrates the three phases of the data collection and data analysis process which will assist me in answering my research questions in the final chapter.



**Figure 5.2: Phases and stages of the data analysis process<sup>1</sup>**

<sup>1</sup>Data collected in Phase 1 Stage one and Phase 2 Stage two constitute baseline data, against which I could later monitor changes (or the absence thereof) subsequent to the implementation of the CLOCKWISE mathematical programme.

In the following section, I explain each phase and the stages of the data analysis process. I commence by describing the research focus and objectives of each phase as well as the processes and findings of the various stages of each phase.

### 5.2.1.1

#### Phase 1: Pre-implementation

**Understanding Grade 2 teachers' concept knowledge of the mathematical concept of time in order to design and introduce the CLOCKWISE mathematical programme to the research participants**

#### *Research focus of Phase 1*

During Phase 1, I primarily focused upon the Grade 2 teachers' interview data since it supported the design of the CLOCKWISE mathematical programme. The CLOCKWISE mathematical programme and research process were also explained and introduced to the research participants. Phase 1 consisted of three data analysis stages. The objectives for Phase 1 and the three stages are discussed in the next sections.

#### *Objectives for Phase 1*

I aimed to explore the six other Grade 2 teachers' (see Section 3.2.1) mathematical and pedagogical content knowledge, teaching strategies and concerns with regard to the teaching and learning of the mathematical concept of time in Stage one. The data generated as well as pedagogical principles and teaching strategies derived from existing literature were employed to design the CLOCKWISE mathematical programme in Stage two. Thereafter, the research processes involved in the implementation of the programme were introduced to the research participants in Stage three.

## 5.2.1.1.1

**Stage one: Exploring Grade 2 teachers' mathematical and pedagogical content knowledge of the mathematical concept of time*****Processes occurring during Stage one***

Stage one involved a 20 minute semi-structured interview conducted with six individual Grade 2 teachers in Afrikaans (see Section 3.4.1.2). I asked the same questions in the same order during the semi-structured interviews with all six of the other Grade 2 teachers at the research site. Two of them participated in the study as my co-researchers which enabled member checking and ensured the authenticity of my research findings. All six Grade 2 teachers' understandings, views and concerns relating to the teaching of the mathematical concept of time were explored in an attempt to enhance the richness of the data and trustworthiness of my co-researchers' and my own findings. Since the Grade 2 teachers regarded the video recorder as intrusive during the interviews, I took descriptive field notes and transcribed the interview data in as much detail as possible (see CD 2, Teachers' understandings). I also made use of member checks with teachers and learners to validate the authenticity of the English transcriptions since the transcribed data also had to be translated into English.

***Findings of Stage one***

The teacher participants were relaxed and willing to provide detailed responses during the semi-structured interviews. They described the teaching strategies they generally employed in their Grade 2 classroom to facilitate the mathematical concept of time in Stage one. I translated my descriptive field notes from Afrikaans to English and started the process of analysis by looking for "patterns of meaning and issues of potential interest" (Braun & Clarke, 2006:86).

As suggested by Ryan and Bernard (2003) as well as TerreBlanche and Durrheim (1999), I searched for recurring statements and concepts and colour-coded the similarities and differences within the collected data. The colour-coded concepts were examined again and quotes or expressions which seemed important were written down

on small index cards (Alhojailan, 2012). I sorted the colour-coded data into two piles which I categorised as *strengths* and *challenges*. Some of the strengths and challenges are described in the following excerpt from my research diary:

*Most of the teachers identified the fact that mathematical time is an abstract concept as a limitation. They also suggested that pm-times, minutes past and minutes to the hour are problematic for learners. However, they believed that the use of concrete materials can strengthen learners' understanding of analogue and digital time.*

*Three of the teachers believed that learners can attain the concept of time if they are able to count in multiples of five and understand vocabulary related to the mathematical concept of time. Lisa also mentioned that knowledge about the function of the two different dials would strengthen learners' understanding. She stated that learners should know 'what it means when the long dial points to a number and what it means when the short dial points to a number'.*

Phase 1 Stage one: Excerpts taken from my personal research diary (RD-20 July 2012)

From the teachers' data it was apparent that they believed that the teaching and understanding of mathematical time in a Grade 2 classroom is problematic since it is an abstract concept. However, they suggested that the use of clock faces will encourage the growth of mathematical understanding of the concept of time.

#### 5.2.1.1.2

#### Stage two: Design of the CLOCKWISE mathematical programme

#### ***Processes occurring during Stage two***

The transcribed data I collected in Stage one as well as the categorical analysis thereof, guided me and my co-researchers in the design of the CLOCKWISE mathematical programme in Stage two (CD 1, CLOCKWISE). Pedagogical principles derived from my literature review as well as the conceptual framework of my study (see Section 2.5) was also considered in this developmental process. Thus, the CLOCKWISE mathematical programme encourages the teaching and learning of mathematical time in a sequential



way. Teaching strategies such as storytelling, games and number lines were also employed in the programme.

### ***Findings of Stage two***

The CLOCKWISE mathematical programme was developed in collaboration with my two co-researchers. Transcribed interview data and data from my research diary (see text box below) guided the design of the CLOCKWISE mathematical programme. I noted in my personal research diary that ‘this is not the final product, since changes may still be necessary as we go along’ (RD-17 July 2012).

*My co-researchers and I talked about what we believed would enhance the learners’ understanding. Mia mentioned that we should definitely make use of play clocks when we discuss time on analogue clocks. I replied that I gained insights from my literature review which suggested that representations, storytelling, games and one-handed clocks would also facilitate understanding of the concept of time.*

*Both of them suggested that we must incorporate them in our programme and Lisa is mostly excited about the story I plan to write. Both of them also believed that my suggestion to simultaneously teach digital and analogue time will work out fine.*

Phase 1 Stage two: Excerpt taken from my personal research diary (RD-22 June 2012)

#### **5.2.1.1.3**

**Stage three: Introduction of the research process and the CLOCKWISE mathematical programme to the research participants**

### ***Processes occurring during Stage three***

During Stage three, I introduced the research process and the implementation strategies of the CLOCKWISE mathematical programme to the research participants and utilised participant observation to reflect on the teacher and learner participants’ reactions. All the learner participants and my co-researchers were gathered in the school hall. In an informal discussion, I explained the ethical considerations (see Section 3.5) of the research project. The signing of the consent and assent forms were

also discussed with the participant teachers and learners respectively. I also introduced the programme and described the kind of activities they could expect. Furthermore, I explained the use of video cameras and photographs in detail. I noted the critical opinions of my co-researchers as well as the learners' reactions in my personal research diary (see excerpt below). My co-researchers were particularly excited about the teaching strategies employed in the CLOCKWISE mathematical programme.

### ***Findings of Stage three***

By the end of this stage my co-researchers indicated in informal discussions that they felt enabled and better equipped to facilitate the CLOCKWISE mathematical programme and to support the learner participants. I ascribed the enthusiasm of my co-researchers and the participant learners to participate in my research project to the sound rapport I have with them as colleagues and learners at the school where I teach.

*I was excited but also uncertain this morning when I summoned all of the learner participants to the school hall. How will the programme be perceived by the learners? Although the programme is planned thoroughly and grounded in research, I hope our ideas will work out.*

*These feelings of uncertainty were soon replaced with excitement when the participants seemed to be very enthusiastic about their participation in the study. They were mostly excited about the games they would play and the story. I hope they will benefit from the research.*

*My co-researchers seemed to be convinced that the teaching strategies we decided upon will have a positive effect on learners' attainment. Mia said she 'cannot wait to work with the collages in 'Window', since the 'collages are unbelievable!' She believed that it would encourage learners to participate in the discussions and that it would draw their attention to concepts of time such as day, night, growing up and birthdays. Lisa was mostly excited about the oral story. She exclaimed: 'I LOVE stories!' She also stated that she often used stories in her classroom to teach concepts.*

Phase 1 Stage three: Excerpt taken from my personal research diary (RD-19 July 2012)

This concluded the analysis stages of Phase 1. The second phase of the analysis process represents the implementation phase of the process, as suggested by Fox *et al.*, (2008).

### 5.2.1.2

#### **Phase 2: Implementation**

**Introducing the concept of mathematical time in Grade 2 through the implementation of the CLOCKWISE mathematical programme**

#### ***Research focus of Phase 2***

In the implementation phase of the CLOCKWISE mathematical programme (Phase 2), I primarily focused upon the analysis of data collected. Data was collected by the research team (see Section 3.2.1) whilst the analysis of the data was primarily my responsibility. Afterwards, I shared my findings with the research team. We discussed the findings to ensure the validity and trustworthiness thereof. Phase 2 consists of three stages.

#### ***Objectives for Phase 2***

Phase 2 was guided by the objectives of exploring Grade 2 learners' understanding of the concept of time and their applied knowledge thereof. The teachers' teaching strategies and the learners' growth of understanding during the implementation of the CLOCKWISE mathematical programme were also explored.

### 5.2.1.2.1

**Stage one: Exploring Grade 2 learners' understanding of the mathematical concept of time**

#### ***Processes occurring during Stage one***

Learners related their own understanding of the concept of time in informal classroom discussions with their classroom teachers. The collages in the book *Window* (Baker,

2000) encouraged the Grade 2 learners to discuss their perceptions and understandings of the mathematical concept of time (see Chapter 4). The learners' perceptions and understandings were utilised by the Grade 2 teachers in the research study during the instruction on the concepts of time. In my personal diary, I noted that 'urbanisation depicted in the collages might have influenced learners' perceptions that time constitutes change' (RD-25 July 2012), but the research team concluded at the end of stage one that learners reflected upon their own experiences to define their understanding of the concept of time. Data generated during these classroom discussions on the concept of time and the collages was captured as descriptive field notes.

Data was also generated from two task-based activities from which learners' understanding of the mathematical concept of time emerged (see Section 4.5.1). In the first activity, learners were asked to draw a series of pictures which illustrate one of the concepts of time they identified in the book *Window* (Baker, 2000). Subsequently, they had to explain the development or changes in their drawings in writing. In the second task-based activity, learners were required to represent a season of their choice and to write descriptive words which they believed define the mathematical concept of time. In addition to the field notes from learners' responses, I relied on the transcriptions of the video recordings of the classroom discussions and observations as well as document analysis of task-based activities to obtain an overview of the learners' understanding of time.

### ***Findings of Stage one***

Since classroom discussions and task-based activities were also video recorded, the participant learners' responses (Alhojailan, 2012) could be transcribed and tabled (see CD 2, Learners' understandings). As suggested by Ryan and Bernard (2003:94), I identified quotes and ideas from the participant learners' data which seemed important to this study, and wrote them "down on small index cards" (see excerpt below). I initially arranged them into two piles, the first being *change* and the second being *specific*

events. Thereafter, I “searched for repetitions, similarities and differences within the two piles” (Ryan & Bernard, 2003:101). I used the quotes from the learners to classify the data (Alhojailan, 2012). The data was classified according to the following categories: *development and deterioration, time goes by and time is recurring*, as well as *actions and events*. Through the analysis process I obtained an overview on the concept of mathematical time as perceived by the Grade 2 learners. I reflected on the data and came to the conclusion that the learners’ understandings could inform our design and implementation of the programme on the mathematical concept of time, thus illuminating the guiding pedagogical principles and teaching strategies employed in the programme.

*We are astonished – the learners’ understanding of the concept of time is not what we expected it to be. Mia mentioned that ‘we underestimate the learners in our classes’. The learners perceive time as something that goes by, changes all the time and is connected to specific events and actions in their daily lives.*

*Learner 59 even suggested that time is ‘life’ and she thinks about ‘snakes’ when she has to define time. On request she explained that ‘each day your life on earth is a day shorter’ and ‘snakes sleep at a certain time of the year’. Learners 3 and 72 mentioned that there are different times in a day such as playtime, bath time and time for school. Learner 22 suggested that it takes a certain amount of time to bake a cake, whilst learner 63 stated that ‘it takes a long time to bake jewellery’. Learner 75 also suggested that ‘multiplication takes a long time to finish’.*

*Only four of the 92 learner participants related time to clocks and watches. I believe their ideas should be used during instruction on the concept to facilitate understanding. In my mind, teachers should focus learners’ attention on the importance of specific times in their daily lives. They should also encourage learners to represent and identify the relevant times on clock faces.*

Phase 2 Stage one: Excerpt taken from my personal research diary (RD-28 July 2012)

### 5.2.1.2.2

**Stage two: Recognising Grade 2 learners' content knowledge and skills concerning the mathematical concept of time and adapting the CLOCKWISE mathematical programme accordingly**

#### *Processes occurring during Stage two*

Whilst Stage one of Phase 1 focused upon Grade 2 teachers' content knowledge, Stage two of Phase 2 commenced with the baseline assessment of the Grade 2 learners' current knowledge and skills. Since this research explored how Grade 2 learners' conceptual understandings of the mathematical concept of time developed as a result of their participation in the CLOCKWISE mathematical programme, I aimed to evaluate "which differences occurred during the project" (Alhojailan, 2012:9).

Semi-structured interviews were conducted with each participant learner by myself and their own classroom teachers on consecutive days (CD 2 Learners' understandings, Fieldnotes). Each learner's attainment of conservation, reversibility, transitivity, classification and seriation was documented on a spreadsheet. All the knowledge of analogue and digital time of the learners in the seven Grade 2 classes at the research site was documented by their own classroom teachers (Addenda CD 2, Learners' understandings, Fieldnotes). This was because this practitioner research project aimed to determine if the Grade 2 learners' understandings of the mathematical concept of time were enhanced by the teaching strategies employed in their respective classrooms.

Although this research project was qualitative in nature, data was also generated to evaluate the effect of the employed teaching strategies on the Grade 2 learners' understanding of the mathematical concept of time. Therefore, this research project generated some numerical data to determine if the understandings of the learner participants and Grade 2 learners in the other Grade 2 classes (see Section 2.3.1) were enhanced by the teaching strategies employed in their own classrooms. The learners were requested to represent specific times such as half past six and 14:45 in a specific

order on their clock faces in Stage two of Phase 2 and also in Stage one of Phase 3 in order to compare the data in the implementation and post-implementation phases.

The semi-structured interviews with participant learners were video recorded and field notes were taken of the task-based activities in collecting and documenting the raw data. The learners' responses in the semi-structured interviews were tabled and provided insight into the learner participants' pre-implementation knowledge of the concept of analogue and digital time. I was confident during the implementation and analysis processes that the data would enable me to measure the possible differences in learners' pre-implementation and post-implementation understanding of the concept of time as a result of their participation in the CLOCKWISE mathematical programme.

### ***Findings of Stage two***

My co-researchers and I discussed the findings of Stage two at the weekly Grade 2 meeting. From the semi-structured interviews we came to the conclusion that almost all our learners could complete the conservation-, reversibility-, transitivity-, classification- and seriation-tasks successfully, but the representation of time on clock faces seemed to be problematic (see excerpt from the pre-implementation results on p. 142). Most of the learners could represent hours and half-hours on analogue clocks, but they had difficulty with minutes to and minutes past the hour as well as with times on digital clocks. Learners could not differentiate between the position of the minute dial when asked to represent minutes to and minutes past the hour on analogue clocks. Therefore, we agreed that it necessitated the different teaching strategies we included in the CLOCKWISE mathematical programme.

| Learner | Conservation | Reversibility | Transitivity | Classification | Seriation | Compare: perceptually | Compare: directly | Compare: indirectly | 6 o'clock | Half past 6 | 5 to 8 | 09:30 | Quarter past 1 | 10 to 2 | 14:45 | 20:10 |
|---------|--------------|---------------|--------------|----------------|-----------|-----------------------|-------------------|---------------------|-----------|-------------|--------|-------|----------------|---------|-------|-------|
| 1       |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 9       |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 16      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 32      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 56      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 67      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 84      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |
| 91      |              |               |              |                |           |                       |                   |                     |           |             |        |       |                |         |       |       |

Phase 2 Stage two: Excerpt taken from learners' pre-implementation representations of time (28 July 2012)

Correct  Wrong

### 5.2.1.2.3

**Stage three: Exploring teaching strategies and learners' growth of mathematical understanding during the implementation of the CLOCKWISE mathematical programme**

#### ***Processes occurring during Stage three***

During the first two weeks of the implementation of the CLOCKWISE mathematical programme, the teachers' and learners' pre-implementation understandings of the concept of time were discussed. In Stage three of Phase 2, the concepts of analogue and digital time were introduced to the learner participants over a five-week period. During these five weeks, different teaching strategies and learning activities were employed. Teaching strategies such as classroom discussions, task-based activities, games and storytelling of the *CLOCKWISE IN AFRICA* story were utilised. They



provided the research team with an extensive amount of raw data which I transcribed and analysed.

During the first week, we focused upon hours on digital clocks. Number lines, flash cards as well as time charts were employed and utilised by the learners. They also made their own 'sunglasses' which were utilised to actively calculate p.m.-times on digital clocks. Participant observations, document analysis, photographs and video recordings of the informal discussions between the teachers and learners and learners and their peers were transcribed and analysed at the end of that week. The participant learners also played the *What time is it?* as well as *Time Bingo* games and illustrated both an a.m. as well as p.m. time on their *Time charts* (see Chapter 4 for a detailed description of task-based activities and games employed in the *CLOCKWISE* mathematical programme). The informal discussions, video recordings of games, task-based activities as well as learners' drawings and the completed worksheets provided raw data which was also analysed.

In the following week (Week 2), a co-seriation task, which highlighted the coordination of the two dials on an analogue clock, preceded discussions of hours on analogue clocks. Learners represented specific times on their own one-handed analogue clocks. They also formed an analogue clock outside with their bodies, and played the *CLOCKWISE* game. I noted in my personal research diary that I could not believe that basic activities such as throwing a pair of dice and playing the *CLOCKWISE* game could generate such an enthusiastic response from the learners involved (see CD 2, Research diary, RD-21 August 2012).

In the next week (Week 3), the focus was upon the identification of half-hours on analogue as well as digital clocks. Activities on one-handed clocks, classroom discussions on the definition of a half-hour, visual representations of half-hours on practice sheets, learners playing *Time Snakes and Ladders* as well as a task-based activity on time duration were video recorded, transcribed and analysed.

During the last two weeks of this implementation stage, the concepts of minutes past and minutes to the hour were exploited. Learners were involved in the activity whilst using number lines, their one-handed analogue clocks and playing games outside. Their actions, as well as verbal and visual representations, were video recorded and transcribed.

### ***Findings of Stage three***

The following data collection instruments provided insight into learners' growth of mathematical understanding and the effect of the teaching strategies employed by all the Grade 2 teachers over an extensive period of five weeks: informal conversations with my co-researchers on a weekly basis, video recordings of classroom discussions and games, learner participant observations, task-based activities, learners' textual data as well as my personal research diary. Visual representations of specific times were analysed and tabled (see CD 2, Learners' understandings). I transcribed all the video recordings of all the classroom discussions and games (see CD 2, Transcribed video recordings). The data was also tabulated, since Alhojailan (2012:9) suggests that the "first principle of data analysis is to compact extensive raw data into a sufficient structure". Being a practitioner researcher in the research process, I was familiar with the generated data but I read the transcribed data once again since I aimed to compare recurring ideas within the teachers' and learners' data (see excerpts below).

*I believe that we have to explain the concept of time periods again before we can go on with the rest of the week's work. In an informal discussion Mia stated that 'learners cannot tell morning, afternoon and night-times apart'. Therefore, I am going to make new time charts for every participant to use. Maybe we should divide a.m. and p.m. times and colour the corresponding hours: such as white for moonshine, yellow for times in the morning and orange for times in the afternoon.*

*The learners loved making their own number twelve sunglasses. Lisa mentioned that the learners in her class were most excited when she told them to lie on their backs in the classroom. The learners in my class could not wait to count the rays hanging from the roof. Playing 'Time Bingo' was also a lot of fun and their enthusiasm made all the long hours of the development of the manipulatives worthwhile.*

*The learners loved going outside to play some games. Mia mentioned that 'they did not even notice that they were actually learning something, mostly from each other. They corrected each other's mistakes in a playful way'. I am pleased that the learners could explain their actions when we got back to class and had to work with 'pen and paper' and our one-handed clocks.' Learner 3 reminded Lisa that the minute dial must jump 'across the rope in the middle of the clock to get to the past side of the clock'.*

*Some of the learners got really involved with the characters in the story. When I told them that the animals could not go back to the CLOCKWISE game reserve since Barry could not swim and therefore could not cross the river, one of them shouted in Afrikaans: 'Swem net man!!! Swem' (Swim, man! Swim!!). Lisa stated that as she read the letter from Pete Parrot which indicated that the animals could answer all of King Lionel Lion's questions correctly, the whole class applauded.*

Phase 2 Stage three: Excerpts taken from my personal research diary (RD-14 September 2012)

As suggested by Braun and Clarke (2006), I read the transcribed video recordings line by line and made notes on the texts. Thereafter, I differentiated between recurring concepts expressed by the participant learners and teachers and colour-coded the data accordingly. I arranged quotes and expressions which I "wrote on small index cards" into two categories, the first being *teaching strategies* and the second *learning processes* (Ryan & Bernard, 2003:94). Afterwards, I "searched for repetitions, similarities and differences" within the two categories (Ryan & Bernard, 2003:101).

At the end of this stage, I obtained an overview of the teaching strategies employed and the learning processes of learners. Through process evaluation, I reflected on the data and informally discussed with my co-researchers my insight that the use of everyday

language by teachers as well as learners facilitated understanding of the concept of time. My co-researchers confirmed my new understanding. This concluded the analysis process through the stages of the implementation phase. In the following section I, discuss the data analysis process through the stages of the post-implementation phase which assisted me in answering the research questions of this study.

### 5.2.1.3

#### **Phase 3: Post-implementation**

**Understanding the Grade 2 learners' learning processes and the effect of the teachers' teaching strategies employed in the CLOCKWISE mathematical programme**

#### ***Research focus of Phase 3***

In Phase 3, the exploration and understanding of learners' learning processes and teachers' teaching strategies employed in the study are emphasised. Phase 3 consists of three stages.

#### ***Objectives for Phase 3***

This phase primarily focused upon the learning processes of learners and teachers' teaching strategies. We aimed to monitor the Grade 2 learners' improved conceptual understanding, challenges influencing understanding or the lack of understanding of the mathematical concept of time that was recorded in Stage one. The teachers' perspectives on the teaching strategies they employed in the CLOCKWISE mathematical programme and the learners' learning processes throughout all phases were investigated and analysed in Stage two. Thereafter, the final thematic analysis process could commence in Stage three.

**5.2.1.3.1 Stage one: Analysing and understanding changes or the absence thereof in learners' understanding of the mathematical concept of time*****Processes occurring during Stage one***

In Stage one of the post-implementation phase, the research team aimed to measure the changes or absence thereof in learners' understanding after the CLOCKWISE mathematical programme was introduced (Alhojailan, 2012). Therefore, all the Grade 2 learners in the seven classes were tested to establish their growth of mathematical understanding of the concept of time or their apparent lack of understanding. Participant observations, field notes of classroom discussions, visual representations and task-based activities were also analysed. The data was tabled (see CD 2, Learners' understandings) and compared against the data gathered in Phase 1 (pre-implementation phase) of the process.

***Findings of Stage one***

The data analysis process enabled the research team to observe the differences and similarities apparent within the data collected in Phases 1 (pre-implementation phase), 2 (implementation phase) and 3 (post-implementation phase) of the CLOCKWISE mathematical programme (Alhojailan, 2012). An apparent growth in participant learners' conceptual understanding of the mathematical concept of time was identified through the process of comparison (as part of the data analysis process).

