

**A MATTER OF TIME: AN INVESTIGATION INTO THE  
LEARNING AND TEACHING OF TIME IN THE MIDDLE  
PRIMARY YEARS**

**Submitted by**

**Margaret Christine Thomas**

**Dip Teach (Bendigo), TTCTD (Rusden), BEd, MEd (La Trobe)**

**A thesis submitted in total fulfilment of the requirements for the  
degree of  
Doctor of Philosophy**

**Faculty of Education and Arts  
Australian Catholic University**

Research Services

Locked Bag 4115

Fitzroy

Victoria 3065

Australia

25/06/2018

## **Declaration of authorship**

This thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No parts of this thesis have been submitted towards the award of any other degree or diploma in any other tertiary institution.

No other person's work has been used without due acknowledgment in the main text of the thesis.

All research procedures reported in the thesis received the approval of the relevant Ethics/Safety Committees (where required).

Signed

Date        25/06/2018

## **Acknowledgments**

I am indebted to a number of people who have helped over the four years it has taken to complete this thesis. I am particularly grateful to my supervisors for their continued support and assistance through every step of the journey. From the very beginning my supervisors, Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson were an exceptional team with whom to work. Their advice and assistance throughout was extremely helpful and highly valued.

I would like to acknowledge the principal, assistant principal and teachers of the trial school who warmly welcomed me into their domain. Their interest in my study made the trialling of my one-to-one task based interview a positive experience.

The principal of the main study school deserves special mention. His belief in the value my research would have for his students was a key factor in the participating teacher and students' willingness to be a part of the study. The teacher of the Year 3/4 class who accepted me into her classroom and gave me unlimited access to her students also deserves a special mention.

The students who participated in the study were enthusiastic and willing to attempt the tasks set for them during the interviews and the lessons. Their contribution to this research is the most important aspect of the data collection.

I would also like to express my appreciation to the helpful people at ACU: Anne Roche who helped me collect supporting data; the library staff who always answered my queries and sent texts to me at home; and the other doctoral students with whom I shared the journey.

My appreciation is also extended to Marika, Remus, Rafferty, Hetty and Connor for their interest in my study.

I acknowledge the support of the Department of Education and Training. The Department of Education and Training approved access to primary schools in regional Victoria to collect data that was valuable to this study.

This research would not have been possible without the encouragement and unequivocal support of my husband, Graham Thomas, and my daughters, Caitlin and Kezia.

## **Dedication**

This thesis is dedicated to my late parents: my father, Chris Metcalf for whom mathematics was a favourite school subject, and my mother Joan Metcalf who instilled in me a love of learning.

## **Publications arising from this study**

- Thomas, M., Clarke, D., McDonough, A., & Clarkson, P. (2017). Framing, assessing and developing children's understanding of time. In A. Downton, S. Livy, & J. Hall (Eds.), *40 years on: We are still learning* (Proceedings of the 40th annual conference of the Mathematics Education Research Group of Australasia, pp. 64-73). Melbourne, Australia: MERGA.
- Thomas, M., Clarke, D. M., McDonough, A., & Clarkson, P. (2016). Understanding time: A research based framework. In B. White, M. Chinnappan, & S. Trenholm (Eds.), *Opening up mathematics education research* (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia, pp. 592-599). Adelaide, Australia: MERGA.
- Thomas, M., McDonough, A., Clarkson, P., & Clarke, D. M. (2016). Time: Assessing understanding of core ideas. In B. White, M. Chinnappan, & S. Trenholm (Eds.), *Opening up mathematics education research* (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia, pp. 600-607). Adelaide, Australia: MERGA.

## **Award arising from this study**

Beth Southwell Practical Implications Award 2017

Mathematics Education Research Group of Australasia (MERGA)

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## **Abstract**

This is a report into the investigation of the learning and teaching of time in the middle years of primary school. The study began with the identification of the major Components for a clear understanding of time by investigating the purposes for and tools by which time has been measured over the centuries. Having identified the major Components of time as Awareness of time, Succession, Duration and Measurement of time, key ideas that gave additional information about each major Component were drawn from the literature and listed.

A Framework for the Learning and Teaching of Time was developed incorporating each of the major Components and the accompanying key ideas. To investigate what students in Years 3 and 4 understood about time, a one-to-one task based interview was developed and trialled based on the major Components of Succession, Duration and Measurement of time. An Awareness of time was deemed to be incorporated into each item as students in Year 3 and 4 were assumed to have an understanding of Awareness of time. The responses given by the students to each interview item were scored according to pre-determined responses; 2 points for a response that demonstrated a clear understanding, 1 point for demonstrating a partial understanding, and 0 points if no understanding was demonstrated.

Twenty-seven students from a Year 3/4 class in a Victorian regional city school were interviewed using the one-to-one task based interview as a means of ascertaining the understanding of time students at this year level could demonstrate. The responses to each interview item were analysed with the lowest scoring items being considered the most challenging items. Following design research methodology an eight-lesson intervention for the Year 3/4 class was planned and implemented focussing on the lowest scoring items from the students' interview scores. Post-intervention interviews were conducted three weeks after the intervention with the results of each student and each item compared. Each student increased their total scores, although not all students improved on every item. The lessons were analysed to identify the pedagogies and experiences that appeared to enhance student understanding.

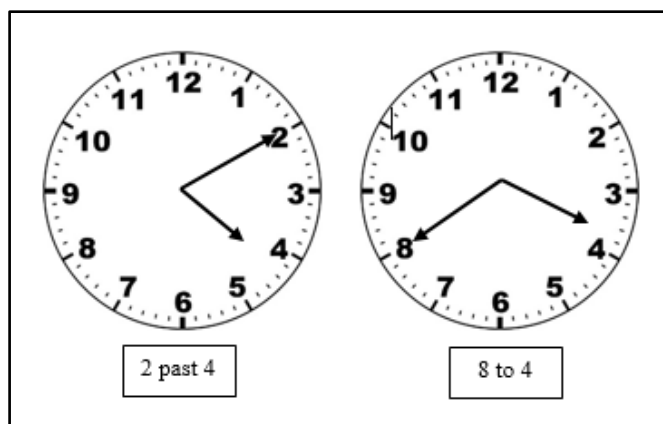
Introducing each lesson with the reading of a children's book that focussed on the lesson foci; physical involvement; manipulating materials and equipment; the use of correct terminology; group work, discussion, self-reflections on their learning; and sufficient time to complete a variety of activities were shown to be advantageous to the students' learning.

This research provides insights into Year 3 and 4 students' understanding of time. It is of benefit to both teachers and researchers as it gives greater direction to the learning and teaching of time than has been previously available.

## CHAPTER 1. It's About Time

### 1.1 The Impetus for the Study