The participant learners were given an opportunity to discuss a painting of Salvador Dali and to express their understanding of what the clocks or painting represents. The data obtained from the informal classroom discussions demonstrated the learners' high level of conceptualisation of the mathematical concept of time (as illustrated in the excerpt below). Data obtained from task-based activities was also analysed. Learners were expected to depict any aspect of the concept of time, to make a drawing and to explain in writing what the drawing meant (see Section 4.5.8). They also brought three photographs or physical objects which represented changes over time and explained

which aspect of time each represented, such as growth, development, deterioration and ageing (see CD 2, Learners' understandings).

*We are amazed– the learners in all three classes noticed things in Salvador Dali's painting and made connections with the concept of time which we would never have thought about.*

- *Learner 11 explained that 'it must have been 5 to 7 in the morning since there is nobody on the beach that early.'*
- *Learner 25 suggested that 'it has to be half past 11 in the morning, since everyone has to keep away from the hot sun.'*
- *Learner 40 explained that one of the clocks on the painting belonged to a fisherman. 'The fisherman was fishing and he did not want the time to go by therefore he took off his watch and threw it into the ocean.'*
- *Learner 50 believed that 'it is 5 to 7 in the evening in the Cape, since the sun is still shining.'*
- *Learner 83 stated that 'the fossil looked like a shirt which someone hang out to dry.'*
- *Learner 2 mentioned that 'the pocket watch looked like an oxygen tank which someone left on the beach early that morning'.*
- *Learner 21 believed that the 'clocks were melting because the sun was hot'.*
- *Learner 23 believed that 'the clocks on the fossil looked like a hat which someone used to keep the sun out of his face.'*

Phase 3 Stage one: Excerpt taken from field notes (FN-18 September 2012)

### 5.2.1.3.2

**Stage two: Exploring teachers' perceptions on the teaching strategies and learners' learning processes emphasised by the CLOCKWISE mathematical programme**

#### ***Processes occurring during Stage two***

Stage two commenced with a 30 minute semi-structured interview in Afrikaans with each of my two co-researchers. I utilised this semi-structured interview to verify and extend information (TerreBlanche & Durrheim, 1999). Each of my co-researchers communicated their perceptions on the effectiveness of the teaching strategies employed in the CLOCKWISE mathematical programme. Since they regarded the video recorder as intrusive, I took descriptive field notes during the interviews and transcribed this data in as much detail as possible (see CD 2, Teachers' understandings). I also made use of member checks to validate the authenticity thereof.

A focus group interview attended by all seven of the Grade 2 teachers at the research site (myself included), called attention to the teaching strategies and learning processes of learners during the implementation phase of the CLOCKWISE mathematical programme (see CD 2, Teachers' understandings). The focus group interview was employed to confirm the findings of the research team. It also provided an opportunity to discuss the effect the CLOCKWISE mathematical programme had on the Grade 2 learners' understanding of mathematical time with our four Grade 2 colleagues who were not part of the research team. The focus group interview also enabled the teachers to raise and pursue issues pertaining to the programme as suggested by Cohen *et al.* (2001). This interview was transcribed and analysed.

### ***Findings of Stage two***

The teacher participants were relaxed and willing to provide detailed responses in the semi-structured interview conducted with them as co-researchers, as well as the focus group interview with all the Grade 2 teachers at the research site (see Section 3.4.1.2). My co-researchers were enthusiastic and displayed insight with regard to the teaching strategies they employed as well as the difficulties and strengths thereof. I translated my descriptive field notes and analysed the teachers' understandings in the data from the semi-structured interviews (Braun & Clarke, 2006). Furthermore, I transcribed and translated the data from the focus group interview which was video recorded. As suggested by Ryan and Bernard (2003), I colour-coded the recurring similarities and differences within the data and categorised them as *strengths* and *challenges* related to the employed teaching strategies (Lankshear & Knobel, 2004).

Thereafter, I compared data from the pre-implementation semi-structured interviews with that of the post-implementation semi-structured and focus group interviews. I therefore utilised the principle of 'folding back' as suggested by the Pirie-Kieren model and moved "back and forward between the entire data set, the coded extracts of data as well as the analysis I produced" (Braun & Clarke, 2006:86; Meel, 2003). Coded relationships between emerged concepts within the whole data set were then graphically displayed (see CD 2, Teachers' understandings). The research team

concluded that the strengths of the CLOCKWISE mathematical programme prevailed over the challenges experienced whilst implementing the programme (see CD 1, Teachers' understandings).

It is apparent from the analysed data (see excerpts below) that the utilisation of

- manipulatives such as one-handed clocks, games, number lines and stories
- learners' own understandings of the concept
- learners' everyday language and explanations of times relevant to their own lives
- as well as the differentiation between time periods
- and the sequence of instruction

enhanced the conceptual understanding of the mathematical concept of time among Grade 2 learners at this particular research site.

- *'Most of the participant learners could represent analogue and digital times on clock faces after the implementation of the programme'* (RD-21 September 2012).
- *Mia noted that 'through the CLOCKWISE IN AFRICA story which was used to explain concepts and vocabulary, the extensive practical work and games which the learners enjoyed terribly, the concept of time was not abstract anymore. They understand it better now.'* (1<sup>2</sup>-24 September 2012: Lisa).
- *Mia stated that 'since learners could set time in different time periods, they were aware of time in their daily lives and it influenced their understanding of digital time'* (1<sup>2</sup>-24 September 2012: Lisa).
- *Lisa mentioned that 'learners enjoyed time more through the story and that they understood the concepts faster especially if the concepts were explained in everyday language'* (1<sup>2</sup>-24 September 2012: Lisa).
- *Lisa stated that teachers 'should have a sound knowledge of what the learners' idea of time is, since you can build on that to teach new concepts'* (1<sup>2</sup>-24 September 2012: Lisa).
- *'The sequence of instruction enabled learners to build upon their new understandings and gain knowledge'* (RD-21 September 2012).

Phase 3 Stage two: Excerpts taken from my personal research diary and semi-structured interview 2

This completed the data analysis through the data analysis process of the study which culminated in the thematic analysis of the complete data set. The thematic analysis process corresponds with the phases of the data analysis process; therefore my repetitive use of the colours. Resulting from the data analysis process during Phase 3 Stage three, I posit the thematic analysis (see Figure 5.2)



## 5.2.2 The thematic analysis process

### *Processes occurring during Stage three*

Before I explored the complete data set again, I focused my attention on the research questions I stated at the beginning of my thesis. Then the complete data set was explored again to consider whether the data related to my research questions (Braun & Clarke, 2006). As a result of working with the data, I found recurring ideas in the teachers' and learners' data. Some of these recurring ideas were already colour-coded in the data analysis process (Taylor-Powell & Renner, 2003).

### *Findings of Stage three*

Subsequently, I could present the results of the data analysis process and thematic analysis process in terms of the overarching emerged themes and categories which are pertinent to my research questions. Through the data analysis process and thematic analysis process the complete data set provided evidence in terms of three main themes:

- Theme 1: Teaching and learning of the concept of time are influenced by learners' and teachers' understanding of the concept
- Theme 2: Mathematical and pedagogical content knowledge of the concept of time emerge from real-life experiences
- Theme 3: Deeper exploration of the concept of time scaffolds and develops learners' and teachers' mathematical knowledge and understanding

The three themes, in conjunction with the identified sub-themes as well as the categories within, (see Table 5.1), provided insight into the Grade 2 learners' and the mathematics teachers' understandings. Therefore, the results in terms of the learners' growth of mathematical understanding and the effectiveness of the teachers' teaching strategies employed in the CLOCKWISE mathematical programme are discussed by referring to the emerged themes, sub-themes and categories in Section 5.3.

**Table 5.1: Themes, sub-themes and categories**

| Theme 1  | Theme 2   | Theme 3  |
|--|---|--|
| <b>Teaching and learning of the concept of time are influenced by teachers' and learners' understanding of the concept</b>   | <b>Mathematical and pedagogical content knowledge of the concept of time emerge from real-life experiences</b>  | <b>Deeper exploration of the concept of time scaffolds and develops learners' and teachers' mathematical knowledge and understanding</b>   |
| Learner  | Learner   | Learner  |
| Sub-theme 1.1  | Sub-theme 2.1   | Sub-theme 3.1  |
| <p><i>Learners have a deeper understanding of mathematical time when they articulate their ideas and thinking about the concept of time</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 1.1.1</b><br/>Learners strengthen their understanding that time implies development and deterioration</li> <li>➤ <b>Category 1.1.2</b><br/>Learners understand that time goes by</li> </ul>   | <p><i>Daily life and real-life experiences influence learners' understanding and representations of the concept of time</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 2.1.1</b><br/>Specific time periods direct learners' attention to personal experiences</li> <li>➤ <b>Category 2.1.2</b><br/>Learners understand the relationships between certain experiences and the time of day through the exploration of time concepts</li> </ul>      | <p><i>Language has a distinctive function in the exploration and communication of time concepts</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 3.1.1</b><br/>Communication encourages active exploration of the vocabulary of time concepts</li> <li>➤ <b>Category 3.1.2</b><br/>The interplay of daily and mathematical language enhances mathematical understanding during the exploration of time concepts</li> </ul>   |
| Teacher  | Teacher   | Teacher  |
| Sub-theme 1.2  | Sub-theme 2.2   | Sub-theme 3.2  |
| <p><i>Innovative teaching strategies provide opportunities for learners to understand the concept of mathematical time</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 1.2.1</b><br/>Learners' new understandings of the concept of time influence the sequence of instruction</li> <li>➤ <b>Category 1.2.2</b><br/>Encouraging learners to represent their own ideas on the concept of time, strengthens their understanding of mathematical time</li> </ul> | <p><i>Daily life and real-life experiences of learners influence the way teachers teach</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 2.2.1</b><br/>Thought-provoking questions encourage learners to think about real-life experiences and to create clear definitions of time concepts</li> <li>➤ <b>Category 2.2.2</b><br/>Task-based activities encourage learners to relate their real-life experiences to specific time periods</li> </ul> | <p><i>Teaching strategies encourage learners' exploration and understanding of the concept of time</i></p> <ul style="list-style-type: none"> <li>➤ <b>Category 3.2.1</b><br/>Teaching strategies such as storytelling and games engage learners in active exploration and meaning-making of mathematical time</li> <li>➤ <b>Category 3.2.2</b><br/>Providing manipulatives such as one-handed clocks encourages learners to make mathematical connections whilst exploring and discovering the concept of time</li> </ul> |

### 5.3 Reporting results through themes

In the following section, I provide a discussion of the emerged themes, sub-themes and categories, as well as evidence which emerged from the data. I present my reflections on the data relevant to the themes. I commence with Theme 1 and provide evidence for the emergence of learners' and teachers' understanding of the concept of time and the related sub-themes and categories.

The abbreviations used with the quotes identify the data collection methods as follows: semi-structured interview 1 (I<sup>1</sup>), semi-structured interview 2 (I<sup>2</sup>), focus group interview (FI), personal research diary (RD), analysis of documents such as learners' drawings and written work (DA), as well as field notes (FN) and video analysis (VA) of classroom discussions which included the unstructured interviews with the learners. The participant learners are identified with (L) and by the number each of them drew from a hat themselves. I also refer to the data collected from my two co-researchers by their pseudonyms: Mia and Lisa.

#### 5.3.1

##### Theme 1: Teaching and learning of the concept of time are influenced by the teachers' and learners' understanding of the concept

In the context of this study, it was important to establish if the teaching strategies employed in the CLOCKWISE mathematical programme enhanced the Grade 2 learner participants' understanding of the mathematical concept of time. Therefore, the first theme explores the learners' understanding of the concept of mathematical time and the teachers' understandings on the effective teaching of time before, during and after the implementation of the CLOCKWISE mathematical programme.

The following sub-themes emerged throughout all the phases of the study, and are constructed as *learners have a deeper understanding of mathematical time when they articulate their ideas and thinking about the concept of time and innovative pedagogical strategies provide opportunities for learners to understand the concept of mathematical time*. In the following section each of the sub-themes and relevant categories are

reflected upon and illuminated by data such as collages of drawings, photographs, written accounts and verbal representations of the participating learners as well as excerpts from my personal research diary, field notes, transcribed video recordings and citations from the translated interview data.

### 5.3.1.1

**Sub-theme 1.1: Learners have a deeper understanding of mathematical time when they articulate their ideas and thinking about the concept of time**

In the pre-implementation phase of this study, the participant teachers supposed that the participant learners' understanding of mathematical time would be enhanced if they knew time vocabulary such as day, night, hours, minutes and months. For that reason, they asked the learner participants to describe the concept of time in the implementation phase of the study (see CD 1, CLOCKWISE, Activity 1.1). The research team was amazed. Only four of the 92 learner participants (FN-23 July 2012: L11,20,60,92) related time to clocks and watches and most of the participant learners perceived time as something that changes all the time and something that goes by (RD-28 July 2012).

The participating learners of the study also expressed their individual understandings in task-based activities and worksheets (see excerpt in Representation 5.1), and also in informal classroom discussions throughout the study.



FN- 23 July 2012, L11



FN- 23 July 2012, L21

*'Time means that everything changes.'*

*'Time is something that comes and goes.'*

**Representation 5.1: Learners' perceptions of the concept of time**

Learners described seasonal changes as: ‘Just as water flows away, the seasons flow from one to another’ (FN-26 July 2012: L4) and ‘Seasons pass with cold and heat’ (FN-19 September 2012: L7). Learner 4 (FN-19 September 2012: L4) also asserted that ‘every hour there is a different time on the clock.’ In her written account, learner 77 explained that her drawing depicted the weather which ‘changes the whole time’ and she noted that ‘sometimes the sun shines, but sometimes it rains, it snows, and hail is falling and the wind blows’ (DA-19 September 2012: L77). Learner 18 stated that ‘mothers and young girls’ clothes looked different’ in the past (FN-19 September 2012: L18).

The above quotes drew attention to the learners’ supposition that time influences the development as well as deterioration of objects, people and nature. Learner 7’s statement that ‘seasons come and go’ also indicated participating learners’ belief that time is recurring (DA-19 September 2012: L7). Therefore, *learners strengthen their understanding that time implies development and deterioration as well as learners understand that time goes by* are relevant categories within this sub-theme.

#### 5.3.1.1.1

##### Category 1.1.1: Learners strengthen their understanding that time implies development and deterioration

The participant learners expressed their understandings of the mathematical concept of time in different ways during the implementation phase of the CLOCKWISE mathematical programme. From their visual representations and informal classroom discussions it became clear that the Grade 2 learners strengthened their understanding that ideas, nature, objects and people develop and deteriorate over time.

Week 1 of the CLOCKWISE mathematical programme commenced with a classroom discussion between the participant teachers and the participant learners on the meaning of the concept of time (see CD, CLOCKWISE, Activity 1.1). From these discussions it was evident that most learners believe that time suggests that ‘years go by’ and that ‘everything changes’ (FN-23 July 2012, L6, L11). Learners were encouraged to make their own drawings of concepts of time, after a painting of Salvador Dali was discussed in the

class by the teacher and learner participants (see CD 1, CLOCKWISE, Activity 8.6). Learner 2 drew a purse and explained that ‘if you persist and keep on working, your purse will become fuller’ (DA-19 September 2012: L2).

In Week 8 of the implementation phase, learners were also requested to bring some objects from home which illustrated a concept of time (see CD 1, CLOCKWISE, Activity 8.8). A number of participating learners stated that ‘as you get older you eat different food, use different toothbrushes, glasses, spoons and suitcases’ and you wear ‘bigger socks and shoes’ (FN-21 September 2012: L47, L86, L39, L27, L18). Learner 2 asserted that time can influence your financial security (FN-21 September 2012: L2). The changing and developing character of one’s interests and intellect was explicated by learner 21. The participant learner brought a first-level reader, storybook and dictionary to class and explained that ‘time is wisdom’ because ‘as you get older your interests and the kind of books you can read change’ (FN-21 September 2012: L21). Learner 50 asserted that with time ‘things change and develop’. This learner stated that the tree-bark, paper and book he brought along, constituted development since ‘they use trees to make paper and then they print books’ (FN-21 September 2012: L50). The development of suburbs and the subsequent increase in buildings were also portrayed by learners in their drawings (DA-25 July 2012).

The participating learners also affirmed that the minutes on a digital clock change ‘when a minute goes by’ (VA-3 September 2012: L2 - line 802). Learner 50 (VA-3 September 2012: L50 - line 808) stated that after 59 minutes on a digital clock ‘it will change and turn to 00’ because then ‘a new hour’ will start. When asked what will happen with the first two digits, learner 61 replied that it will change to 09, since it will be ‘nine o’clock’ (VA-3 September 2012: L61 - line 815).

According to the participating learners, elements of nature and objects also deteriorate over time. Learners 40 and 25 (DA-25 July 2012: L40, L25) asserted that ‘we almost do not have any forests left’ because ‘people build even more houses’. When they had to bring something from home which would represent the concept of time (see Section 4.5.8), learner 11 brought three horseshoes, one new, one old and one rusted, and stated that ‘things which are exposed to the elements will rust over time’ (FN-21 September 2012: L11).

Learner 23 drew a seed which germinates and grows into a big tree. He also drew that specific tree which died eventually. The learner suggested (DA-19 September 2012: L23) that ‘when you plant a seed and you care for it, a tree will develop, but it will eventually die’ and deteriorate (see CD 1, CLOCKWISE, Activity 8.6). In accordance, learner 76 also believed that butterflies and flowers deteriorate as time goes by. The learner drew a rag doll with flowers and a butterfly in the garden and stated: ‘When you are little you play with a rag doll but when you grow up you play with different toys. Butterflies and flowers can die, but time does not go by for a rag doll’ (DA-19 September 2012: L76). Inherent in the above statement is the learner’s understandings that not all things deteriorate and develop over time. In general, learners also believe that time goes by and has a recurring nature.

#### 5.3.1.1.2

#### Category 1.1.2: Learners understand that time goes by

The learners’ understandings that time constitutes change, goes by and has a recurring nature guided their visual and verbal representations. From the following citations: ‘It’s like time that passes from morning to night’ (VA-26 July 2012: L21 - line 165) and ‘With time the seasons pass’ (VA-26 July 2012: L50 - line 121), the research team concluded that learners believe that time goes by. Learner 39 stated that the hour hand should ‘climb over the three’ when it is ten minutes past 3 because ‘it has been three o’clock already’ (VA-6 September 2012: L39). The learners’ understandings were clearly illustrated in their verbal and visual representations as well as the objects they brought to depict a concept of time (see Sections 4.5.1 and 4.5.8).

Several learner participants suggested that time goes by and that it represents the ending of an action or a lifetime. Learner 12 (DA-19 September 2012: L12) explained that the two women in the drawing have finished their work for the day therefore ‘they sit and chat with each other whilst the day passes’, whilst the women in learner 21’s drawing ‘tries to make the day longer because she still has a lot of work to do. Therefore, she tries to hold back time’. Learner 59 (FN-23 July 2012: L59) asserted that ‘at the end of each day your



life is one day shorter’, whilst learner 37 (FN-26 July 2012: L37) affirmed that ‘time is like flowers that grow and die’.

It is evident from the data that learners understand that the speed with which time passes can be measured. Learner 35 (FN-26 July 2012: L35) commented that ‘time goes by quickly when it is your birthday, but it takes longer to wait for your birthday’. Learner 11 (DA-19 September 2012: L11) drew athletes running a race in Activity 8.6 (see CD 1, CLOCKWISE) and explained that ‘the winners’ time will be the fastest and the last one’s time will be the slowest’. Learner 17 (DA-19 September 2012: L17) drew a butterfly and suggested that it illustrates ‘how seasons fly by’ as well as a tortoise to demonstrate ‘how slowly time goes by.’

A few learners also suggested that ‘as time goes by things change.’ One noted that ‘a flower is closed and then it opens. Then the leaves fall off and the flower dies’ (DA-21 September 2012: L76). Learner 53 and learner 78 explained that ‘as you get older the size of your pants change and you can play with larger balls’ (DA-21 September 2012: L53, L78). Furthermore, learner 7 suggested that ‘when pencils are sharpened and used over time they turn out to be shorter’ (DA-21 September 2012: L7), whilst learner 2 mentioned that ‘hard work will make you richer as time goes by’ (DA-21 September 2012: L2) – (see CD 1, CLOCKWISE, Activity 8.8).

Learner 7’s (FN-26 July 2012: L7) statement that ‘seasons pass and return with cold and heat’ also drew attention to the participating learners’ perception that time is recurring. Learners participating in the study indicated that time have a recurring nature which affects their own lives and natural occurrences. Their representations and descriptions consequently primarily focused on events such as urbanisation, birthdays, seasons as well as days and nights which are recurrent. A citation such as ‘As time goes by you are born, you go to school and you are a teenager and then a mother. Then your child goes to school...’ (DA-19 September 2012: L40); highlighted learner participants’ perception that growth and destruction can be recurrent.

Since Jeannie Baker's book *Window* (Baker, 2002) chronicles urbanisation, learners initially focused their attention on the destruction of nature which they indicated can be recurrent. Nevertheless, they also explored the possibility that destruction and growth are closely related. Learner 50 (FN-21 September 2012: L50) initially focused on the destruction of the trees in Baker's book, but eventually concluded that they also 'use trees to make paper'. Learner 82 (DA-25 July 2012: L82) also noticed that 'the wood of the shed has deteriorated', but he realised that the washing line which was built in its place and which will also eventually deteriorate represented development. Participating learners knew that 'seasons start when you are born and continue until you die' (FN-26 July 2012: L37) and that 'seasons always come in a specific order' (FN-26 July 2012: L2). Learner 75 (FN-19 September 2012: L75) noted that 'low tide and high tide' is a recurrent phenomenon at the seaside, whilst many participating learners' affirmed that day and night are also recurrent. The assertion that 'it is light and then it turns into darkness and then it is light again' and 'it is day and then night and then day again' supports their perception (FN-26 July: L53, L26). Finally, learners also believed that birthdays are recurrent. Learner 35 (FN-26 July: L35) proclaimed that birthdays come around every year on the same day but he also mentioned that 'grownups do not like it, but children do' since they would like 'to be big'. He noted that he could not wait for his birthday to come around every year, because he wants to grow up quickly to 'be a policeman and to catch criminals'.

The innovative teaching strategies, such as the collages in the book *Window* (Baker, 2000), the painting of Salvador Dali and objects which depicted a concept of time, elicited the participant learners' curiosity. It also encouraged learners to build upon their own understandings. Therefore, the participant teachers provided opportunities for the participant learners to build upon their personal understandings of the concept of time.

### 5.3.1.2

**Sub-theme 1.2: Innovative teaching strategies provide opportunities for learners to understand the concept of mathematical time**

During the pre-implementation phase of the CLOCKWISE mathematical programme, Mia stated that instruction should begin with the identification of hours on analogue

clocks, followed by the introduction of half-hours and then minutes past the hour and minutes to the hour (I<sup>1</sup>-18 June 2012: Mia). Lisa corroborated Mia's statement and suggested that 'then digital time can follow' (I<sup>1</sup>-18 June 2012: Lisa). One of the other Grade 2 teachers at the research site also suggested that hours and half-hours should be taught first (I<sup>1</sup>-20 June 2012). The Grade 2 teachers at the research site also suggested, in their semi-structured interviews in the pre-implementation phase of the study, that learners' understanding of the mathematical concept of time would be enhanced if each of them had their own clock face to work with (I<sup>1</sup>-19-20 June 2012). Primarily, the Grade 2 teachers believed that the sequence of instruction and the use of clock faces encouraged the learners' growth of mathematical understanding of the concept of time. However, all of them suggested, in the pre-implementation phase of this study, that Grade 2 learners still struggled with minutes to and minutes past the hour on analogue clocks and p.m.-times on digital clocks.

In the post-implementation interview with the participant teachers, Mia was asked to explain the effect the implementation of the CLOCKWISE mathematical programme had on her teaching. She exclaimed: 'I realised that where I initially started with the teaching of time, was a TOTAL lost case scenario!' (FI-15 October 2012: Mia). She also mentioned that the learners 'must understand and describe certain times and time vocabulary in their own words' (I<sup>2</sup>-24 September 2012: Lisa). Lisa also stated that 'you can build on learners' understandings to teach new concepts' and she also mentioned that the learner participants could 'explain why they write or draw something' (I<sup>2</sup>-24 September 2012: Lisa). Therefore, *learners' new understandings of the concept of time influence the sequence of instruction and encouraging learners to represent their own ideas on the concept of time strengthens their understanding of mathematical time* are relevant categories within this sub-theme.

#### 5.3.1.2.1

**Category 1.2.1: Learner's new understandings of the concept of time influence the sequence of instruction**

Instruction in the CLOCKWISE mathematical programme started with hours on digital clocks, followed by hours on analogue clocks. Thereafter, half-hours on analogue and

digital clocks were discussed. Furthermore, the programme focused firstly on minutes past the hour on digital clocks and secondly on minutes past the hour on analogue clocks before the instruction of minutes to the hour on analogue clocks and digital clocks commenced (FI-15 October 2012). During the post-implementation phase of the programme, I reflected in my research diary that the sequence of instruction encouraged learners' growth of understanding of the concept of time (RD-10 October 2012). Mia explained that she had always been under the impression that learners should at least understand the meaning of vocabulary such as hours, half-hours, quarters and minutes to understand mathematical time. Since starting with the programme, she realised that 'it is definitely NOT what they needed' (FI-15 October 2012, Mia). Therefore, Mia suggested that it is imperative to initially focus on the learners' understandings that 'a day has 24 hours' (FI-15 October 2012, Mia) when the teaching of mathematical time commences. Lisa also suggested that teachers 'must know what the learners' perceptions of time are' (I<sup>2</sup>-24 September 2012, Lisa).

Instruction in the implementation phase of this study started with the 24 hours on digital clocks (see CD 1, CLOCKWISE, Activity 3.2), since learners must 'understand that there are 24 hours in one day' (FI-24 September 2012, Mia). Activity 3.6 and Activity 3.12 focused upon the differentiation between times in the morning, afternoon and night. I noted in my personal research diary that Mia and I discussed learners' apparent struggle with the concept of time periods (RD-14 September 2012). Hence, the research team decided to adapt the activity. It culminated in the learners' ability to successfully complete a task-based activity (see CD 1, CLOCKWISE, Activity 3.18) which required them to represent different a.m. and p.m. times and time periods on a time chart. The participant learners were able to distinguish between times and actions in the morning, afternoon and night. Learner 70 (FN-17 August 2012: L70) asserted that he 'is still in bed at 03.00, whilst his dad goes to work very early in the morning'. Learner 29 (FN-17 August 2012: L29) asserted that 'it is a cloudy day', therefore the lights are on in the house at 14:00.

Thereafter, the instruction of hours on analogue clocks could commence, since learners could explain that the minute hand is on the twelve because 'it is exactly where a new

hour will start' (VA-27 August 2012: L2 – line 559). Instruction of hours was followed by half-hours on analogue and digital clocks, since learners' expressions indicated that they grasped the concept of 30 minutes. Learners stated that the hour hand must 'exactly be in the middle of two numbers' since the hand 'is halfway on its way to the next hour' (VA-27 August: L25 – line 569, L2 – line 571). Activity 5.3 (see CD 1, CLOCKWISE) was utilised to establish how many minutes there are in a half-hour. After cutting the analogue clock in half, learners understood that a half-hour 'is half of an hour' (VA-27 August: L40 – line 597), that it 'equals 30 minutes' (VA-28 August: L60 – line 627) and therefore the minute dial should be on the 6 'because it is precisely in the middle' (VA-27 August: L25 – line 569). Subsequently, learners also realised that ':30' indicated half-hours on digital clocks (VA-28 August 2012: L83, line 689).

Learners' explained that 'you write an eight and then you make two dots followed by a ten' (VA-3 September 2012: L38 – line 785) and 'you write a 21 because it was 9 o'clock at night and a 20 because it has already been twenty minutes past nine' (VA-3 September 2012: L50 – lines 833-839). Furthermore, learners had no problem with minutes past on analogue clocks. Activity 6.4 (see CD 1, CLOCKWISE) encouraged learners to jump across a rope which divided an analogue clock in half, in order to distinguish between the two sides of an analogue clock (RD-5 September 2012). Thereafter, they seemed to be knowledgeable of the fact that minutes past indicated that the hour in question had already passed, therefore the hour hand must cross the hour in question and the minute hand must be on the right side of the clock. Minutes to the hour are a difficult concept, as we realised during the pre-implementation interviews with all the Grade 2 teachers (I<sup>1</sup>-18-20 June 2012), however, many learners attained this concept since the 'position of the hour and minute hands as well as counting of minutes in multiples of five had not been a problem' (RD-13 September 2012) (see CD 2, Results).

Lisa corroborated my observation that the sequence of instruction influenced the learners' attainment of hours, half-hours, minutes past the hour and minutes to the hour (FI-15 October 2012). She also affirmed that after the CLOCKWISE mathematical programme was implemented, 'learners could explain why they write or represent' times in a certain

way (I<sup>2</sup>-24 September 2012, Lisa). Representation of their own ideas on the concept of time, therefore, also strengthened their understanding of the mathematical concept of time.

#### 5.3.1.2.2

**Category 1.2.2: Encouraging learners to represent their own ideas on the concept of time, strengthen their understanding of mathematical time**

During the pre-implementation phase of the CLOCKWISE mathematical programme, participant teachers agreed that the utilisation of analogue clock faces would enhance learners' understanding of the mathematical concept of time (I<sup>1</sup>-19, 20 June 2012). Visual representations such as pictures, learners' drawings, physical objects and a painting of Salvador Dali were, however, also employed by participating teachers in the implementation phase of the CLOCKWISE mathematical programme. These representations encouraged learners to think about the concept of time in their daily lives and to apply their new knowledge in situations within their daily lives.

Mia (I<sup>2</sup>-24 September 2012) stated in the post-implementation semi-structured interview, that 'the drawings which they continuously made, enhanced their understanding'. She explained that, whilst examining the collages in the book *Window* by Jeannie Baker all by themselves, the learners came to the conclusion that 'time goes by and that time is recurring' and that over time things change (FI-15 October 2012: Mia) (see CD 1, CLOCKWISE, Activity 1.1 and 1.2). Learners' drawings and their explanations were also utilised to assess their growth of understanding of the concept of time during the implementation phase of the study.

During Week 3 of the implementation phase, the participant teachers focused upon the teaching of time periods and subsequently on the representation of hours on digital clocks. To assess the learners' attainment of hours on digital clocks, they encouraged the participant learners to represent their understanding of digital times by means of different coloured lights shining through the windows of a house (see CD 1, CLOCKWISE, Activity 3.18). Learner 70 explained that the yellow lights shining through the windows suggested that at 19:00 they have to switch on the lights since it is dark

inside the house (FN-17 August 2012: L70). Learner 80 drew a picture of himself sleeping in bed at 03:00. He explained that 'he is dreaming of cars jumping over ramps' at that time of day (FN-17 August 2012: L80). During Week 8 of the implementation phase, the participant teachers discussed the painting of Salvador Dali, *The Persistence of Memory*, with the participant learners. These discussions encouraged the learners to reflect upon their own ideas and perceptions of what the clocks or painting represents. Thereafter, the learner participants had the opportunity to draw anything which they believed portrayed the concept of time (see CD 1, CLOCKWISE, Activity 8.6). Learner 73 drew a deserted park and identified the time as nine o'clock in the morning. The learner explained that 'the children are at school at nine o'clock in the morning' but there will be 'people in the park every afternoon at three o'clock' (FN-19 September 2012: L73). Learner 59 drew a rising sun and explained that 'the sun rises, then time goes on' (FN-19 September 2012: L59).

To conclude the implementation phase of the CLOCKWISE mathematical programme, the participant learners were required to bring objects to school which symbolised a concept of time (see CD 1, CLOCKWISE, Activity 8.8). Learner 47 brought baby food, a slice of bread and a biscuit and explained that 'as you get older and your teeth grow, you will start eating different food' (FN-21 September 2012: L47), thus strengthening her understanding that things change and develop as time goes by. The participant teachers' strategy to utilise learners' representations of time concepts to strengthen the learners' understanding of the concept of time, can therefore be described as successful within this study.

The learners' and teachers' understandings of the mathematical concept of time directed Theme 1. The collated data also provided insights into the effect of and the importance of the participants' personal experiences of time in their daily lives. Thus, the meaning of mathematical time in terms of their personal experiences is explicated in Theme 2.

**5.3.2****Theme 2: Mathematical and pedagogical content knowledge of the concept of time emerge from real-life experiences**

In this study, it is evident from all the Grade 2 teachers' pre-implementation interview data (I<sup>1</sup>-18-20 June 2012) that their mathematical content knowledge influenced their pedagogical content knowledge (teaching strategies) (see Section 2.3). The teachers believed that Grade 2 learners should understand that a single day consists of 24 hours and that the hour-dial and the minute dial have different functions, in order to understand the concept of analogue and digital time. Hence, their pedagogical content knowledge encouraged them to utilise clock faces to differentiate between the function of the hour- and minute dials on an analogue clock. They also defined a.m.-times as times in the morning (01:00-12:00) and p.m.-times as times in the afternoon and night (12:00-00:00). The Grade two teachers, however, stated that Grade 2 learners struggled to differentiate between the positions of the minute and hour dials, minutes past and minutes to the hour on digital clocks and p.m.-times (I<sup>1</sup>-18-20 June 2012). This study, therefore, explored how real-life experiences influenced the teachers' teaching and learners' learning of the mathematical concept of time. The sub-themes are therefore constructed as *daily life and real-life experiences influence learners understanding and representation of the concept of time* and *daily life and real-life experiences of learners influence the way teachers teach*.

**5.3.2.1****Sub-theme 2.1: Daily life and real-life experiences influence learners' understanding and representations of the concept of time**

In addition to their understanding that time constitutes change, learners believed that there is a relationship between specific times and specific events or actions. In the post-implementation interview with Mia (I<sup>2</sup>-24 September 2012: Mia), she stated that since learners understood the different time periods, 'they were aware of time in their daily lives'. When the participant learners were asked to portray their understanding of time, their drawings, written accounts and verbal representations all through the study suggested that they, as Grade 2 learners, were familiar with mathematical concepts



such as morning, afternoon, night, seasons, as well as hours, and the influence thereof on their personal lives and daily activities. Hence, their notion that time directs specific events or actions, is significant in their identification of time periods (see Representation 5.2 below).



**Representation 5.2: The significance of time in learners' daily lives**

Learner 93's assertion that 'time is a clock which tells you what to do now' (FN-23 July 2012) therefore underpins this sub-theme. Consequently, categories of this sub-theme were recognised as *specific times periods direct learners' attention to personal experiences* and *learners understand the relationships between certain experiences and the time of day through the exploration of time concepts*.

**5.3.2.1.1 Category 2.1.1: Specific time periods direct learners' attention to personal experiences**

During the implementation phase of the CLOCKWISE mathematical programme, it was apparent that the participant learners could identify the three time periods within one

day as morning, afternoon and night. In the post-implementation focus group interview with all the Grade 2 teachers at the research site, Mia mentioned that ‘it opened worlds for the learners when she demonstrated to them which hours represent time in the morning and which hours represent night time’ (FI-15 October 2012). Participating learners could also distinguish between the four seasons in a year. The participants’ data revealed that they believed that time directed the change of seasons, special events and milestones in one’s life and important occurrences. When asked in Activity 1.5 (see CD 1, CLOCKWISE) to illustrate what time is all about, many learners described and represented seasons. Learner 25 (DA-19 September 2012) explained that the picture she drew of a swimming pool and girl with a swimsuit illustrates summer, which is ‘a time to swim and have green grass and pretty flowers in our gardens’. Many learners could distinguish between the four seasons and associated certain events with each of them. Learner 11 (FN-26 July 2012: L11) noted that when seasons change it becomes cold or warm. Winter has been associated with rain in Cape Town (VA-26 July 2012: L61 – line 130), snow on mountain peaks (VA-26 July 2012: L26 – line 128), birds flying away (FN-26 July 2012: L18) and the hibernation of snakes (VA-26 July 2012: L59 – line 135). The learners also seemed to be knowledgeable of the fact that the colours of leaves change in autumn, and that it is hot in summer but cooler in spring. Learner 2 (FN-26 July 2012: L2) proclaimed that ‘it must be spring in December because it is school holiday and it is too warm when it is summer time in December’. However, learner 61 (FN-26 July 2012: L61) wished that it could be winter in December. He stated that ‘it is Christmas and I would like to play in the snow and sit in front of the fireplace’. Learner 12 (FN-26 July 2012: L12) wished that winter could be in April, May, July and August since it is cold in winter and she ‘loves the cold air and to eat soup and bread’. She explained that it must be autumn in June since ‘it is not as cold as winter’ and she wanted ‘to play netball’. Then winter could start all over again.

During the implementation of the CLOCKWISE mathematical programme, learners had to discuss concepts which they believed a picture of burning candles represented (see CD 1, CLOCKWISE, Activity 1.4). Most of the participating learners asserted that the candles represented someone’s birthday which comes only once a year on a specific day. On the contrary, a few learners (FN-26 July 2012: L11, L70, L76) declared that the candles

were burning because there had been an electricity failure. They asserted that ‘since it is dark and seven o’clock at night, it is necessary to use burning candles to move around safely’ (VA-26 July 2012: L11 - line 79, L70 - line 75, L76 - line 82).

Learner 78 stated that ‘you must be on time. If you arrive later than 08:00 at the church you can’t enter’ (DA-19 September 2012: L78). This supposition emphasises learners’ belief that specific events take place at specific times. They noted that there is a time to go to school, to play, to bath, to hunt, to sleep, to work and to camp. Learner 31’s statement that the driver of the car she drew ‘is now old enough to drive a car’, corroborates learners’ understanding that time directs special milestones in one’s life (DA19 September 2012: L31). In addition to learners’ understanding that time periods direct certain events in their lives, many learners indicated that time also imposes specific actions such as sleeping, watching television, working, playing, sunset, sunrise and low tide.

### 5.3.2.1.2

**Category 2.2.2: Learners understand the relationships between certain experiences and the specific time of day through the exploration of time concepts**

The learners had much to say about the relationship between specific actions or experiences and the time of day or night. The learners were required to draw something which depicts the concept of time (see CD 1, CLOCKWISE, Activity 8.6). Learner 3 (DA-19 September 2012: L3) stated that ‘at a certain time of day you must prepare food in the kitchen’, whilst learner 82 (DA-19 September 2012: L82) concluded that the girl in the drawing ‘must water the plant at the right time to keep it from burning in the sun, so that it can flower in the spring’. Even the lions in learner 42’s drawing ‘want to catch the horses, but they wait for the right time’ which supposedly is ‘six o’clock’ (DA-19 September 2012: L42). Learner 73 (DA-19 September 2012: L73) also concluded that ‘the park is empty because the children are at school at 9 o’clock. But every afternoon at 3 o’clock there are people in the park’. When learners had to discuss concepts which they believed a picture of a diary represented (see CD 1, CLOCKWISE, Activity 1.4), a few proclaimed

that it is a book which directs your attention to important meetings and appointments which take place at specific times (FN-26 July 2012).

The participating learners seemed to have an understanding of their own actions at a specific time of day. This highlights their understanding of the relationship between experiences and the specific time of the day. Many corroborated learner 7's statement that 'when the sun rises it is morning and when the sun sets or the moon rises it is night-time' (FN-26 July 2012: L7). Whilst many of the participating learners suggested that you have to switch the lights in your home on at night, learner 21 and learner 92 stated that their lights are switched off at 19:00 to illuminate the view of the television and to save electricity respectively (FN-17 August: L21, L92).

Lisa stated that 'since learners were familiar with times in their daily lives, teachers could relate time periods to learners' lived experiences (I<sup>1</sup>-24 September 2012: Lisa). From the data analysed and presented in this category it is evident that the learner participants could also focus upon time periods, which affected the teachers' teaching.

### 5.3.2.2

#### Sub-theme 2.2: Daily life and real-life experiences of learners influence the way teachers teach

I noted in my personal diary (RD-3 August 2012) in the implementation phase of this study that the participant learners struggled to grasp the concept of time periods. Therefore, they initially could not divide the 24 hours of a day into morning, afternoon and night periods. The research team then decided to focus their attention on times in their daily lives and on their real-life experiences to enhance their understanding of the concepts of time such as time periods. In the post-implementation phase of this study, Lisa stated that 'when they can divide the day into 24 hour-zones, they can write and read digital time' (I<sup>2</sup>-24 September 2012: Lisa). The participant teachers in this study therefore asked thought-provoking questions and they elicited task-based activities to encourage learners to think about their real-life experiences. Thus, the following categories are relevant to this sub-theme: *thought-provoking questions encourage learners to think about real-life*

*experiences and to create clear definitions of time concepts and task-based activities encourage learners to relate their real-life experiences to specific time periods.*

### 5.3.2.2.1

**Category 2.2.1: Thought-provoking questions encourage learners to think about real-life experiences and to create clear definitions of time concepts**

The Grade 2 teachers at the research site did not mention in the pre-implementation phase of this study that it is important to relate specific times to the learners' real-life experiences in order to enhance their understanding of mathematical time. The participant teachers, however, noted in their post-implementation interviews that it is important to focus learners' attention on the vocabulary related to mathematical time and to relate times to their personal experiences (I<sup>2</sup>-24 September 2012: Mia, Lisa). Thought-provoking questions were therefore employed to encourage learners to describe concepts and their personal experiences in their own words.

In Week 3, Activity 3.6 (see CD 1, CLOCKWISE), the participant teachers asked their respective learners to explain what the term 'day' means. Learner 50 explained that day means it is 'morning and afternoon' (VA-14 Augustus 2012: L50 – line 226). On request, he also stated that it is night-time when it is dark outside. The participant learners subsequently understood that there are 24 hours in one day (VA-14 Augustus 2014). Learners then realised that 'there is not enough space for 24 numbers on an analogue clock', therefore, 'the hour hand has to go round the clock twice in one day' (FN-21 August 2012: L2 – line 543). On request, learner 2 stated that 'the hour hand goes around twice in one day' (FN-21 August 2012: L2 – line 545), 'once in the morning and once in the afternoon or night'.

The participant learners were also requested to devise a plan to help people differentiate between times in the morning, afternoon and night on analogue clocks (VA-20 August 2012). Learner 26 (VA-20 Augustus 2012: L78 – line 306) suggested that both the dials and the digital time should be on the clocks. According to learner 92, 'you can put a picture in the clock and in that picture there can be a sun and a moon. Then, if there is a moon, it

is night' (VA-20 Augustus 2012: L92 – line 314). In Activity 4.6 (see CD 1, CLOCKWISE) the participant learners were asked the difference between 8 a.m. and 8 p.m. Learner 50 explained that 'eight o'clock at night it is dark and cold. Eight o'clock in the morning the sun comes up and it is light' (VA-20 August 2012, L50 – line 535-536). These statements highlighted the participant learners' understanding that time periods can be related to specific times of the day and that they created clear definitions of time concepts such as day and night. Mia (FI-15 October 2012: Mia) stated in the post-implementation phase of this study that 'participant learners could differentiate between day-times and night-times'. She said 'it opened the world to them!' This understanding encouraged the participant teachers to employ task-based activities to encourage learners to relate their real-life experiences to specific time periods.

#### 5.3.2.2.2

**Category 2.2.2: Task-based activities encourage learners to relate their real-life experiences to specific time periods**

As revealed in the data, many participant learners' daily activities were central to most of their drawings and discussions. This influenced the participant teachers' teaching strategies. Mia (FI-15 October 2012) concluded, in the post-implementation focus group interview, that the CLOCKWISE mathematical programme enabled learners 'to divide the 24 hours of each day into time periods'. She also stated that 'this knowledge directed their attention to time in their own schedules, which consequently made the understanding of specifically digital times easier to grasp'.

In Activity 3.18 (see CD 1, CLOCKWISE) during the implementation phase, a house with two windows was cut out of cardboard. Learners could then choose between blue, yellow or black papers which represented daylight, indoor lights and darkness respectively, to cover the windows. They also had to choose a time of day and an action which was represented by the covered windows. Hence, learners could exploit their own understandings to differentiate between hours of the day. Learners who attained this knowledge could for instance differentiate between 03:00 which for most of them exemplified early morning, darkness and sleep and 15:00 when their homework is done and they can play outside whilst the sun is shining (FN-17 August 2012). Many learners

described what they did in the afternoon on Worksheet 2 (see CD 1, CLOCKWISE, Activity 3.19). Some of them noted that they play video games at 15:00, whilst others stated that they play outside with their friends, dogs or with a ball when their homework is done (FN-17 August 2012).

The participant teachers also expressed opinions on the effect of the CLOCKWISE mathematical programme and the teaching strategies. They emphasised that participants were verbally, visually and physically involved in the construction of knowledge in the implementation phase of this study. Therefore, I report on the teaching strategies the participant teachers employed with the intention of enhancing the participant learners' active exploration of the concept of time in Theme 3.

### 5.3.3

#### **Theme 3: Deeper exploration of the concept of time scaffolds and develops learners' and teachers' mathematical knowledge and understanding**

The collated data revealed that informal discussions and applied teaching strategies facilitated the active participation of both teacher and learner participants. The classroom discussions encouraged learners to 'explain time vocabulary such as minutes to the hour, minutes past the hour and half-hours in their own words' (I<sup>2</sup>-24 September 2012: Mia). The participant teachers and learners also discussed the CLOCKWISE IN AFRICA story (see CD 1, CLOCKWISE), which enabled the participant teachers to assess the participant learners' growth of understanding of the concept of time unobtrusively. The participant teachers in the study also utilised number lines, one-handed clocks and games to encourage the participant learners to explore time concepts such as minutes to and past the hour. These discussions, storytelling, games and innovative manipulatives encouraged the active participation of the learner participants, which culminated in the attainment of the mathematical concept of time (I<sup>2</sup>-24 September 2012: Mia, Lisa) (see CD 2, Results).

The following sub-themes emerged throughout the study: *language has a distinctive function in the exploration and communication of time concepts and teaching strategies*

*encourage learners' exploration and understanding of the concept of time.* In the following section I describe each of the sub-themes and relevant categories.

**Sub-theme 3.1: Language has a distinctive function in the exploration and communication of time concepts**

**5.3.3.1**

In the pre-implementation phase of this study, Mia (I<sup>1</sup>-18 June 2012: Mia) was convinced that the participant learners must learn and use terms such as hours, half-hours and minutes to the hour, for them to understand the mathematical concept of time. She, however, stated in her post-implementation semi-structured interview (I<sup>2</sup>-24 September: Mia) that learners' must describe and explain mathematical time vocabulary in their own words' in order to master analogue and digital time. In accordance, Lisa also stated that learners 'should understand and explain their actions and half-hours, hours and minutes in their own words' (I<sup>2</sup>-24 September: Lisa). The data therefore highlighted the distinctive function of communication in learners' explorations of the vocabulary of time concepts.

**5.3.3.1.1**

**Category 3.1.1: Communication encourages active exploration of the vocabulary of time concepts**

Communication skills usually imply verbal communication, however, the term encapsulates verbal, visual as well as written language in this study. During the pre-implementation phase of the CLOCKWISE mathematical programme, my co-researchers and the other Grade 2 teachers believed that basic mathematical language such as hours, half-hours and minutes must be learnt by learners (I<sup>1</sup>-18-20 June 2012). They also proclaimed that Grade 2 learners need to know what each side of the analogue clock is called in order for them to identify the position of the minute dial on analogue clocks. The Grade 2 teachers, however, noted that learners still had problems with the identification of the different sides of analogue clocks in the pre-implementation phase of the study (I<sup>1</sup>-18-20 June 2012).

Whilst participating in the activities during the implementation phase, many participant learners expressed their growth of understanding visually. Numerous pictures were drawn to illustrate specific events, times on clocks and concepts of mathematical time



(see CD 1, CLOCKWISE, Activities 3.19 and 5.11). 'From these drawings, teachers could make inferences about learners' growth of mathematical understanding to make timely adjustments to their teaching and to learners' understanding' (FN-13 August 2012). Learners were also asked to represent their understanding in writing (see Representation 5.3). It facilitated member checking which made the learners' perceptions and understanding apparent to the teachers and their friends.



'It's 8 o'clock at night. I am sleeping but mom and dad are still awake.'

'My friend and I play outside with a ball. Our homework is done and it is 3 o'clock in the afternoon.' (FN-L9: 16 August 2012)

### Representation 5.3: Learners' communication of the concept of time

Whereas in the pre-implementation phase, Mia was convinced the learners need to learn these terms, in the post-implementation phase of this study, Mia asserted that 'learners must explain vocabulary such as hours, half-hours and minutes in their own words if they are expected to understand the concepts and to apply the knowledge' (12-24 September 2012). She also proclaimed that learners understood concepts better when the concepts are 'explained in everyday language'. Learners were able to verbalise why the left or right side of an analogue clock represents minutes to or past respectively, because they could relate to the actual actions they performed whilst jumping across the rope and telling their friends where they landed in Activity 6.4 (see CD 1, CLOCKWISE).

During the implementation phase, learners were also encouraged to describe their actions whilst working with the manipulatives such as number lines and one-handed clocks in the CLOCKWISE mathematical programme. Learners understood half-hours in the post-implementation phase of the study; they were able to describe that the hour hand passed the exact hour and is ‘precisely in the middle of the two hours’ (VA-27 August 2012: L59 - line 569) because the minute dial is ‘halfway around the clock’ (VA-27 August 2012: L23 - line 603). Many learners understood that the hour hand shows approximate times, whilst the minute hand shows exact times on analogue clocks (FI-15 October 2012), therefore they could immediately identify that the hour hand is still ‘on its way to the next hour’, whilst the minute dial is ‘exactly on 10 minutes to’ the hour (FN-11 September 2012, L38). These conclusions also highlighted the interplay of daily and mathematical language.

#### 5.3.3.1.2

#### **Category 3.1.2: The interplay of daily and mathematical language enhances mathematical understanding during the exploration of time concepts**

During the pre-implementation phase of the CLOCKWISE mathematical programme, teachers’ instruction focused primarily on the reading of times on clock faces. Thus learners’ instrumental understanding was the focus of their instruction. Both Mia and Lisa however asserted that mathematical time then still is an ‘abstract concept for learners’ (I<sup>1</sup>-18 June 2012: Mia, Lisa). Post-implementation, Mia (I<sup>2</sup>-24 September 2012: Mia) asserted that ‘learners must be able to describe mathematical vocabulary in their own words in order to really understand the concepts and to apply their knowledge’.

I therefore concluded that ‘teachers should initially focus on learners’ explanations and understandings before introducing mathematical language’ (FI-15 October 2012). After our attention was drawn to learners’ understandings, concepts were explained using everyday language within the CLOCKWISE IN AFRICA story. Learners were not told that the minute hand must be on the twelve to indicate hours, but they were given the opportunity to express their own ideas about how time on analogue and digital clocks should be presented. Learner 25 (RD-14 August 2012: L25) explained that the twelve must be at the top of the analogue clock, since it indicates that ‘the new day starts here’ and then

the minute hand goes around the clock and then ‘the afternoon starts at the twelve too’. Lisa concluded that ‘learners could explain in their own words why the hour or minute hands had to be on certain numbers, therefore it was much easier to identify times on clock faces’ (I<sup>2</sup>-24 September 2012). Learner 80 noted that we should write ‘:30’ to indicate half-hours on digital clocks, since it is half of an hour and ‘halfway on the way’ to the next hour (VA-28 August 2012: L80 – line 664).

The learners were allowed to initially express their understanding in their own language, which according to Lisa (I<sup>2</sup>-24 September 2012: Lisa) effected their growth of understanding. She stated that ‘learners understood the concepts of time much quicker’. It was not expected of them to use mathematical language from the start but they were encouraged to use mathematical vocabulary as the programme proceeded. Learner 28 stated that the minute dial must ‘climb across the four’ on the analogue clock if we want to represent twenty minutes past four. When prompted, the learner could explain that the time is twenty minutes past four not ‘twenty minutes across the four’. The learner knew which action to perform, why the action should be performed and the learner used mathematical language to read the time with precision (VA-28 August 2012: L28 – line 664).

In Activities 5.7 and 5.8 (see CD 1, CLOCKWISE), a poster was utilised to describe half past the hour on digital clocks. The participant learners were encouraged to describe the position of the car on the poster. Learner 39 noticed that the car is ‘halfway past the 06 road-sign’. When prompted, the learner stated that it is ‘half past 6 in the morning’ (VA-29 August 2012: L39 – line 664). Teaching strategies, consequently, encouraged learners’ exploration of the concept of time which culminated in the use of the mathematical language of time.

### 5.3.3.2

**Sub-theme 3.2: Teaching strategies encourage learners’ exploration and understanding of the concept of time**

During the pre-implementation phase of the CLOCKWISE mathematical programme, teachers’ instruction focused primarily on the reading of times on clock faces. Teachers acknowledged that mathematical time was then still an ‘abstract concept for learners’ (I<sup>1</sup>-

18 June 2012). Therefore, my co-researchers and I agreed that different teaching strategies should be employed to teach the mathematical concept of time. Teaching strategies such as storytelling, games and manipulatives were employed in the implementation phase of this study. Therefore, in this sub-theme and categories *teaching strategies such as storytelling and games engage learners in active exploration and meaning making of mathematical time* and *providing manipulatives such as one-handed clocks encourage learners to make mathematical connections whilst exploring and discovering time concepts* are relevant.

#### 5.3.3.2.1

#### **Category 3.2.1: Teaching strategies such as storytelling and games engage learners in active exploration and meaning-making of mathematical time**

In the pre-implementation phase, teachers believed that time concepts such as hours and minutes past the hour should be explained using mathematical language. Thus, teachers proclaimed in the pre-implementation interview (I<sup>1</sup>-18 June 2012) that learners should know and use vocabulary such as ‘hours, half-hours, quarter of an hour and minutes’. Teachers also used these terms in previous years prior to the implementation of the CLOCKWISE mathematical programme, to explain and teach analogue and digital clock reading.

After the CLOCKWISE mathematical programme was implemented, Lisa as well as Mia stated in their individual semi-structured interviews that the CLOCKWISE IN AFRICA story facilitated mathematical language and the conceptualisation of the concepts of mathematical time, since the concepts were ‘described in everyday language which the learners understood’ (I<sup>2</sup>-24 September 2012). Concepts such as a.m. and p.m. times, minutes to the hour, minutes past the hour as well as the position of the hour dial and minute dial on an analogue clock, were discussed by the animals in the story. Whilst listening to the Clockwise in Africa story, learners also discovered that there ‘is not enough space on an analogue clock for 24 numbers, therefore the hour hand goes around twice in one day’,

(FN-21 August 2012: L2 – line 545).

My attention was drawn to learners' understandings of minutes past and minutes to, when learners played a game outside which gave them the opportunity to identify the two sides of an analogue clock (see CD 1, CLOCKWISE, Activity 6.4). According to Mia (FI-15 October 2012: Mia), actions and changes in the position of their bodies, which are facilitated by visual games such as *What's the time?* (see Section 4.5.3) and *Time Snakes and Ladders*' (see Section 4.5.5), developed learners' relational understanding 'since the concept of mathematical time was not abstract anymore'.

Before the pre-implementation phase of the CLOCKWISE mathematical programme, participating teachers asserted that 'practical work and the use of clock faces are important to teach mathematical concepts of time effectively' (I<sup>1</sup>-18 June 2012). After the implementation of the CLOCKWISE mathematical programme, Mia asserted that 'the CLOCKWISE story, practical work and games which the learners enjoyed immensely, culminated in a better understanding of the mathematical concept of time' (I<sup>2</sup>-24 September 2012: Mia). This assumption was corroborated by Lisa (I<sup>2</sup>-24 September 2012: Lisa). She stated that 'I recognised that learners enjoyed it a lot, especially the games they played outside to facilitate the position of the minute hand on analogue clocks'. Nevertheless, manipulatives were also employed in the CLOCKWISE mathematical programme to encourage learners to make mathematical connections whilst exploring and discovering the concept of time.

#### 5.3.3.2.2

**Category 3.2.2: Providing manipulatives such as one-handed clocks encourages learners to make mathematical connections whilst exploring and discovering the concept of time**

Prior to the implementation of the CLOCKWISE mathematical programme, the Grade 2 teachers at the research site believed that each learner should have a clock face to work with, in order to develop an understanding of the mathematical concept of time (I<sup>1</sup>-18-20 June 2012). They also believed that the handling of clock faces is prerequisite for learners' understanding to progress to a stage where times could be identified on worksheets (I<sup>1</sup>-20 June 2012). Therefore, teachers focused primarily on the use of clock

faces in their teaching before the CLOCKWISE mathematical programme was implemented in their classrooms. However, they also stated that learners still had problems especially with minutes to and past the hour (I<sup>1</sup>-18-20 June 2012).

The participant teachers provided learners with one-handed clocks during the implementation phase of the CLOCKWISE mathematical programme. It culminated in learners' ability to 'initially focus on one hand on an analogue clock in order to avoid confusion of the hands' (RD-21 August 2012). Learners were encouraged to initially only focus upon the hour dial in order to describe approximate times on clock faces. Learners could identify that the hour hand is 'on the ten' when it is ten o'clock (VA-5 September 2012: L35 – line 863), 'halfway on its way to the five' when it is half past four in the day (VA-27 August 2012: L2 – line 571), and 'past the three' when it is ten minutes past three (VA-6 September 2012: L39 – line 863).

In Activity 5.3 (see CD 1, CLOCKWISE), learners had the opportunity to cut a paper analogue clock in half to determine how many minutes a half-hour represents. Thereafter, learners could explain that the minute dial has to be on the six because it 'indicates the middle of the clock which is 30 minutes' (VA-27 August 2012: L40, L25: line 597, 599). Each learner also had the opportunity to individually find the position of their own minute dial on printed analogue clocks which highlighted the 'past' side of the clock (see Representation 4.25). Subsequently learners could distinguish between the position of the hour dial and the minute dial. Learner 39 identified that it was three o'clock if the hour dial is on the three (VA-6 September 2012: L39 – line 908), whilst learner 50 recognised that it was quarter past if the minute dial is on the three (VA-6 September 2012: L50 – line 910).

Teachers encouraged learners to use number lines to 'count backwards and forwards in order to identify the time on digital clocks' (FI-15 October 2012: Lisa). Number lines and pictures were also employed to teach minutes past (see Representation 4.23) and minutes to (see Representation 4.27) the hour as well as half past the hour (see Representation 4.21) on digital clocks respectively. Lisa stated that 'it helped [her] as well as the learners a lot to first subtract one hour on the number line before the minutes were

added to represent half past and minutes to the hour' (FI-15 October 2012: Lisa). Participating learners also discovered that half-hours are represented by ':30' on digital clocks, 'not because their teacher told them, but because they established that 30 minutes equals half past' in Activity 5.3' (as discussed above) (FI-15 October 2012). A poster of a car which is halfway on its way to the next hour, was also employed to encourage learners to represent half-past the hour times on digital clocks (see CD 1, CLOCKWISE, Activity 5.7 and 5.9). The participant learners could then make the mathematical connection that if the car is halfway on its way to the next hour we write :30, 'since it represents half of an hour, which is 60 minutes' (VA-28 August 2012: L60 – line 627). Learners also established that they have to write 05: since the car is still halfway on its way to the 06 when they have to represent half past five on a digital clock (VA-29 August 2012: L11 – line 741). They also realised that they had to write 15: if they had to represent half past three in the afternoon on a digital clock, since the car had already passed the road-sign with the 15 written on it.

## 5.4 CONCLUSION

The data analysis process and thematic analysis process resulted in the identification of three main themes, with sub-themes as well as categories within each of the themes. The data revealed that the employed teaching strategies of the CLOCKWISE mathematical programme facilitated learning processes which consequently encouraged Grade 2 learners' growth of mathematical understanding of the concept of time. In the next chapter, I address my research questions, which I support with statements and arguments from literature and the conceptual framework of this study. I also provide conclusions, recommendations and limitations of the study and conclude with final suggestions for further research.

## CHAPTER SIX: SIGNIFICANCE OF THE INQUIRY



### 6.1 Introduction

In Chapter 5, I delineated the results of this study by presenting the findings which emerged through the data analysis process and the thematic analysis process. In this final chapter I firstly reflect on the research process as, in this practitioner research project, the research process and data analysis process were integrated (see Figure 6.1). Thereafter, I give a synoptic overview of the study and present the findings of the study in terms of the emerged conceptual framework. I also present literature that supports my findings. In addition, I present findings which are contradictory to the body of literature in this research domain. Findings on which the literature is silent are also presented. New insights that emerged from the study are presented and interpreted. In the following sections I answer the research questions that guided the study. I also present my conclusions, recommendations and the limitations of the study. In conclusion, I present my reflective insights as practitioner researcher and my final thoughts on my research project.

### 6.2 The research process at a glance

This study focused on the teaching and learning of the mathematical concept of time in Grade 2 in a South African context. The study therefore explored pedagogical principles and teaching strategies which would encourage the growth of mathematical understanding of the concept of time in Grade 2. The principles and teaching strategies which were deduced from literature and semi-structured interviews with Grade 2 teachers at the research site, assisted the research team to design the CLOCKWISE mathematical programme in the pre-implementation phase of this study. The CLOCKWISE mathematical programme became the core of the study through which teachers' teaching and learners' learning of the mathematical concept of time were



enhanced (see Figure 6.1). Furthermore, this study identified Grade 2 learners' understanding of the concept of time which influenced their conceptual understanding and teachers' teaching of time during the implementation phase of the study. The research emphasised that Grade 2 learners have a deeper understanding of mathematical time when they articulate their ideas and thinking about the concept of time. The study also underlined the need for teachers to employ innovative teaching strategies which will provide opportunities for learners to explore the mathematical concept of time.

In addition, the study examined how mathematical and pedagogical content knowledge of the concept of time emerged from real-life experiences. It was evident that the learners' daily life and real-life experiences influenced the learners' understanding and representations and also the way the teachers teach. The question of how Grade 2 learners' conceptual understanding of time develops as a result of their exploration of the concept of time was also investigated and discussed in the post-implementation phase of the study. This study indicated that language and the teachers' teaching strategies encouraged the learners' exploration and understanding of the concept of time. In the next section I give a synoptic overview of this study.

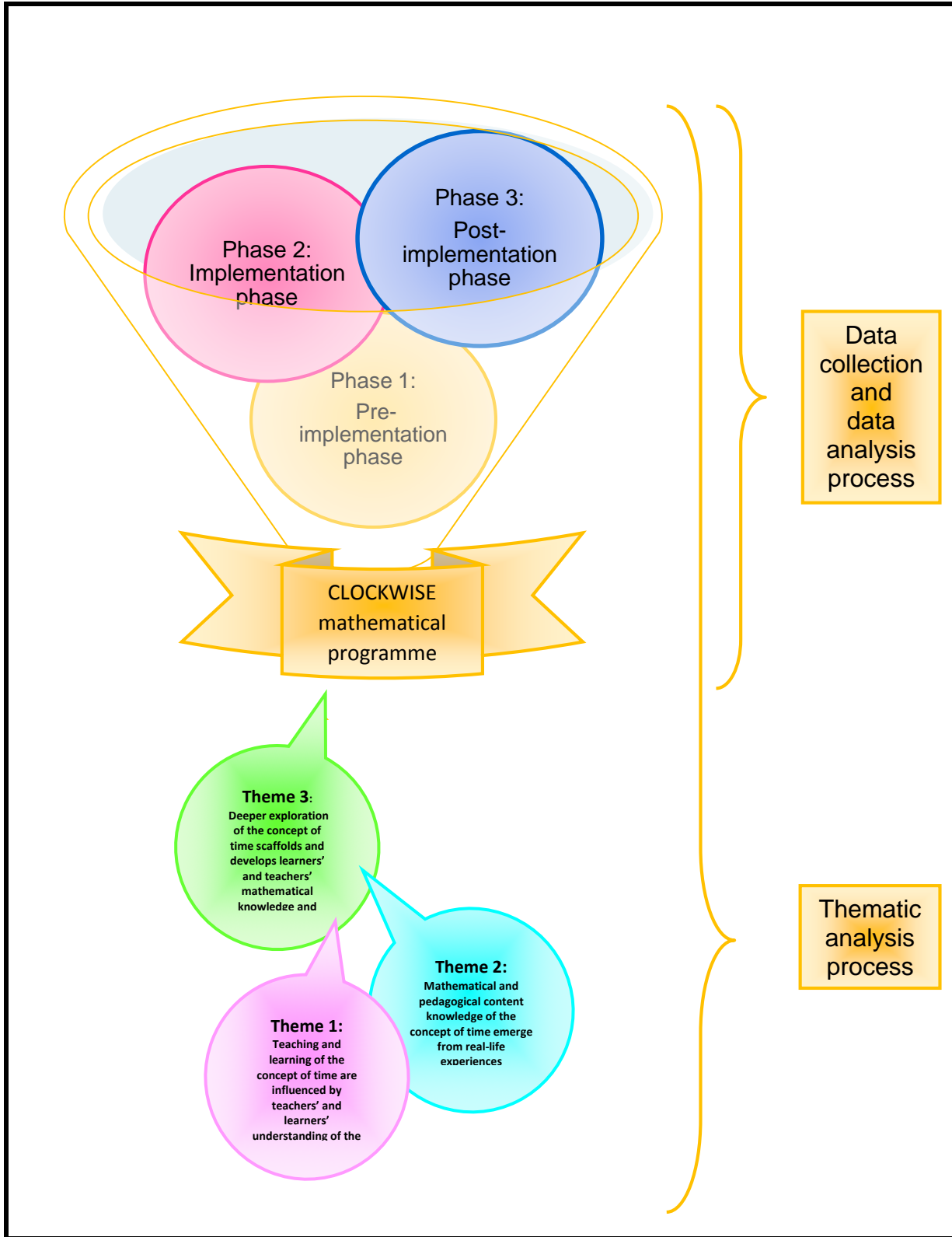


Figure 6.1: A graphical representation of the research process

### 6.3 A synoptic overview of the study

This study was about the teaching of the mathematical concept of time in Grade 2. The purpose of the study was to explore teaching strategies so as to improve Grade 2 learners' conceptualisation of the mathematical concept of time. Furthermore, this study aimed to understand how Grade 2 learners' understanding of the mathematical concept of time developed.

**Chapter 1** focused on the background to the study. It introduced the reader to the research problem, the significance of the study as well as the purpose of the study in relation to the teaching of the mathematical concept of time in Grade 2 classrooms.

In **Chapter 2**, the literature review focused firstly on the theoretical principles which guided the research process as well as the design of the CLOCKWISE mathematical programme. It further explored learning and teaching components related to mathematical time. Pedagogical principles which guided the implementation of the CLOCKWISE mathematical programme were also discussed and this enabled me to present my own conceptual framework for the understanding of the mathematical concept of time.

In **Chapter 3** the research methodology of practitioner research and my role as practitioner researcher were discussed. Furthermore, the sampling procedures and data collection methods as well as data analysis process were described. To conclude this chapter, the ethical considerations as well as the trustworthiness of the study were set out.

**Chapter 4** explored the design of the CLOCKWISE mathematical programme and elucidated the suppositions of the programme as well as the essence of the programme. In conclusion, I reported on challenges and recommendations related to the implementation of the programme.

**Chapter 5** presented a discussion of the integrated data analysis and thematic analysis process of the collated data, which resulted in the identification of three themes. The three themes illuminated key elements of the teaching and learning of mathematical time in Grade 2.

In this **Chapter 6**, as the final chapter, I support my findings with statements from literature. I answer my research questions and address the conclusions, recommendations and limitations of my study.

In the next section I discuss the findings of this study in terms of the conceptual framework.

#### **6.4 Findings in terms of the emerged conceptual framework**

The theoretical principles of the Pirie-Kieren theory for the growth of mathematical understanding and the social constructivist theory of Vygotsky (Pierie & Kieren, 1989; Vygotsky, 1960) assisted me in drafting the conceptual framework of this study. Since *the emergent conceptual framework for the understanding of the mathematical concept of time* (see Section 2.5) puts the Grade 2 learners in the center of the framework, the teaching strategies employed in the study focused upon the active engagement of the learners. Focusing on the learners' personal understandings of mathematical time and their lived experiences, encouraged the learners to actively participate in classroom discussions and to use their knowledge of mathematical time in different contexts.

The utilisation of manipulatives such as number lines and games such as *Time Bingo* illuminated the properties of the concepts of time, which culminated in the learners' growth of mathematical understanding of the concept of time. In addition, learners subsequently started to use mathematical language whilst explaining their visual representations of time. Most learners were also able to convert analogue time to digital time and vice versa. The learners could also apply their new knowledge when they designed their own time-painting which illustrated something about the concept of time. Findings of this study, therefore, indicate that the development of the participant

learners' mathematical understanding of the concept of time was congruent with the developmental levels of the conceptual framework. In the next section, I present the findings of the research project against the background of existing literature in Tables 6.1 to 6.4.

## 6.5 Findings of the study against the background of existing literature

In order to substantiate the findings of this study (in terms of themes and categories), I begin the section by presenting literature which supports the research findings (see Table 6.1). Secondly, I discuss findings which are contradictory to the existing literature (see Table 6.2). Thereafter, I present aspects which are generally found in literature on this research focus, but is silent in my data (see Table 6.3). Lastly, I offer new insights from my findings (see Table 6.4).

### 6.5.1 Supportive evidence within existing literature

**Table 6.1: Comparing research findings to existing knowledge: supportive evidence**

| Category  | Author and year   | Existing knowledge  | Interpretive discussion   |
|---|---|---|---|
| Learners' new understandings of the concept of time influence the sequence of instruction                                     | Donovan & Bransford (2005)<br>Griffin (2004)<br>Holmes (1985) | The teacher should integrate new knowledge with what the learners already know. | This study focused upon the learners' attainment of specific time concepts before new concepts were introduced in subsequent lessons.     |
| Encouraging learners to represent their own ideas on the concept of time strengthens their understanding of mathematical time | Finesilver (2006)<br>Van Oers & Poland (2007)                 | Learners' representations illuminate their thinking and understanding.          | In this study, learners' drawings indicated that they connect the concept of time to something significant in their daily lives.          |
|   | Wilson & Stein (2013)   | If learners discuss their representations, their understanding is enhanced.     | In this study, learners were able to discuss their drawings, actions and the objects they brought from home both verbally and in writing. |

| Category   | Author and year   | Existing knowledge  | Interpretive discussion   |
|--|---|---|---|
|  | Carruthers & Worthington (2006)   | Learners must be encouraged to represent concepts in ways which make sense to them.                       | In this study, learners depicted their ideas of the concept of time in drawings and with objects they brought from home. They also made suggestions on how they believed analogue and digital time should be presented on clocks. |
| Specific time periods direct learners' attention to personal experiences   | Zhang (2005)  | The teaching of mathematical concepts should start from learners' own experiences.                        | The implementation of the CLOCKWISE mathematical programme started with a discussion on what learners believed the concept of time entails.   |
|  | Kamii (2004)  | Discussion of everyday situations can be utilised in the classroom.                                       | In this study, learners were encouraged to describe their actions and events at certain times of the day.   |
| Thought-provoking questions encourage learners to think about real-life experiences and to create clear definitions of time concepts | Johnson (2000)  | Learners need to understand the concept of 'day' before instruction on clock faces can commence.          | This study found that if learners understand the concept of day, they can identify time periods and specifically digital time.  |
| Communication encourages active exploration of the vocabulary of time concepts   | Choy (2013)<br>Carruthers & Worthington (2006)<br>Cathcart <i>et al.</i> (2003)<br>Wolfe (2005) | Classroom discussion will encourage learners to think about the concepts.                                 | In this study, learners used time vocabulary regularly when they participated in classroom discussions, played games and completed task-based activities.   |
| The interplay of daily and mathematical language enhances mathematical understanding during the exploration of time concepts         | Cockcroft (1982)  | Both everyday language and mathematical language by learners must be used whilst exploring time concepts. | In this study, learners were allowed to describe their ideas in their everyday language, but thought-provoking questions asked by teachers encouraged them to use time vocabulary too.  |

| Category   | Author and year  | Existing knowledge   | Interpretive discussion  |
|--|--|--|--|
|  | Cathcart <i>et al.</i> (2003)                                    | The language used to describe a concept, influences the learners' understanding of the concept.                                      | In this study, concepts of time were initially described in the learners' everyday language, which encouraged them to discuss their ideas related to the concepts.   |
|  | Columba (2012)   | It is necessary to repeatedly link mathematical language with more familiar words until learners internalise the mathematical words. | In the <i>CLOCKWISE IN AFRICA</i> story, the concepts of analogue and digital time were described in the learners' everyday language, whilst the characters in the story also utilised mathematical vocabulary to explain the time concepts. |
| Teaching strategies such as storytelling and games engage learners in active exploration and meaning-making of mathematical time | Bell (1980)  | Playing games are fun and it will enhance learners' conceptualisation of mathematical concepts.                                      | The actions performed whilst playing the <i>CLOCKWISE game</i> and <i>What's the time?</i> games outside, could be reproduced and explained by learners when they had to represent time on clock faces.                                      |
|  | Grinstein & Lipsey (2001)  | Learners' understanding of concepts will be enhanced if the concept is integrated into children's literature.                        | The Grade 2 learners in this study could explain their actions whilst representing certain times on clock faces, since they could relate them to the actions performed by the characters in the <i>CLOCKWISE IN AFRICA</i> story.            |
|  | Bell (1980)<br>Cockcroft (1982)<br>Schminke <i>et al.</i> (1978) | Learners learn more Mathematics when it is presented in the context of fun.  | This study employed games such as the <i>CLOCKWISE game</i> , <i>Time Snakes and Ladders</i> and <i>Time Bingo</i> which encouraged learners to utilise their new knowledge of time in a fun way.  |

| Category  | Author and year                                     | Existing knowledge   | Interpretive discussion   |
|---|---|--|---|
|   | Goral & Gnadinger (2006)<br>Schiro (2004)           | Storytelling can be employed to enhance learners' understanding of mathematical concepts.                      | This study employed the <i>CLOCKWISE in Africa</i> story to introduce the concepts of time in a sequential way. It also encouraged learner participation and understanding of the mathematical concept of time. |
| Providing manipulatives such as one-handed clocks encourages learners to make mathematical connections whilst exploring and discovering the concept of time | Van de Walle (2004)                                 | The teaching of time on analogue clocks should begin with the use of one-handed clocks.                        | This study successfully utilised one-handed clocks to represent analogue time on clock faces.   |
|   | Wagner (2005)                                       | The handling of manipulatives enhances learners' concept formation.  | The use of one-handed clocks and number lines enhanced learners' understanding of especially minutes past and minutes to the hour on analogue and digital clocks.   |
|   | Columba (2012)<br>Van de Walle <i>et al.</i> (2010) | Concept formation of mathematical concepts will be enhanced if the concepts are represented in different ways. | This study utilised one-handed clocks, number lines, time charts and games to represent the concepts of time meaningfully.  |

The literature confirms the findings of this study that Grade 2 learners' understanding of the mathematical concept of time is influenced by their own lived experiences and by classroom discussions in the learners' everyday language. The findings of this study are also congruent with statements in literature that learners' representations illuminate their thinking and enhance their understanding of the mathematical concept of time. As suggested in the literature, my findings also confirmed that storytelling and games were perceived as fun by the learners. The utilisation of manipulatives such as one-handed clocks encouraged learner participation. Some of the findings of this study, however are contradictory to existing knowledge.



### 6.5.2 Contradictory evidence to existing literature

**Table 6.2: Comparing research findings to existing knowledge: contradictory evidence**

| Category  | Author and year  | Existing knowledge   | Interpretive discussion  |
|---|--|--|--|
| Learners' new understandings of the concept of time influence the sequence of instruction                                     | Olsson (2009)<br>Thyer & Maggs (1971)<br>Van de Walle (2004) | Learners are taught to first read hours on analogue clocks, then half-hours, minutes past the hour and lastly minutes to the hour on analogue clocks. Thereafter instruction on digital clocks starts. | In this study analogue and digital time are taught simultaneously which is contradictory to general teaching strategies. Instruction initially starts with hours on digital clocks, then on hours on analogue clocks. Thereafter, half-hours on analogue clocks and digital clocks follow. Minutes past the hour on digital clocks are then focused upon, which is followed by minutes past the hour on analogue clocks. Lastly, attention is given to minutes to the hour on digital and analogue clocks. |
|   | Dunphy (2009)  | Teachers' teaching strategies are influenced by their own ideas and beliefs.   | In this study, the teachers' teaching strategies were influenced by the learners' understanding of the concept of time.  |
| Encouraging learners to represent their own ideas on the concept of time strengthens their understanding of mathematical time | Slaten (2006)  | Teachers use representations to convey their own mathematical knowledge to the learners in their own classrooms.   | The teachers in this study built upon the learners' knowledge of time which was represented in the learners' representations.  |
|   | Ball <i>et al.</i> (2005)                                    | Teachers should use representations.   | In this study, the focus was primarily on the representations of the participant learners.   |
|   | Grinstein & Lipsey (2001)                                    | Learners must view different representational forms.   | In this study, learners did not only view different representational forms of the concept of time, but they also represented the time concepts themselves.   |

| Category  | Author and year  | Existing knowledge  | Interpretive discussion   |
|---|--|---|---|
| Thought-provoking questions encourage learners to think about real-life experiences and to create clear definitions of time concepts                        | Ball <i>et al.</i> (2005)                              | Learners will understand concepts if they are clearly defined.              | Thought-provoking questions, asked by teachers, encouraged learners to define the concepts of time in their own words, which enhanced their understanding.  |
| The interplay of daily and mathematical language enhances mathematical understanding during the exploration of time concepts                                | Cai <i>et al.</i> (2009)<br>Charlesworth & Lind (2013) | Learners must use mathematical language to explain their thought-processes. | In this study, learners were initially encouraged to explain their thought-processes in their everyday language first. Then they used mathematical vocabulary that had been integrated in storytelling.                   |
|   | Rudd <i>et al.</i> (2008)                              | Teachers should use mathematical vocabulary to motivate learners.           | The teachers in this study initially utilised storytelling in the learners' everyday language to motivate learners to think about the concept of time. Subsequently, they were encouraged to use mathematical vocabulary. |
| Providing manipulatives such as one-handed clocks encourages learners to make mathematical connections whilst exploring and discovering the concept of time | Charlesworth & Lind (2013)                             | Clock faces with two hands should be used to teach the telling of time.     | Clock faces with only the hour-dial attached to them were utilised in this study to teach analogue time.  |

Findings of this study contradict literature which suggests a sequence of instruction for the concept of time. The sequence of instruction employed in the CLOCKWISE mathematical programme emerged as a new insight in this study (see Section 6.5.4). The literature indicates that teachers' teaching strategies are influenced by the teachers' understandings. In this study, Grade 2 teachers' choice of teaching strategies are influenced by their ability to analyze and respond to Grade 2 learners' understandings of mathematical concepts. Hence, I cannot substantiate the claim made by Johnson

(2000) that teachers' own understandings and expectations primarily influence the teaching strategies they employ in the classroom.

In addition, literature suggests that teachers should clearly define concepts of time whilst using mathematical language. The findings of this study suggest that when learners are encouraged to describe concepts in their own words and in their everyday language, they understand the underlying principles of the concept of time. The findings of this study also contradict literature which suggests that teachers should use representations and manipulatives such as clock faces to enhance the Grade 2 learners' understanding of the concept of time. This study suggests that teachers should use learners' representations and manipulatives such as one-handed clocks as well as number lines to enhance the learners' understanding.

In the next section I describe the silences in the research data. The significance of this section is to emphasise findings which I expected from studying the literature but did not find in my data.

### 6.5.3 Silences in the research data

**Table 6.3: Comparing research findings to existing knowledge: silences in the data**

| Trend  | Author and year   | Interpretive discussion  |
|--|---|--|
| Literature indicates that since it is prerequisite for the conceptualisation of analogue and digital time, teachers should be aware of Grade 2 learners' proficiency in reversibility, conservation, classification, transitivity and seriation. | Charlesworth & Lind (2013)<br>Copeland (1984)<br>Holmes (1985)<br>Kamii & Clark (1997)<br>Louw & Louw (2007)<br>Sarama & DiBaise (2004) | In the pre-testing of the learner participants, it was evident that not all the learners had attained the concepts of reversibility, conservation, classification, transitivity and seriation. In the post-testing, however, most of the learners could identify and represent the mathematical concept of time. Since this was a qualitative study, the research is inconclusive as to the prerequisite relationship between learners' attainment of reversibility, conservation, classification, transitivity and seriation and the conceptualisation and understanding of the mathematical concept of time. Future research could possibly determine the prerequisite relationship in a quantitative study. |

Literature suggests that the attainment of the concepts of reversibility, conservation, classification, transitivity and seriation are prerequisite for the understanding of the mathematical concept of time (Charlesworth & Lind, 2013; Copeland, 1984; Holmes, 1985). In the pre-implementation phase of the CLOCKWISE mathematical programme, the learners' attainment of these concepts was tested individually. It was apparent from the data that a vast majority of participant learners had not yet attained the concept of conservation and reversibility. More than 80 per cent of the participant learners, however, attained the mathematical concept of time as a result of their participation in the CLOCKWISE mathematical programme (see CD 2, Results). The reason might be that the participant learners attained the concepts of reversibility, conservation, classification, transitivity and seriation whilst participating in the CLOCKWISE mathematical programme. Hence, the research is inconclusive as to the prerequisite relationship between learners' attainment of reversibility, conservation, classification, transitivity and seriation and the conceptualisation and understanding of the mathematical concept of time. In the next section I explore new insights of the study.

#### 6.5.4 New insights from the study

**Table 6.4: Comparing research findings to existing knowledge: new insights**

| Sub-themes and categories   | Description   | Interpretive discussion  |
|---|---|--|
| Learners have a deeper understanding of mathematical time when they articulate their ideas and thinking about the concept of time | Grade 2 learners should be encouraged to articulate and represent their understanding of the concept of time in drawings and with objects which they relate to the concept of time. | If learners represent time visually, they depict something that is significant in their daily lives. From the learners' visual representations it became clear that the learners in this study believed that things and people develop and deteriorate over time. They also believed that time is recurrent and that time goes by. |
| Learners' new understandings of the concept of time influence the sequence of instruction   | The teaching of digital and analogue time is introduced simultaneously and each lesson builds on the previous lesson.   | The sequence of instruction is influenced by the learners' current understandings. In general, new concepts are introduced when learners understand the underlying principles of the concepts.   |

| Sub-themes and categories  | Description   | Interpretive discussion  |
|--|---|--|
| Teaching strategies encourage learners' exploration and understanding of the concept of time | When teachers use innovative teaching strategies such as games and storytelling, learners make mathematical connections whilst exploring and discovering time concepts. | Learners can explain and reproduce on clock faces the actions performed by the animals in the <i>CLOCKWISE IN AFRICA</i> story and by the learners whilst playing the <i>CLOCKWISE</i> game and <i>What time is it?</i> outside. |

New insights into the Grade 2 learners' understanding of the mathematical concept of time were derived from classroom discussions and innovative teaching strategies. Jeannie Baker's book *Window*, the *CLOCKWISE in Africa* story and Salvador Dali's painting *The Persistence of Memory*, facilitated classroom discussions and encouraged learners to visually represent their own ideas on the mathematical concept of time. It was evident that learners in this study believed that time is recurrent, as depicted in their pictures of seasonal changes and birthdays which come around every year. In addition, the Grade 2 learners' representations of shoe-sizes which become bigger as you get older and flowers which die after a while, emphasised learners' beliefs that ideas, things and people develop or deteriorate whilst time goes by.

In the context of my study, these understandings of the mathematical concept of time were significant for the Grade 2 learners' growth of mathematical understanding. Their understandings also influenced the way the teachers presented the concept of time to the learners in their classrooms.

The teaching of the mathematical concept of time in a sequential way is well documented (Cockburn, 1999; Holmes, 1985; Thyer & Maggs, 1971; Van de Walle, 2004). National curricula also suggest that the teaching of the concept of time on clock faces should start with the identification of hours, followed by half past the hour and time to the nearest five minutes (Common Core State Standards Initiative, 2010; Department of Basic Education, 2011; Department for Education, 2013a; Ministry of Education, 2012). The identification of hours should be followed by the teaching of digital time. This study, however, supported the view of Grinstein and Lipsey (2001:761) that "digital and analogue clocks are used in an integrated manner in modern society". The

CLOCKWISE mathematical programme encouraged the simultaneous teaching of digital and analogue time, which resulted in new insights on the sequence of instruction. Instruction started with hours on digital clocks, followed by hours on analogue clocks. Half past the hour on analogue and digital clocks were then discussed on subsequent weeks. This was followed by minutes past the hour on digital clocks and analogue clocks. Lastly, the CLOCKWISE mathematical programme focused upon minutes to the hour on digital clocks and then on minutes to the hour on analogue clocks.

It is also evident from the research data that storytelling and games, which are specifically designed to facilitate the active exploration of time concepts in the context of fun, enhanced Grade 2 learners' understanding of the mathematical concept of time. These new insights also enabled me to address the research questions of my study.

## 6.6 Findings in terms of the research questions

The research questions which guided my study are answered in the following sections. The answers to the sub-questions provide the scaffolding on which the answer to the main question is based.

### 6.6.1 Sub-question one:

*Which pedagogical principles inform the design of a mathematical programme on the conceptualisation of time in Grade 2?*

The research team discussed the concepts of time which were set out in curricula. The analysis of the concepts we needed to teach, enabled us to design the CLOCKWISE mathematical programme. In turn, it gave each Grade 2 learner the best possible opportunity to build upon his or her personal understanding of the mathematical concept of time in order to attain the necessary concepts. Thus, the learners' prior knowledge was considered when the CLOCKWISE mathematical programme was designed. Offering a foundation for mathematics teachers to build upon, the *CLOCKWISE IN AFRICA* story was created. Storytelling elicited the learners' curiosity and encouraged them to discuss their own ideas, and the actions of the characters in the story, in their everyday language. In this CLOCKWISE mathematical programme, analogue and

digital time were taught simultaneously. Key teaching strategies such as games, storytelling and the use of the learners' everyday language engaged learners in active participation and meaning-making. The programme facilitated cooperative learning. Learners studied the concepts of time and shared their ideas and knowledge in classroom discussions, whilst manipulating number lines and one-handed clocks, and whilst they were playing games outside. The programme also encouraged learners to complete worksheets and task-based activities independently.

Classroom discussions, task-based activities and learners' visual representations enabled the teachers to assess the learners' growth of understanding of the concept of time on a continuous basis. The teaching strategies offered opportunities for teachers to provide timely instructional feedback and support to the learners. The sustained feedback also encouraged the mathematics teachers to revise or enhance the knowledge which the learners had already attained. In this CLOCKWISE mathematical programme, the learners' attained knowledge was enriched with task-based activities such as their own Salvador Dali drawings and the objects they brought from home to represent concepts related to mathematical time.

The pedagogical principles that were derived from literature and were set out in Section 2.4.2 are shown here to have been successfully incorporated in the devised programme. With regard to these pedagogical principles embedded in the CLOCKWISE mathematical programme, the study found that these principles influenced the teachers' teaching and the learners' learning of the mathematical concepts of time in Grade 2.

### **6.6.2 Sub-question two:**

*How does the conceptual understanding of time develop in Grade 2 learners as a result of their participation in the CLOCKWISE mathematical programme?*

In this study, it became clear through the experiences and representations of the Grade 2 participating learners that the teaching strategies employed in the CLOCKWISE mathematical programme enhanced the learners' understanding of the mathematical

concept of time. It was apparent that classroom discussions which reflected upon the Grade 2 learners' personal ideas and conceptions, encouraged the learners to discuss the mathematical concept of time in their daily lives.

Listening to the *CLOCKWISE IN AFRICA* story, learners realised that a day has 24 hours which can be divided into different time periods. The learners also related specific hours to their real-life experiences in their drawings. Hence, they could determine between a.m. and p.m. times on digital clocks. Thereafter, learners were encouraged to explain the position of the hour dial and minute dial on analogue clocks. They recognised that the hour dial is exactly on the number, whilst the minute dial is on the twelve to indicate that it is the beginning of a new hour. In the *CLOCKWISE* mathematical programme, learners were also encouraged to cut an analogue clock in half. In so doing, the learners were able to determine why the minute dial should be on the six when half-hours are represented on analogue clocks. Learners then also realised that the ':30' on digital clocks represented half-hours. Since the learners were encouraged to describe the position of the two dials on analogue clocks in their everyday language, they could also describe the position of the hour dial as being 'in the middle of two numbers'.

The learners were encouraged to play outside and to jump from one side of the clock to the other side. Subsequently, learners had no problem with the representation of minutes past the hour on analogue clocks. The learners acknowledged that minutes past indicates that the hour in question has already passed, therefore the hour dial must cross the hour in question and the minute dial must be on the right-hand side of the clock. The learners also understood minutes past the hour on digital clocks. Since they had already attained the knowledge of time periods, they could distinguish between a.m. times and p.m. times on digital clocks. The *CLOCKWISE IN AFRICA* story focused the learners' attention on the attributes of minutes to the hour. The difficulty which the animals experienced when wanting to cross the river, and the actions the learners performed whilst playing the *Minutes to the hour* game outside, drew attention to the position of the minute dial and hour dial on analogue clocks. The learners were



able to explain that the minute dial should be on the left-hand side of the clock and that the hour dial had not yet crossed the hour in question. The learners were also encouraged to count backwards using number lines, or to represent minutes to the hour on an analogue clock before representing minutes to the hour on a digital clock. The utilisation of the number lines and analogue clocks, enhanced the learners' understanding of minutes to the hour on digital clocks. I therefore came to the conclusion that it was through the use of all the sequences and varied aspects of the CLOCKWISE mathematical programme that the Grade 2 learners' understanding of the mathematical concept of time was enhanced.

### 6.6.3 Sub-question three:

*How do Grade 2 teachers experience the teaching of the mathematical concept of time during the implementation of the CLOCKWISE mathematical programme?*

The CLOCKWISE mathematical programme integrated innovative teaching strategies such as storytelling, games and drawings with the use of manipulatives, carefully sequenced lessons and direct teaching, all of which are frequently used in mathematics classrooms. The Grade 2 teachers' changed perspectives on the teaching of the mathematical concept of time were evident in their post-implementation interviews.

It was evident that teachers valued the learners' participation and representation of their thinking and ideas on the mathematical concept of time in this study. The participant teachers noted that the collages in the book *Window* (Baker, 2000), encouraged learners to actively participate in classroom discussions. The *CLOCKWISE IN AFRICA* story, also enabled the participant teachers to teach the mathematical concept of time in a sequential way. The story focused the learners' attention on the properties of the time concepts and explained the concepts in learners' everyday language. The teachers therefore proclaimed that storytelling and the use of the learners' everyday language in classroom discussions, were instrumental in the learners' growth of mathematical understanding of time.

According to the participant teachers of this study, the games which the learners played and the manipulatives they used reinforced the learners' knowledge. The teachers also stated that the utilisation of games and manipulatives such as number lines and one-handed clocks, enabled them to represent the concept of mathematical time in the context of fun. The teachers valued the use of number lines, especially when they had to explain the representation of half-hours on digital clocks. The teachers concluded that the concept of time was not an abstract entity which they had to describe to Grade 2 learners anymore.

Teachers in this study also noted that the learners' representations of the concept of time enabled them to continuously and unobtrusively assess the learners' growth of understanding. Not only did the Grade 2 learners represent certain times on analogue and digital clocks, they could also relate certain times to their real-life experiences. These real-life experiences were depicted in their drawings and in the objects they brought from home. The teachers especially valued the learners' ideas and understandings on what the clocks in the painting of Salvador Dali, and eventually in their own drawings, represented. I therefore concluded that the teachers in this study valued the teaching strategies employed in the CLOCKWISE mathematical programme.

#### **6.6.4 Main question:**

*How does the CLOCKWISE mathematical programme enhance Grade 2 teachers' teaching strategies and learners' understanding of the mathematical concept of time?*

As demonstrated in my study, learners' understanding of the mathematical concept of time improved when teaching strategies were learner-centred in addition to lessons being presented in the context of fun. In this section I discuss both of these findings in an integrated way in an attempt to answer the main research question.

During the course of the study, learners were encouraged to voice and represent their own opinions which in turn put emphasis on their growth of understanding of the concept of time. The collages in the book *Window* from Jeannie Baker as well as the

*CLOCKWISE IN AFRICA* story and Salvador Dali's *The Persistence of Memory* elicited the learners' curiosity and encouraged them to talk about concepts presented in the collages, story and painting. Since they were initially allowed to use their everyday or home language, they had confidence in voicing their opinions. From these classroom discussions with their teachers and peers, their knowledge of the mathematical concept of time could develop. The discussions encouraged them to think about the mathematics and how it related to their personal experiences. As a result, teachers could also assess the learners' attainment of the mathematical concept of time in an unobtrusive manner which permitted them to make timely instructional changes if necessary.

Teachers also employed strategies which were activity-based. Visual representations, manipulatives as well as games were utilised to determine and enhanced the Grade 2 learners' growth of mathematical understanding of the concept of time. In this study, learners were encouraged to represent their ideas and knowledge of mathematical time on one-handed clock faces and number lines, in drawings and in writing.

Consequently, as demonstrated in this study, the focus shifted from formal assessment tools such as worksheets to informal assessment tools such as listening and observation of learners whilst they were actively engaging with the mathematical concept of time. Teachers of the mathematical concept of time were also encouraged in the *CLOCKWISE* mathematical programme to listen to learners' discussions and explanations of their visual representations. The teachers also observed the learners' actions whilst they worked with manipulatives and played games. Hence, assessment of learners' mathematical understanding took place in the context of having fun.

The results of the study have shown that classroom discussions, storytelling, games, drawings, and informal assessment tools are effective strategies in the teaching of the mathematical concept of time. The teaching strategies in the *CLOCKWISE* mathematical programme facilitated the active participation of the Grade 2 learners in their own meaning-making and the growth of their understanding of the mathematical concept of time.

## 6.7 Conclusions of the study

In this section the conclusions in terms of the Grade 2 learners' understandings, innovative teaching strategies, the sequence of instruction and the curriculum are discussed.

### 6.7.1 Conclusion one: Grade 2 learners' understandings and learning of the mathematical concept of time

It became clear in this study that most of the Grade 2 learners were aware of the concept of time in their daily lives. As a result, it is recommended that mathematics teachers encourage learners to articulate and represent their ideas and understandings. These visual and verbal representations will enable learners to actively participate in their own meaning-making and to develop a deeper understanding of the mathematical concept of time. It will also enable mathematics teachers to build upon the learners' understandings and gained knowledge when they plan subsequent lessons. Through discussing their own ideas on the concept of time, solving problems, answering thought-provoking questions, representation of their own ideas and connecting ideas to their real-life experiences, learners' mathematical process skills as well as understanding of the mathematical concept of time can be developed.

### 6.7.2 Conclusion two: Innovative teaching strategies in teaching the mathematical concept of time

Mathematics teachers often focus more on teaching the actual reading of time than on the underlying principles of the concept of mathematical time. Hence, Grade 2 learners are mostly encouraged to represent time on clock faces. Furthermore, emphasis is put on independent work in workbooks and on worksheets. This study encouraged teachers to reflect on their teaching strategies and to employ innovative teaching strategies which will encourage learners' exploration and understanding of the concept of time.

The results of this study show that storytelling, the visual representation of concepts of time, games and classroom discussions employed in the *CLOCKWISE* mathematical programme can be effective teaching strategies. Integrating the mathematical concept of time into the *CLOCKWISE IN AFRICA* story, elicits the learners' curiosity. The story

and the use of the learners' own language in classroom discussions as well as in the story, can also encourage learners to verbalise their thoughts and beliefs.

Using the collages in the book *Window*, pictures of seasonal trees and candles and the painting of Salvador Dali, also facilitated the exploration of time concepts in a creative manner. In addition, one-handed clocks and number lines and games such as the *CLOCKWISE game* can be utilised to focus learners' and teachers' attention on the properties of time concepts. The study also emphasised that games and task-based activities can reinforce learners' knowledge and encourage learners' participation in the mathematics classroom. I concluded that task-based activities, classroom discussions, learners' representations and games should be employed to assess learners' acquisition of the mathematical concept of time, rather than independent work in workbooks.

### **6.7.3 Conclusion three: Curriculum aspects related to the mathematical concept of time**

The results of this study provide evidence that the teaching strategies employed in the *CLOCKWISE* mathematical programme, can support Grade 2 learners' growth of mathematical understanding of the concept of time. The South African curriculum (Department of Basic Education, 2011), however, does not propose teaching strategies which will enhance the learners' process skills and understanding of the mathematical concept of time. I therefore conclude that most learners' understanding of the mathematical concept of time will be enhanced if the curriculum also proposes teaching strategies to facilitate the learning of the mathematical concept of time.

This study emphasised the importance of connecting new ideas to existing knowledge. The simultaneous teaching of analogue and digital time consequently enabled teachers to focus learners' attention on important properties of the mathematical concept of time and to build on existing knowledge. Once learners, for instance, grasped that a half-hour represents thirty minutes on an analogue clock, they were empowered to represent half-hours on digital clocks as ':30'. In turn, when learners understood that a day represents twenty-four hours which can be divided into three time periods, they

understood that the hour dial has to go around twice in one day on an analogue clock. Thus, I concluded that the simultaneous teaching of analogue and digital time enabled helpful sequences of instruction and enhanced Grade 2 learners' understanding of the mathematical concept of time.

The teaching of digital time only commences in Grade 3 in a South African context (Department of Basic Education, 2011). The results of this study, however, show that Grade 2 learners' understanding of mathematical time improves when the teaching of mathematical time commences with digital time. I concluded that learners' understanding of time periods in their daily lives and on digital clocks, determines their acquisition of an understanding of time on analogue clocks. I therefore propose that digital time should be part of the Grade 2 mathematics curriculum. In the next section I offer recommendations on various levels.

## **6.8 Recommendations and future directions for research**

As an interpretivist, I have constantly reflected upon my teaching strategies and the reaction of the learners in order to come to a deeper understanding. I have formulated recommendations about the teaching of the mathematical concept of time to the Department of Basic Education and to mathematics teachers in Grade 2 classrooms. In the following sections, I also emphasise the need for further research on the teaching of the mathematical concept of time.

### **6.8.1 Recommendation one: Grade 2 learners' understandings and learning of the mathematical concept of time**

The conclusions of this study clearly indicate that it is important to particularly focus upon the Grade 2 learners' understanding and representations of the mathematical concept of time. Therefore, I recommend that the mathematics teachers should encourage the learners to represent the concept of time verbally and visually with drawings and objects. These representations will enhance learners' process skills and encourage learners to connect the concept of time to experiences in their daily lives

which are significant to them. Learners' will acquire a deeper knowledge of the mathematical concept of time.

### **6.8.2 Recommendation two: Innovative teaching strategies in teaching the mathematical concept of time**

I recommend that the Department of Basic Education should direct their attention to the professional development of mathematics teachers by including teaching strategies in the curriculum. It is not only important to know what to teach, but it is imperative that teachers should know how the proposed concepts can be facilitated in order to enhance the learners' understanding. The findings of this study may raise awareness at the Department of Basic Education, that the teaching strategies employed in the CLOCKWISE mathematical programme can support Grade 2 learners' growth of mathematical understanding of the concept of time. I therefore recommend, that the Department of Basic Education provides mathematics teachers with clear guidelines on innovative teaching strategies such as storytelling, games and learners' drawings, which most probably will enhance the Grade 2 learners' conceptualisation of the concept of time in a South African context.

### **6.8.3 Recommendation three: Curriculum aspects related to the mathematical concept of time**

The findings of this study have shown that the teaching of digital time should be part of the Grade 2 mathematics curriculum in a South African context. In addition, this study suggested that the mathematical concept of time should be scaffolded and taught over a prolonged period of time and that the teaching of digital and analogue time should be taught simultaneously in Grade 2 classrooms. I recommend that Grade 2 mathematics teachers should focus on hours on digital and analogue clocks in the first term of the school year. This can be followed by half-hours on analogue and digital clocks in the second term. Instruction in the third term could then focus upon minutes past the hour on both digital and analogue clocks. Subsequently, instruction of minutes to the hour on digital and analogue clocks can commence in the fourth term of the school year. The prolonged period of instruction will provide many opportunities for teachers and learners

to represent, explore and explain time concepts, which will enhance learners' understanding of the mathematical concept of time.

#### **6.8.4 Recommendation four: Further research**

This study recommends the following areas for further research:

- Further research is needed to establish if the CLOCKWISE mathematical programme will enhance Grade 2 learners' understanding of the concept of time in different contexts and in different cultural groups in a South African context.
- Further research is needed to establish if the teaching strategies employed in this study can be extended to other mathematical content in the curriculum.

#### **6.9 Limitations of the study**

This practitioner research study explored the implementation of the CLOCKWISE mathematical programme in three Grade 2 classes at the same primary school. The results of this study can therefore not be generalised to include all contexts. The findings can, however, be transferred to similar cases as I have given a detailed description of the research site and the research process (Seale, 1999). To enhance the trustworthiness of my study I have explained in-depth the activities and manipulatives employed in the CLOCKWISE mathematical programme (see CD 1, CLOCKWISE). The concepts foundational to the programme are grounded in the literature and the theories consulted. The programme will be made available to researchers and teachers interested in teaching the mathematical concept of time.

Time constraints influenced the implementation of this study. The programme and the other content areas prescribed in the national mathematics curriculum, were implemented simultaneously at times allocated for mathematics on the daily time schedule. The data revealed that teachers found it challenging to focus on more than one content area at a time. Therefore, it is recommended that the CLOCKWISE mathematical programme be implemented over a prolonged period of time.



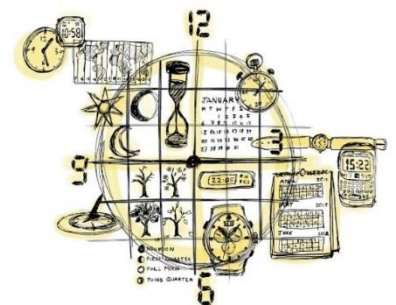
Despite the limitations mentioned, this study gives encouragement to the notion that improved levels of understanding can occur when mathematics teachers' teaching strategies focus upon the Grade 2 learners' personal understandings, real-life experiences and exploration of the mathematical concept of time.

## 6.10 Reflective insights as practitioner researcher

The primary goal of this study was to improve the teaching and learning of the mathematical concept of time. In searching for ways to achieve this goal, the two theoretical perspectives were foundational to my study. As an interpretive practitioner researcher, I aimed to gain an in-depth understanding of the Grade 2 learners' growth of mathematical understanding within the natural setting of my own classroom (Babbie & Mouton, 2001; Mouton, 2001). Hence, I could actively interact with the learners in my class in order to portray the learners' understanding of the situation and the effect of the employed teaching strategies (Fox, Martin & Green, 2008). I could also confirm the learners' meanings and understandings during classroom discussions and whilst they were playing games. Observations made by my co-researchers were also frequently compared with my own to enhance and substantiate the validity and trustworthiness of my findings. In the course of this study, I gained knowledge of learners' learning and teaching strategies which enabled me to improve my own teaching of the mathematical concept of time.

## 6.11 Conclusion

This study focused upon two important aspects, namely the teaching of the mathematical concept of time and Grade 2 learners' growth of mathematical understanding of the mathematical concept of time. Thus, the study contributes to the literature of the teaching of mathematical time by providing research-based evidence on the effect of the teaching strategies employed in the CLOCKWISE mathematical programme.



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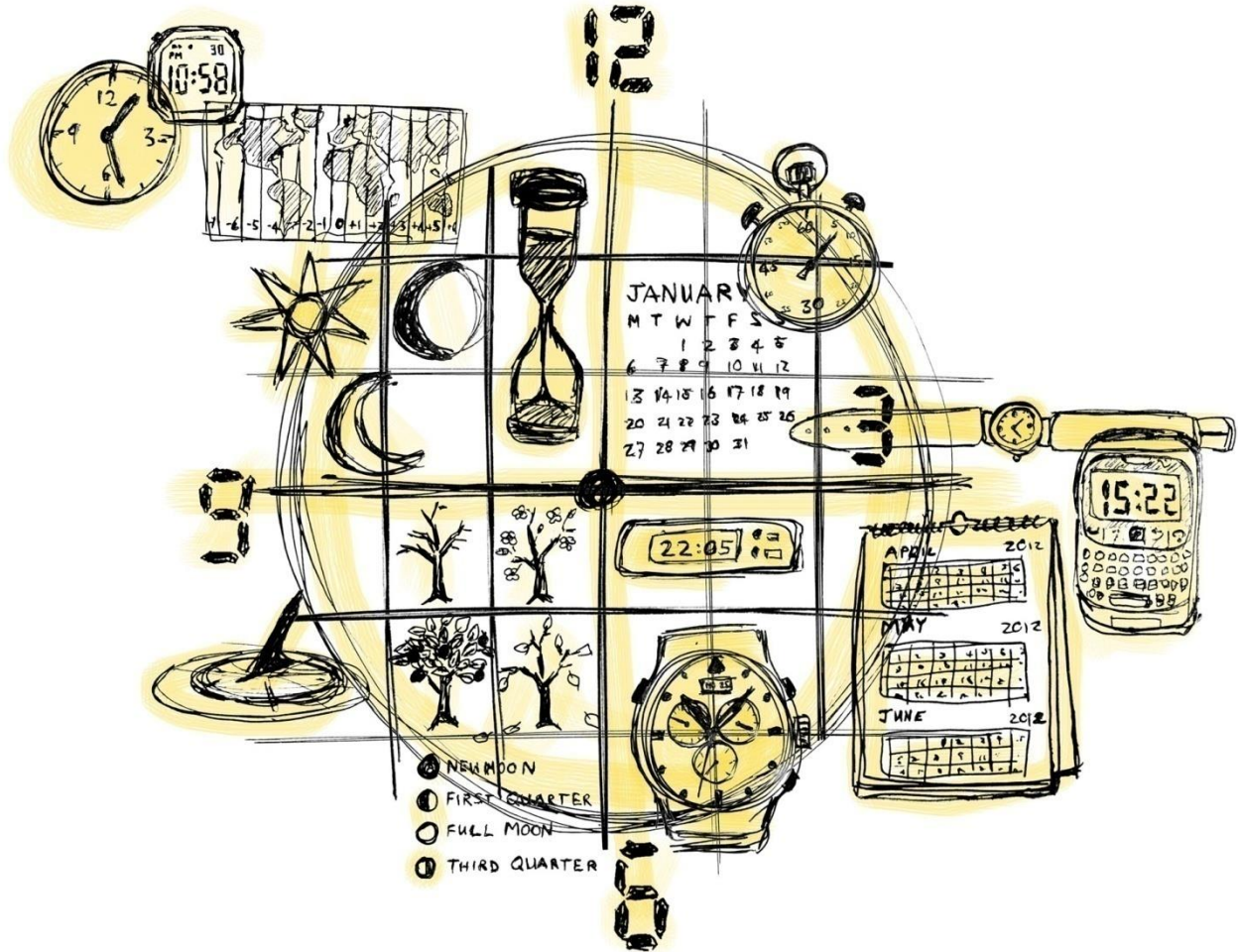
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# Appendix A



Ethical clearance certificate:  
University of Pretoria





UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA  
Faculty of Education

RESEARCH ETHICS COMMITTEE

**CLEARANCE CERTIFICATE  
DEGREE AND PROJECT**

**INVESTIGATOR(S)**

**DEPARTMENT**

**DATE CONSIDERED**

**DECISION OF THE COMMITTEE**

CLEARANCE NUMBER :

EC 12/04/03

PhD

Teaching the mathematical concept of time in grade 2

Margareth Georgina Steyn

Early Childhood Education

8 September 2014

APPROVED

Please note:

*For Masters applications, ethical clearance is valid for 2 years*

*For PhD applications, ethical clearance is valid for 3 years.*

**CHAIRPERSON OF ETHICS  
COMMITTEE**

Prof Liesel Ebersöhn

DATE

8 September 2014

CC

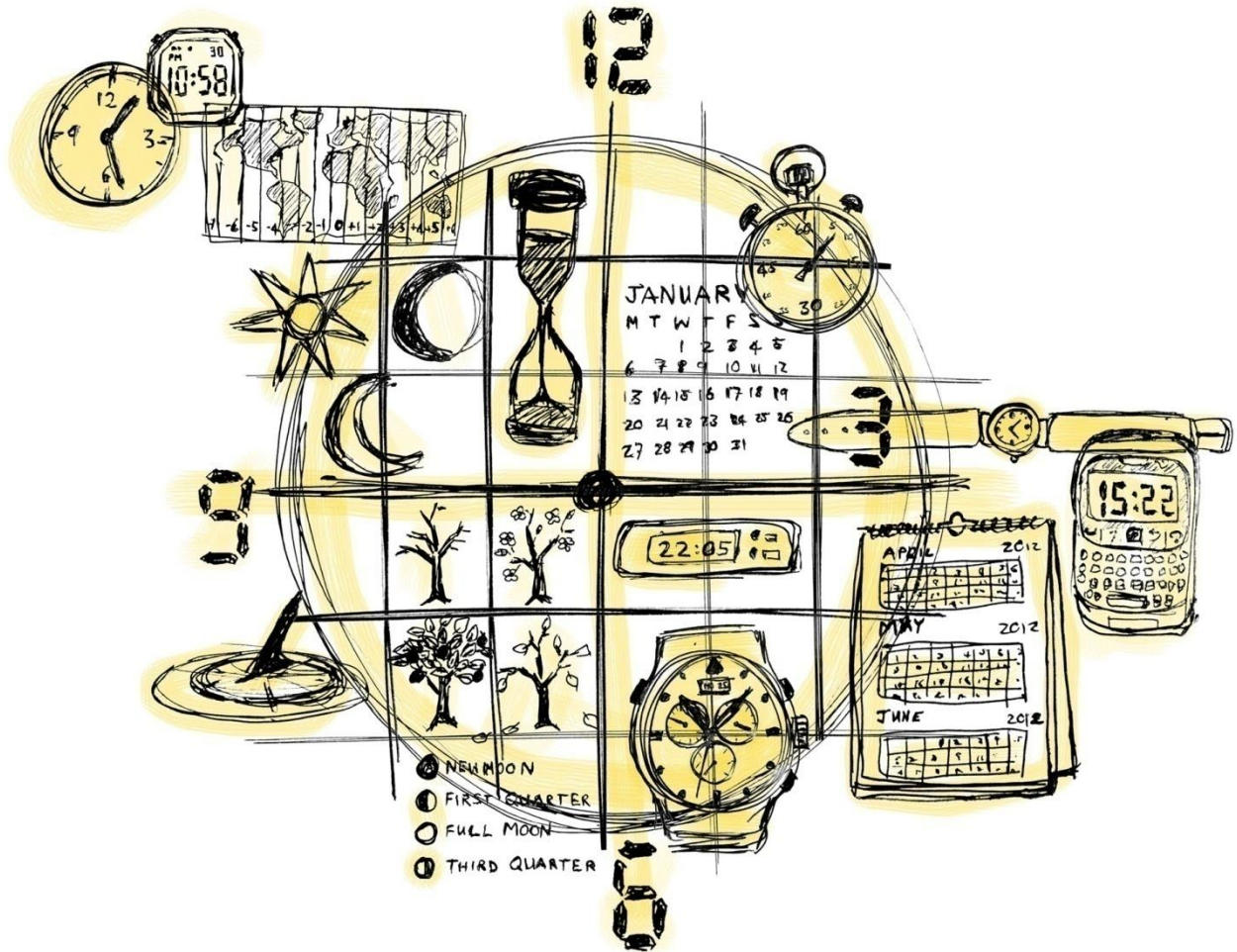
Jeannie Beukes  
Liesel Ebersöhn  
Prof CG Hartell  
Dr M Botha  
Dr JC Joubert

This ethical clearance certificate is issued subject to the following condition:

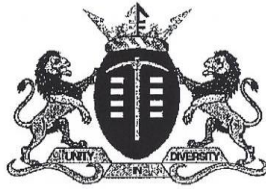
1. It remains the students' responsibility to ensure that all the necessary forms for informed consent are kept for future queries.

Please quote the clearance number in all enquiries.

# Appendix B



Letter of consent:  
Gauteng Department of Education



**education**  
Department: Education  
GAUTENG PROVINCE

For administrative use:  
Reference no. D2013/40

## GDE RESEARCH APPROVAL LETTER

|                                |  |
|--------------------------------|--|
| Date:                          | 9 May 2012                                     |
| Validity of research Approval: | 9 May 2012 to 30 September 2012                |
| Name of Researcher:            | Steyn M.G.                                     |
| Address of Researcher:         | 59 Callista Crescent<br>Annlin X36<br>0182     |
| Telephone Number:              | 012 543 9999 / 072 514 2954                    |
| Fax Number:                    | 012 543 0828                                   |
| Email address:                 | maretha.steyn@iburst.co.za                     |
| Research Topic:                | The teaching of the concept of time in Grade 2 |
| Number and type of schools:    | ONE Primary School                             |
| District/s/HO                  | Tshwane North                                  |

### **Re: Approval in Respect of Request to Conduct Research**

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.

*Making education a societal priority*

### **Office of the Director: Knowledge Management and Research**

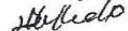
9<sup>th</sup> Floor, 111 Commissioner Street, Johannesburg, 2001  
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506  
Email: David.Makhado@gauteng.gov.za  
Website: www.education.gpg.gov.za

*Makhado*

4. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
12. On completion of the study the researcher must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
14. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards



Dr David Makhado

2012/05/10

Director: Knowledge Management and Research

**Office of the Director: Knowledge Management and Research**

9<sup>th</sup> Floor, 111 Commissioner Street, Johannesburg, 2001  
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506  
Email: David.Makhado@gauteng.gov.za  
Website: www.education.gpg.gov.za



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Faculty of Education  
Department of Early Childhood Development

14 March 2012

Head: Gauteng Department of Education  
Head Office  
Johannesburg

**SUBJECT: REQUEST TO CONDUCT QUALITATIVE RESEARCH IN THE TSHWANE NORTH DISTRICT**

I am presently enrolled for my PhD studies at the Department of Early Childhood Development at the University of Pretoria. The title of my thesis is *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time*.

I hereby request permission from the Gauteng Department of Education to implement this mathematics intervention programme, *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time*, as part of an action research process at Laerskool \_\_\_\_\_ in the Tshwane North district. I have already discussed this research project with the principal and he has guaranteed his full cooperation – see his letter attached.

m

Worldwide (Zhang, 2005:5; Young-Loveridge, 2004:83), curriculum reforms suggest that the mathematics curriculum should focus on the conceptual understanding of mathematics because learners should be able to use what they have learnt in 'real-life' situations beyond school (Lesh & English, 2005:192). Nevertheless, current research asserts that the conceptual understanding of mathematical concepts is challenging (Skemp, 1989:22; Botha, Maree & De Witt, 2005:697; Kruger, 2011:1). Measurement is the concept from the foundation phase mathematics curriculum that is used most directly in learners' daily lives (Carruthers & Worthington, 2006:387). However, the literature and foundation phase mathematics teachers alike affirm that teachers and learners find the measurement strand of the curriculum one of the most challenging, especially the concept of time (Dunphy, 2009:12; Cockburn, 1999:84). As a Grade 2

teacher with twenty-one years' experience, and as head of the Foundation Phase in the primary school where I teach, I observe that some learners are able to identify important dates and times important to them in their daily schedules, but many of them struggle with analogue and digital time. Foundation Phase Mathematics teachers also assert that the concept of analogue and digital time often has to be re-taught in Grade 3. This signifies that the methodologies used to teach the concept most likely need revision. Thus, there is a pressing need for further research into classroom discourse processes in the early years (Munn, 2011:36). Literature and mathematics curriculums alike provide suggestions on the facilitation of time, but it mainly focus on the instruments used to tell time and not on the conceptual understanding of the attributes, units and processes of what it means to measure time (Carruthers & Worthington, 2006:388). To get closer to strategies for forming learners' way of thinking about time (Waller & Bitau, 2011:3), this study will investigate learners' representation of time, their voices and the reading strategies they employ to read time.

My envisaged qualitative study will therefore focus on the design, implementation and evaluation of a mathematics programme which will focus on the teaching and learning of analogue and digital time and the possible enhancement of Grade 2 learners' conception of time. Since the content is part of the Grade 2 mathematics curriculum, the implementation of the programme will not compromise learners' or teacher's school hours or planning. The possible influence of the intervention programme on the learners' conceptualization will be monitored continuously. Possible shortcomings in the teaching approaches can also be identified and improved upon.

I am a Grade 2 teacher with twenty-one years' experience and I am the head of the Foundation Phase at Laerskool \_\_\_\_\_. It is an Afrikaans medium primary school in the Tshwane North district. The school has seven heterogeneous Grade 2 classes with thirty or more learners in every class. The research will be conducted with learners in three Grade 2 classes in July 2012 – one of the classes will be my own - whilst lessons will be facilitated as suggested by the current curriculum in the other four Grade 2 classes. The teachers implementing the CLOCKWISE

programme have 31 years, twenty one years and six months of teaching experience respectively. I will conduct semi-structured interviews with all six Grade 2 teachers in advance and during the implementation of the programme to verify and extend information on what they believe the effect of the programme to be. Assessment of learners in all seven heterogeneous Grade 2 classes will take place during mathematics time on the time-table within the first week of the third term before the implementation of the programme commences. The teachers involved with the research project will receive training and teaching materials on a weekly basis. The training will not take more than 30 minutes. The teachers will not receive incentives. After completion of the programme, the learners of all seven Grade 2 classes will be assessed again to determine the effectiveness of the intervention.

The learner participants and their parents will be informed about this research project and a letter of consent will be signed by the parents – see the letter attached. The privacy of the participants will be respected and their identity will not be revealed in my thesis. The participants will be participating of their own free will and may at any time withdraw from the research project without being penalised. The findings from this research could be useful for Grade 2 mathematics teachers and learners alike, as an understanding of the concept of telling time would imply that the learners would be able to use it in everyday life (Kheong, 2009:1).

I have undertaken to comply with the ethical requirements of the University of Pretoria at all times. I shall at all times be prepared to disclose my methodology and techniques of data analysis. My study will contain references to all participants' contributions. No secret research will be conducted and my research and results will be published to be evaluated and assessed, as suggested by Mouton (2001:240). I undertake to keep all participants informed of my findings and the results of the research.

I trust that this application will be favourably considered.

Thank you

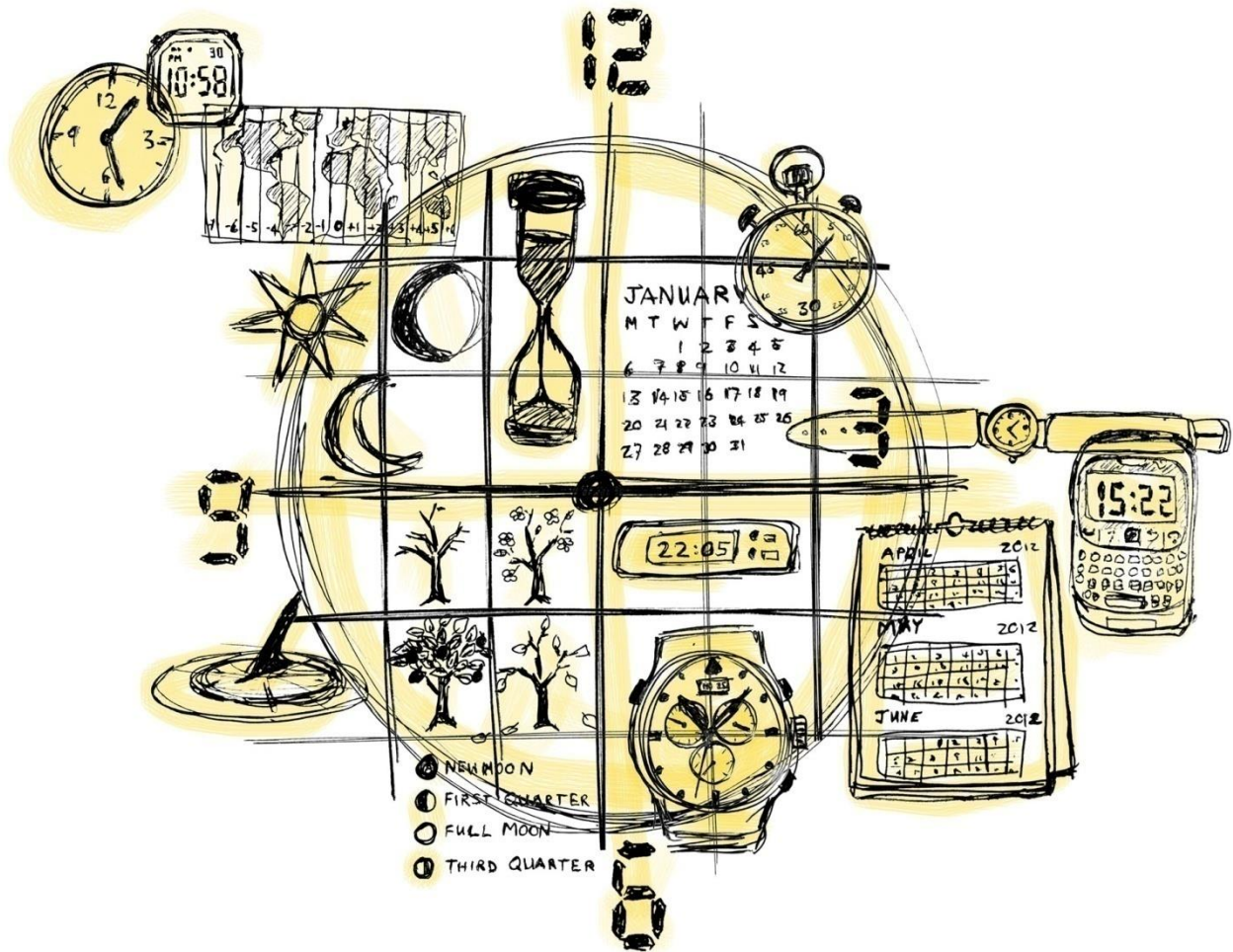
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Me Maretha Steyn (Student)

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Dr Ina Joubert (Supervisor)

# Appendix C



Letter of consent:  
Governing Body





UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Fakulteit Opvoedkunde  
Departement Vroeë Kinderontwikkeling

14 Maart 2012

Die Beheerliggaam

Laerskool \_\_\_\_\_

Posbus \_\_\_\_\_

Geagte \_\_\_\_\_

### **Toestemming vir die implementering van 'n PhD-navorsingsprojek in Laerskool**

\_\_\_\_\_

Ek is tans 'n ingeskrewe doktrale student in die Departement Vroeë Kinderontwikkeling aan die Universiteit van Pretoria. Die titel van my proefskrif is *The teaching of the concept of time in Grade 2*.

Soos reeds met Mnr. \_\_\_\_\_ bespreek, rig ek graag 'n versoek tot die Beheerliggaam van Laerskool \_\_\_\_\_ om in die derde kwartaal van 2012 hierdie kwalitatiewe intervensie program, *CLOCKWISE*, in drie graad 2-klasse te implementeer. Die volledige *CLOCKWISE*-program sal in die skool se onderrigtaal (Afrikaans) aangebied word en na voltooiing van die program sal dit die eiendom van die Universiteit van Pretoria bly.

Skriftelike toestemming sal by die betrokke onderwysers, ouers en leerders verkry word alvorens die program geïmplementeer word. U, die graad 2 onderwyseresse asook die leerders se privaatheid sal gerespekteer word en die betrokke partye se identiteite sal nie bekend gemaak word in my proefskrif nie. Die deelnemers neem vrywillig deel en mag enige tyd aan die navorsing onttrek, sonder dat hul te na gekom sal word.

Die voortoetsing van al sewe graad 2-klasse se kennis met betrekking tot tyd sal binne die eerste week van die derde kwartaal geskied voordat die implementering van die

*CLOCKWISE* wiskunde intervensie program 'n aanvang neem. Twee graad 2 onderwyseresse, sal weekliks opleiding en onderrigmateriaal ontvang om die program saam met my te implementeer. Opleiding sal nie langer as 15 minute per week duur nie. Ek sal ook op 'n weeklikse basis met die onderwyseresse vergader om sodoende die program se implementering te monitor. Na afloop van die program sal daar weer 'n natoets op die leerders van al sewe graad 2-klasse gedoen word om die effektiwiteit van die program te bepaal en om moontlike tekortkominge met betrekking tot onderrigstrategieë en –materiaal te identifiseer. Video-opnames sal ook van sommige lesse gemaak word.

Wees verseker dat hierdie program nie met die leerders se daaglikse program of kurrikulum sal inmeng nie. Die vakinhoud wat in die program aangespreek word maak deel uit van die graad 2 kurrikulum soos voorgeskryf deur die Departement van Basiese Onderwys. Die program sal dus deel uitmaak van die geskeduleerde wiskunde tyd op die rooster.

Dit is vir my van kardinale belang dat die etiese beskouings van die Universiteit van Pretoria deurgaans in aanmerking geneem word. 'n Hoë standard vir etiese praktyk in die konseptualisering en in die implementering van die opvoedkundige navorsing word verlang deur die deelnemers en die navorser (Universiteit van Pretoria: Etieseklaring 2011). Ek sal u deurgaans op hoogte hou. Ek onderneem om die resultate verkry uit die navorsing ook aan u en die skool bekend te maak.

Ek vertrou dat u hierdie projek met groot entoesiasme sal ondersteun aangesien die leerders daarby kan baat.

Met opregte dank en waardering.

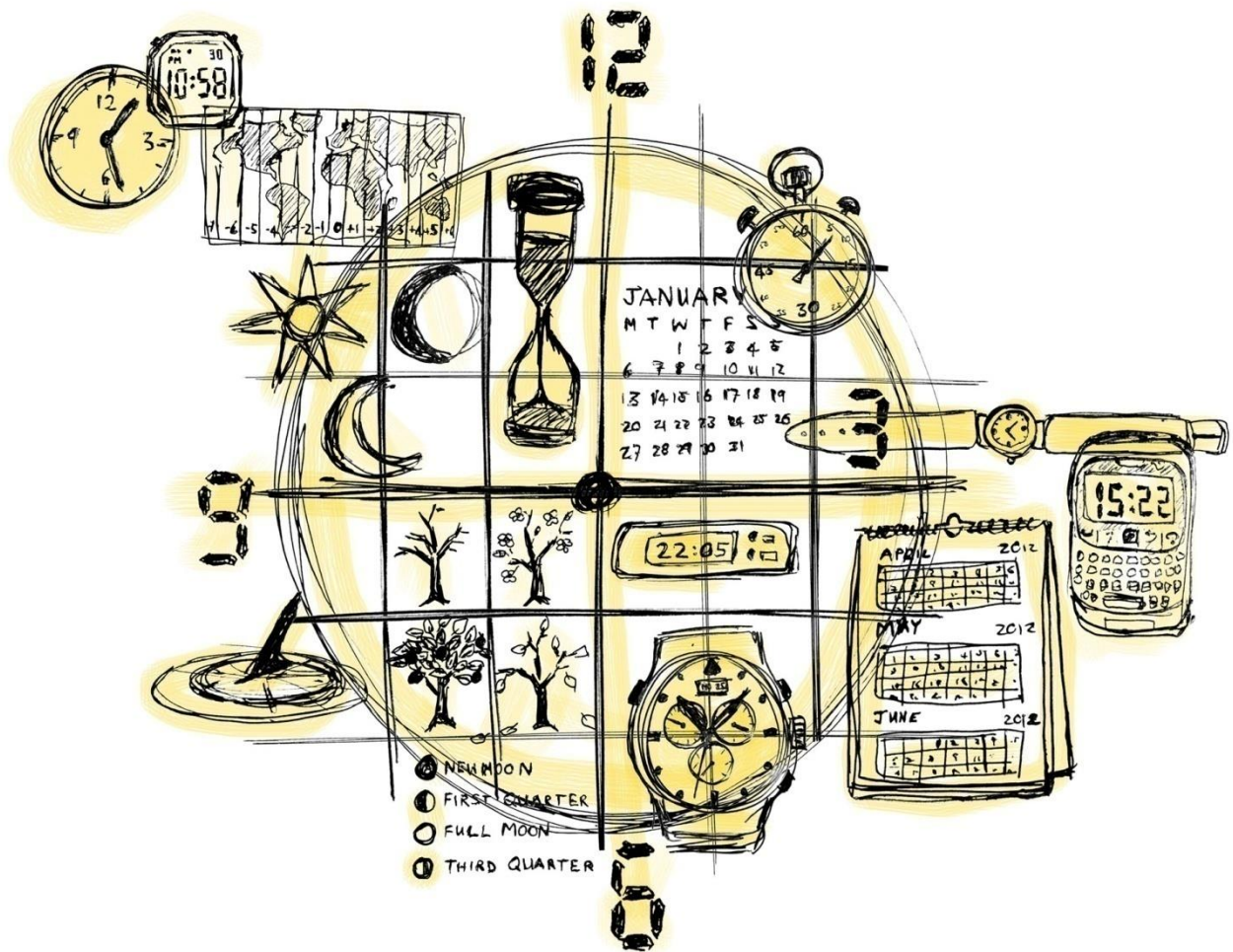
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Me Maretha Steyn (Student)

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Dr Ina Joubert (Studieleier)

# Appendix D



Letter of consent:  
School



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Fakulteit Opvoedkunde  
Departement Vroeë Kinderontwikkeling

14 Maart 2012

Die Hoof  
Laerskool \_\_\_\_\_  
Posbus \_\_\_\_\_

Geagte mnr. \_\_\_\_\_

### **Toestemming vir die implementering van 'n PhD-navorsingsprojek in Laerskool**

\_\_\_\_\_

Ek is tans 'n ingeskrewe doktrale student in die Departement Vroeë Kinderontwikkeling aan die Universiteit van Pretoria. Die titel van my proefskrif is *Teaching the concept of time in Grade 2*.

Soos reeds met u bespreek, sal ek graag in die derde kwartaal van 2012 hierdie kwalitatiewe wiskunde intervensie program, *CLOCKWISE*, in drie graad 2-klasse wil implementeer. Die volledige *CLOCKWISE*-program sal in die skool se onderrigtaal (Afrikaans) aangebied word en na voltooiing van die program sal dit die eiendom van die Universiteit van Pretoria bly.

Toestemming sal skriftelik by die Gautengse Departement van Onderwys en die betrokke onderwysers, ouers en leerders verkry word alvorens die intervensieprogram geïmplementeer word. U, die graad 2 onderwyseresse asook die leerders se privaatheid sal gerespekteer word en die betrokke partye se identiteite sal nie bekend gemaak word in my proefskrif nie. Die deelnemers neem vrywillig deel en mag enige tyd aan die navorsing onttrek, sonder dat hul te na gekom sal word.

Die voortoetsing van al sewe graad 2-klasse se kennis met betrekking tot tyd sal binne die eerste week van die derde kwartaal geskied voordat die implementering van die *CLOCKWISE* wiskunde intervensie program 'n aanvang neem. Twee graad 2

onderwyseresse, sal weekliks opleiding en onderrigmateriaal ontvang om die program saam met my te implementeer. Opleiding sal nie langer as 15 minute per week duur nie. Ek sal ook op 'n weeklikse basis met die onderwyseresse vergader om sodoende die program se implementering te monitor. Na afloop van die program sal daar weer 'n natoets op die leerders van al sewe graad 2-klasse gedoen word om die effektiwiteit van die program te bepaal en om moontlike tekortkominge met betrekking tot onderrigstrategieë en –materiaal te identifiseer. Video-opnames sal ook van sommige lesse gemaak word.

Wees verseker dat hierdie intervensie program nie met die leerders se daaglikse program of kurrikulum sal inmeng nie. Die vakinhoud wat in die program aangespreek word maak deel uit van die graad 2 kurrikulum soos voorgeskryf deur die Departement van Basiese Onderwys. Die program sal dus deel uitmaak van die geskeduleerde wiskunde tyd op die rooster.

Dit is vir my van kardinale belang dat die etiese beskouings van die Universiteit van Pretoria deurgaans in aanmerking geneem word. 'n Hoë standard vir etiese praktyk in die konseptualisering en in die implementering van die opvoedkundige navorsing word verlang deur die deelnemers en die navorser (Universiteit van Pretoria: Etieseklaring 2011). Ek sal u deurgaans op hoogte hou. Ek onderneem om die resultate verkry uit die navorsing ook aan u en die skool bekend te maak.

Ek vertrou dat u hierdie projek met groot entoesiasme sal ondersteun aangesien die leerders daarby kan baat vind.

Met opregte dank en waardering.

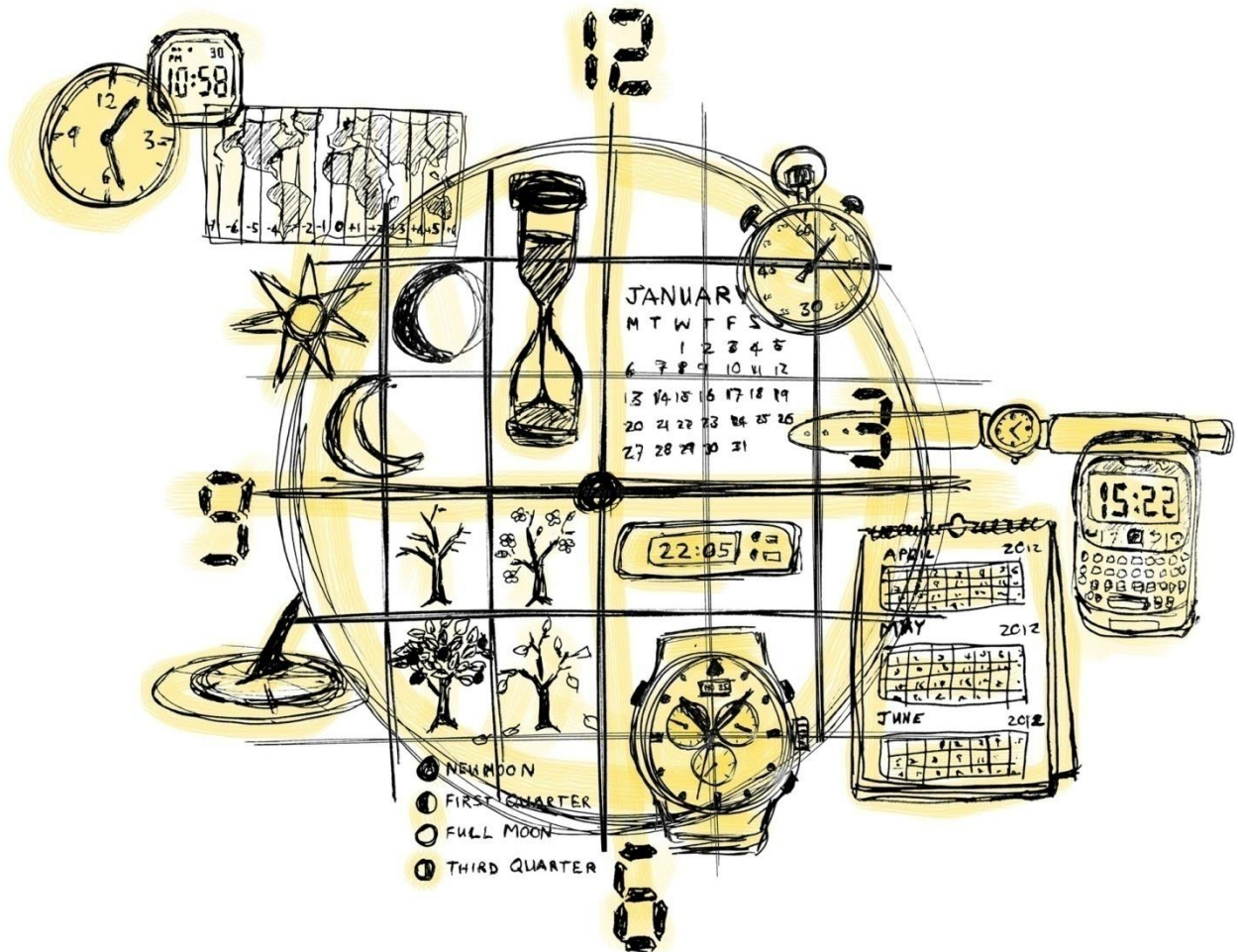
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Me Maretha Steyn (Student)

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Dr Ina Joubert (Studieleier)

# Appendix E



Letter of consent:  
Parents or guardians



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Fakulteit Opvoedkunde  
Departement Vroeë Kinderontwikkeling

14 Maart 2012

Laerskool \_\_\_\_\_  
Posbus 1355  
Sinoville  
0129

Geagte ouers

**Toestemming vir deelname aan 'n PhD-navorsingsprojek met graad 2-leerders.**

Ek is tans 'n ingeskrewe doktrale student aan die Departement Vroeë Kinderontwikkeling van die Universiteit van Pretoria. Die titel van my proefskrif is, *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time.*

Soos reeds met die skoolhoof bespreek, rig ek graag 'n versoek tot u om in die derde kwartaal van 2012 hierdie kwalitatiewe intervensie-program, *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time*, in u kind se graad 2-klas te implementeer. Die volledige *CLOCKWISE*-program sal in die skool se onderrigtaal (Afrikaans) aangebied word en na voltooiing van die program sal dit die eiendom van die skool bly.

Dunphy (2009:12) en Cockburn (1999:84) asook Grondslagfase onderwyseresse het aangetoon dat die konseptualisering en bemeestering van meting een van die vakinhoudes is waarmee meeste Grondslagfase leerders dikwels probleme ondervind. Meer spesifiek word aangetoon dat die konsep van tyd vir leerders problematies is. Derhalwe poeg ek met die navorsingsprojek om 'n Wiskundige intervensie-program genaamd *CLOCKWISE* te ontwerp en te implementeer om te bepaal watter metodologiese beginsels moontlik effektief gebruik kan word om analogiese en digitale tyd in 'n graad 2-klas aan te leer.

Die navorsing behels dat die 2012 graad 2-leerders van drie klasse in Laerskool \_\_\_\_\_ betrek word by die program. Die ander 4 graad 2-klasse sal terselfdertyd dieselfde vakinhoud aanleer, maar nie met gebruikmaking van dieselfde metodologie nie. Die leerders se privaatheid sal gerespekteer word en hul identiteite sal nie bekend gemaak word nie – nommers of skuilname sal gebruik word in my proefskrif. U kind se deelname aan die navorsingsprojek is vrywillig en u kind mag enige tyd aan die navorsing onttrek, sonder dat hy of sy te na gekom sal word.

Die voortoetsing van al sewe graad 2-klasse se kennis met betrekking tot tyd sal binne die eerste week van die derde kwartaal geskied voordat die implementering van die CLOCKWISE wiskunde program 'n aanvang neem. Na afloop van die program sal daar weer 'n natoets op die leerders van al sewe graad 2-klasse gedoen word om die effektiwiteit van die program te bepaal en om moontlike tekortkominge met betrekking tot onderrigstrategieë en –materiaal te identifiseer. Video-opnames sal soms van die lesse in die fokusgroep gemaak word.

Wees verseker dat hierdie program nie met die leerders se daaglikse program of kurrikulum sal inmeng nie. Die vakinhoud wat in die program aangespreek word maak deel uit van die graad 2 kurrikulum soos voorgeskryf deur die Departement van Basiese Onderwys. Die program sal dus deel uitmaak van die geskeduleerde wiskunde tyd op die rooster. Die program sal ook in u kind se eie klaskamer deur sy of haar eie onderwyseres geïmplementeer word. Hierdie onderwyseresse sal deur myself opgelei word en hul sal dieselfde onderigmateriaal ontvang.

Dit is vir my van kardinale belang dat die etiese beskouings van die Universiteit van Pretoria deurgaans in aanmerking geneem word. 'n Hoë standard vir etiese praktyk in die konseptualisering en in die implementering van die opvoedkundige navorsing word verlang deur die deelnemers en die navorser (Universiteit van Pretoria: Etieseklaring 2011). Al die werk, vordering, data en resultate sal te alle tye aan belanghebbendes beskikbaar gestel word.



Ek vertrou dat u hierdie projek met groot entoesiasme sal ondersteun aangesien die leerders daarby kan baat vind. U betrokkenheid as ouers word hoog op prys gestel.

Voltooi asseblief meegaande skeurstrokie oor die aangeleentheid en stuur dit aan u kind se klasonderwyseres terug.

My opregte dank en waardering

Me Maretha Steyn (Student)

Dr Ina Joubert (Studieleier)

***Voltooi asseblief en stuur terug na die klasonderwyseres***

Ek, \_\_\_\_\_ ouer van \_\_\_\_\_  
in graad 2 \_\_\_ gee hiermee toestemming en goedkeuring dat my kind aan die navorsingsprojek van die Universiteit van Pretoria mag deelneem en afgeneem mag word.

\_\_\_\_\_  
**Handtekening van ouer**

\_\_\_\_\_  
**Kontaknommer**

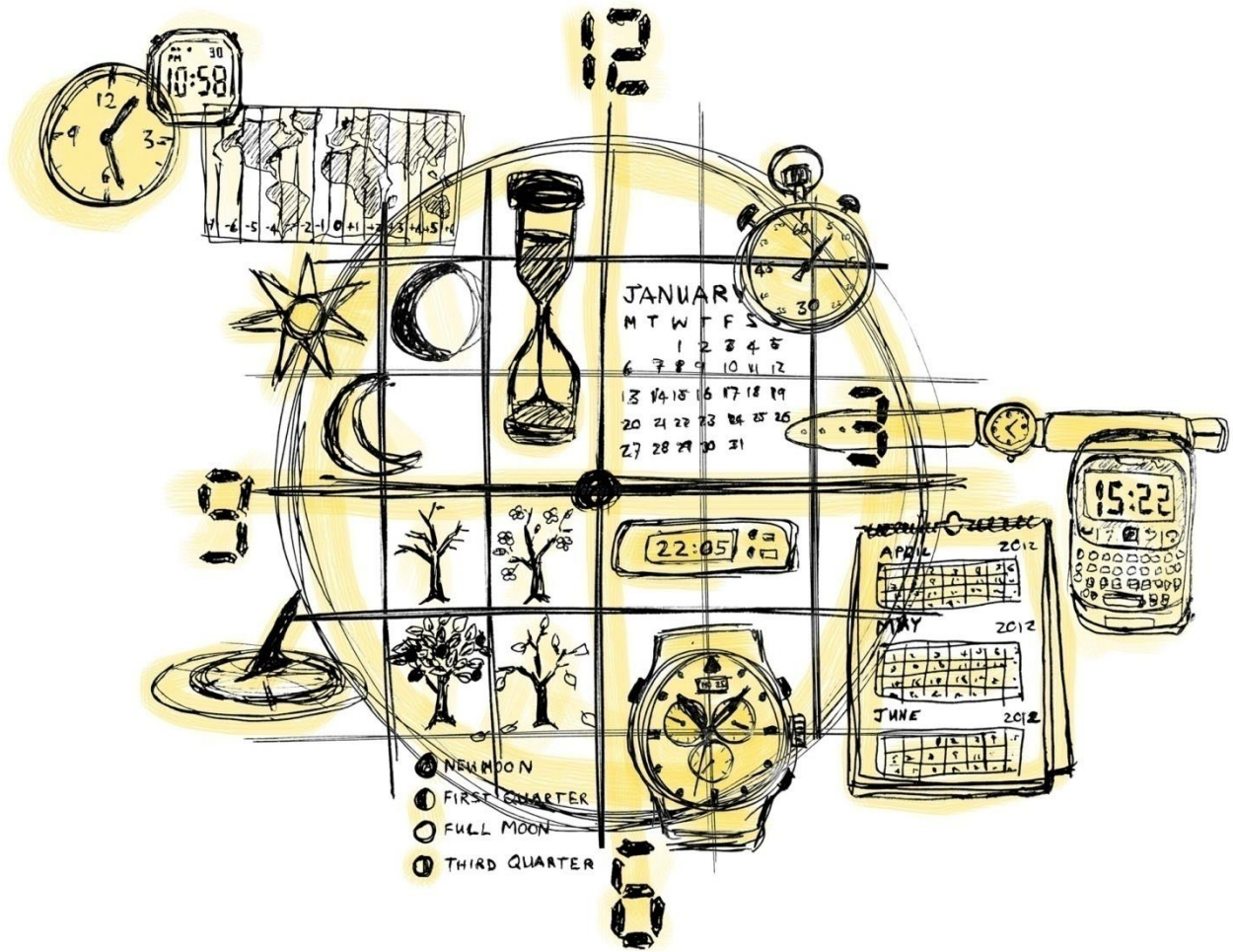
***OF***

Ek, \_\_\_\_\_ ouer van \_\_\_\_\_  
in graad 2 \_\_\_ gee nie toestemming en goedkeuring dat my kind aan die navorsingsprojek van die Universiteit van Pretoria mag deelneem en afgeneem mag word nie.

\_\_\_\_\_  
**Handtekening van ouer**

\_\_\_\_\_  
**Kontaknommer**

# Appendix F



Letter of assent:  
Learners



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Fakulteit Opvoedkunde  
Departement Vroeë Kinderontwikkeling

14 Maart 2012

2012

Liewe \_\_\_\_\_

Juffrou Maretha leer by die Universiteit van Pretoria.

Dit is 'n baie groot skool.

Ek het jou en jou klasmaats nodig om my te help.

Ons gaan saam meer van tyd en horlosies leer.

As jy nie meer lus het om my te help nie gaan ek nie vir jou  
kwaad wees nie.

Jy moet net vir my of vir jou juffrou sê.

Pappa en Mamma weet dat jy my gaan help.

Hulle weet ook dat jy afgeneem gaan word.

Ek sal vir niemand vertel wie jy is nie.

Maak asseblief 'n regmerkjie langs die woordjie JA as jy my wil help of maak 'n  
kruisie langs die woordjie NEE as jy nie wil nie.

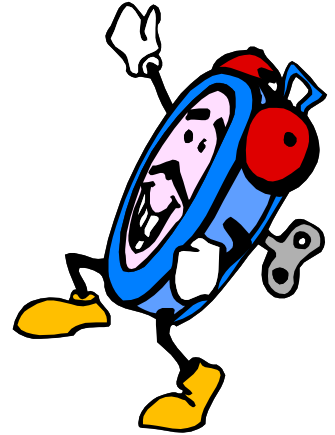
Ek gaan nie vir jou kwaad wees nie.

Baie dankie

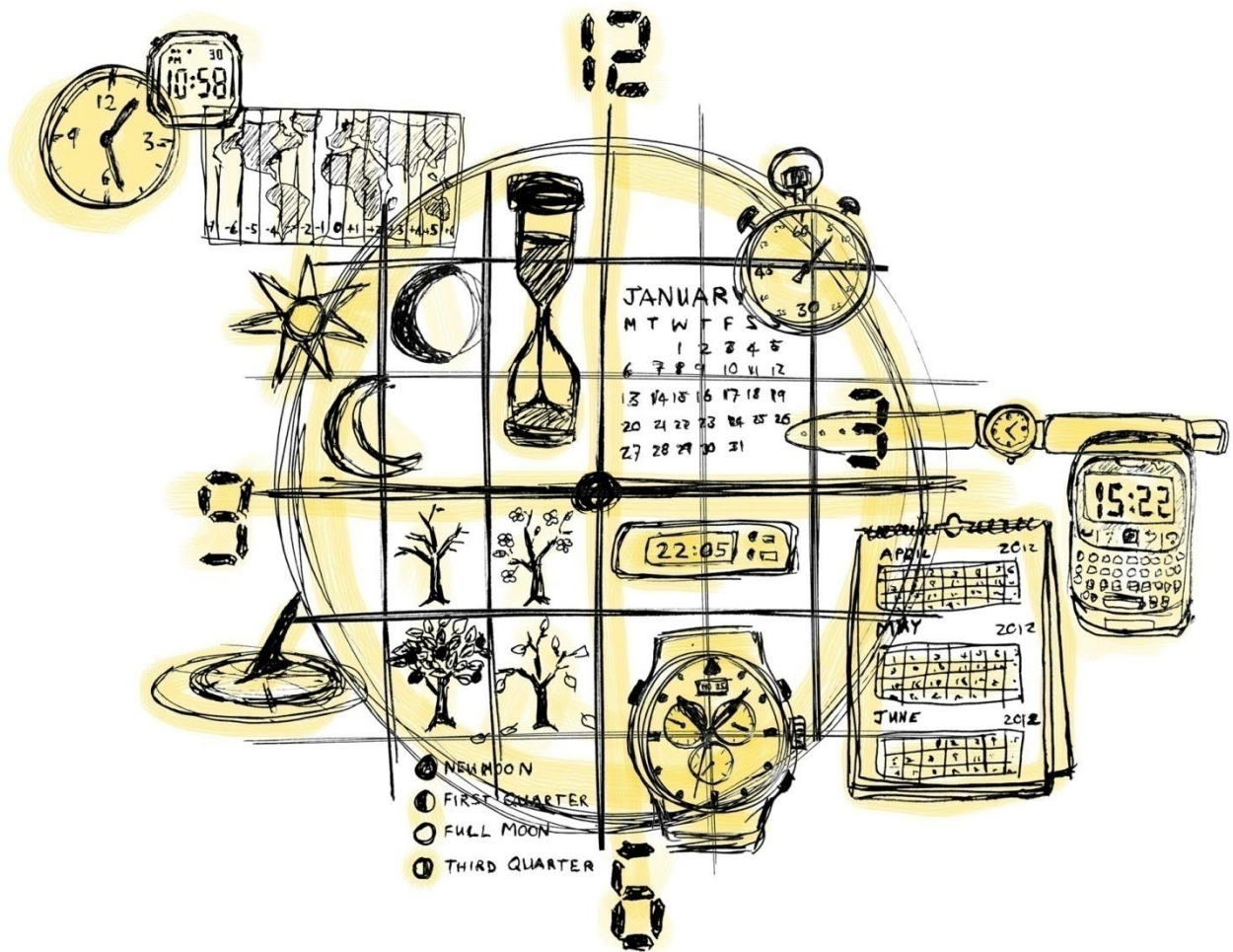
Juffrou Maretha

Ek, \_\_\_\_\_ sê

|     |  |
|-----|--|
| JA  |  |
| NEE |  |



# Appendix G



## Letter of consent: Teachers



UNIVERSITEIT VAN PRETORIA  
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Fakulteit Opvoedkunde  
Departement Vroeë Kinderontwikkeling

14 Maart 2012

Graad 2-onderwyseres  
Laerskool \_\_\_\_\_  
Posbus 13553  
Sinoville  
0129

Geagte kollega

**Toestemming vir deelname aan 'n PhD-navorsingsprojek in Laerskool \_\_\_\_\_**

Ek is tans 'n ingeskrewe doktorale student aan die Departement Vroeë Kinderontwikkeling van die Universiteit van Pretoria. Die titel van my proefskrif is, *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time*.

Soos reeds met Mnr. \_\_\_\_\_ bespreek, rig ek graag 'n versoek tot u om in die derde kwartaal van 2012 hierdie kwalitatiewe intervensie-program, *CLOCKWISE: a perspective on Grade 2 learners' conceptualization of time*, in u graad 2-klas te implementeer. Die volledige *CLOCKWISE*-program sal in die skool se onderrigtaal (Afrikaans) aangebied word en na voltooiing van die program sal dit die eiendom van die skool bly.

Skriftelike toestemming sal by u klas se ouers en leerders verkry word alvorens die program geïmplementeer word. U, asook die leerders se privaatheid sal gerespekteer word en die betrokke partye se identiteite sal nie bekend gemaak word in my proefskrif nie. Die *CLOCKWISE*-program sal terselfdertyd ook deur myself in my eie graad 2-klas geïmplementeer word. Wees verseker dat ek as u Departementshoof aan u die versekering bied dat u en die leerders vrywillig deelneem aan die navorsing en dat u nie te nagekom sal word indien u of enige leerder enige tyd van die navorsing wil onttrek nie.

Die voortoetsing van al sewe graad 2-klasse se kennis met betrekking tot tyd sal binne die eerste week van die derde kwartaal geskied voordat die implementering van die *CLOCKWISE* wiskunde program 'n aanvang neem. U sal weekliks opleiding en onderrigmateriaal ontvang om die program saam met my te implementeer. Opleiding sal nie langer as 15 minute per week duur nie. Ek sal ook op 'n weeklikse basis met u vergader om sodoende die program se implementering te monitor. Die ander graad 2-onderwyseresse mag enige tyd ook insette lewer. Na afloop van die program sal daar weer 'n natoets op die leerders van al sewe graad 2-klasse gedoen word om die effektiwiteit van die program te bepaal en om moontlike tekortkominge met betrekking tot onderrigstrategieë en –materiaal te identifiseer. Video-opnames sal soms van die lesse gemaak.

Wees verseker dat hierdie program nie met die leerders se daaglikse program of kurrikulum sal inmeng nie. Die vakinhoud wat in die program aangespreek word maak deel uit van die graad 2 kurrikulum soos voorgeskryf deur die Departement van Basiese Onderwys. Die program sal dus deel uitmaak van die geskeduleerde wiskunde tyd op u rooster.

Dit is vir my van kardinale belang dat die etiese beskouings van die Universiteit van Pretoria deurgaans in aanmerking geneem word. 'n Hoë standaard vir etiese praktyk in die konseptualisering en in die implementering van die opvoedkundige navorsing word verlang deur die deelnemers en die navorser (Universiteit van Pretoria: Etieseklaring 2011). Ek sal u deurgaans op hoogte hou. Ek onderneem om die data verkry uit die navorsing met u te kontroleer alvorens die resultate bekendgemaak word.

Ek vertrou dat u hier projek met groot entoesiasme sal ondersteun aangesien die leerders daarby kan baat vind.

Met opregte dank en waardering

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Me Maretha Steyn (Student)

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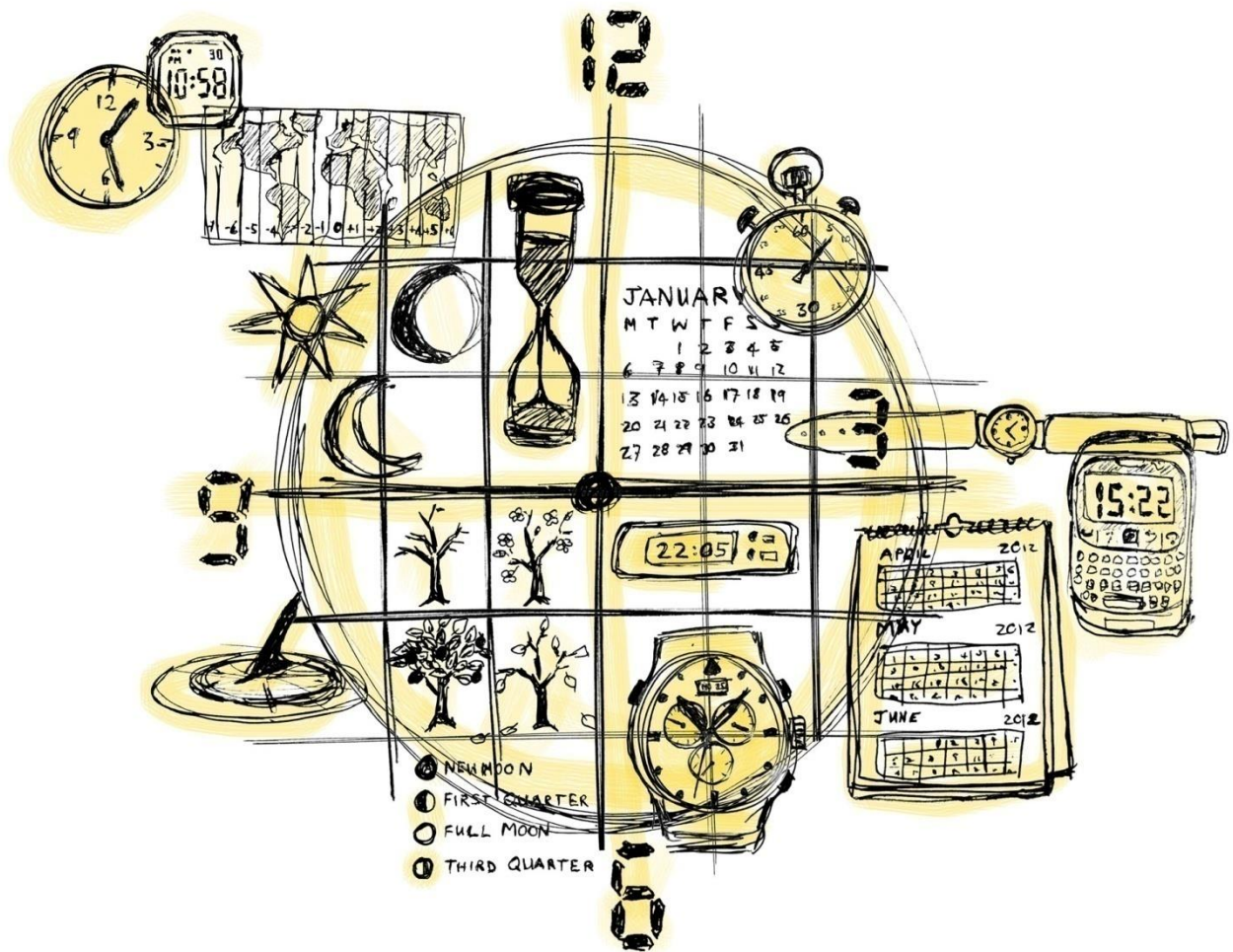
Dr Ina Joubert (Studieleier)

Ek, \_\_\_\_\_ klasonderwyseres van graad 2 \_\_\_\_  
onderneem om deel te neem aan die navorsingsprojek van die Universiteit van Pretoria.  
Ek is daarvan bewus dat ek te enige tyd van die projek kan onttrek.

Handtekening \_\_\_\_\_

Kontaknommer \_\_\_\_\_

# Appendix H



## Interview schedule: Teachers



## **Individual semi-structured interview schedule**

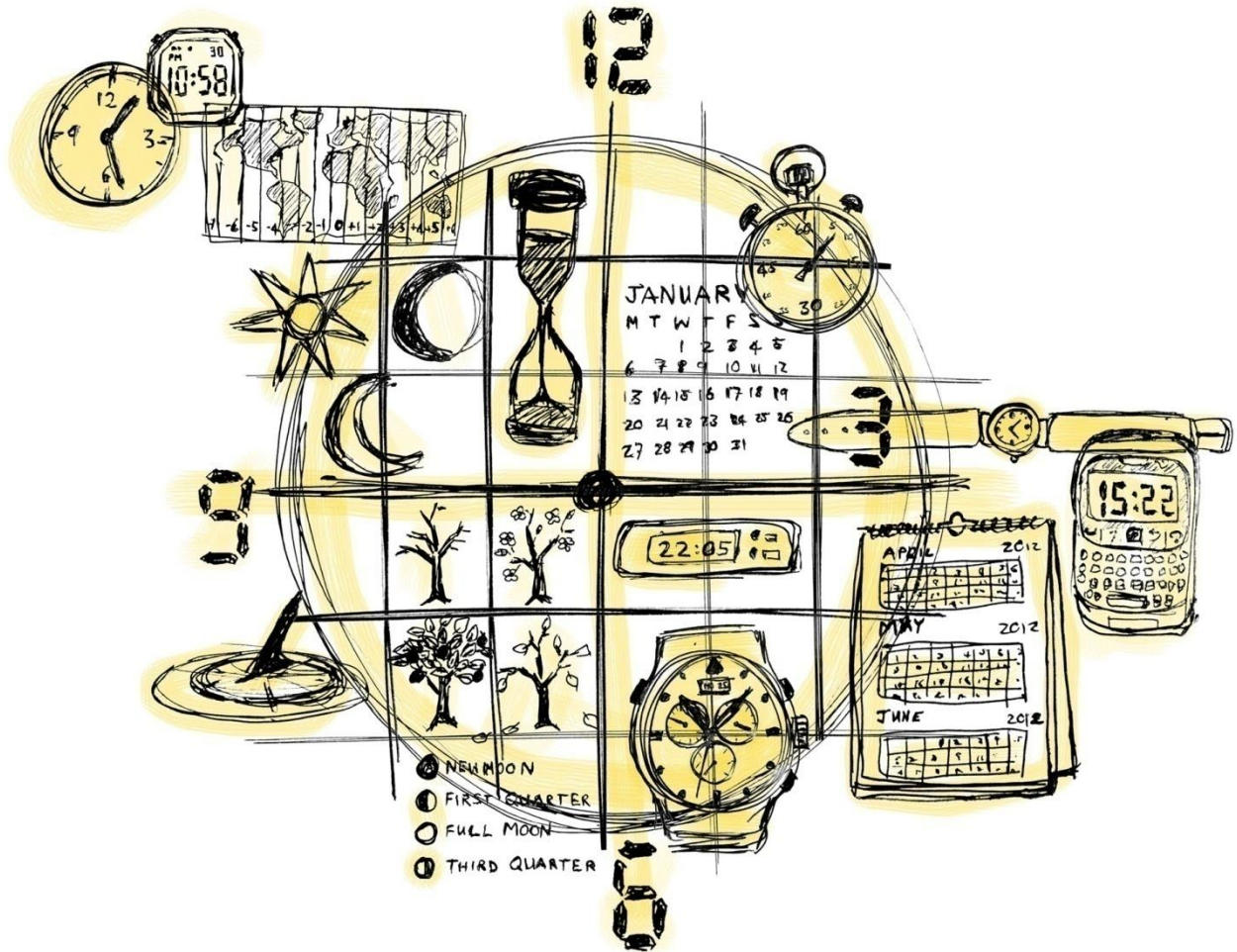
Conducted in the pre-implementation phase, with all six Grade 2 teachers at the research site

1. What do you believe are prerequisite for the effective teaching of the mathematical concept of time in Grade 2?
2. Do you believe that Grade 2 learners find it difficult to understand the mathematical concept of time? Why?
3. How can these challenges (if any), that you experience, be addressed?
4. Which key concepts must Grade 2 learners understand in order to develop an understanding of the mathematical concept of time?
5. Which concepts of analogue time do learners find most difficult?
6. Which concepts of digital time do learners find most difficult?
7. Can you offer any advice in terms of the teaching of the mathematical concept of time?
8. Do you have any ideas to share?

Conducted in the post-implementation phase, with my co-researchers

1. What do you believe are prerequisite for the effective teaching of the mathematical concept of time in Grade 2?
2. Do you believe that Grade 2 learners find it difficult to understand the mathematical concept of time? Why?
3. Did the CLOCKWISE mathematical programme address any of the challenges you experienced previously?
4. Which key concepts must Grade 2 learners understand in order to develop an understanding of the mathematical concept of time?
5. Which concepts of time did the learners attain, or not?
6. Discuss some of your experiences during the implementation of the CLOCKWISE mathematical programme.
7. Did the implementation of the CLOCKWISE mathematical programme change your perception on the teaching and learning of the mathematical concept of time?
8. Do you have any ideas to share?

# Appendix I



Declaration of language editor  
Sharon R Ball

## SHARON (SHEYNE) R BALL TTD (JCE)

Editorial Services  
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Tel: (012) 460-9032 Tel/Fax: (012) 460-9737 Cell: 082 214 8949 Email: ball@mweb.co.za

1 September 2014

### CERTIFICATE OF EDITING

To whom it may concern

This certifies that I have edited the PhD thesis, TEACHING THE MATHEMATICAL CONCEPT OF TIME IN GRADE 2, by Maretha G Steyn, prior to it being finalised and submitted to the University of Pretoria in September 2014.

#### Disclaimers

1. I focused on language issues, including grammar, tenses, subject-verb agreement, punctuation, and consistency with regard to UK spelling.
2. I improved the word order where necessary to facilitate the logical flow of the story line.
3. A complete edited copy was provided. Final decisions rest with the author as to which suggestions to implement.



**Sheyne R Ball**  
Language editor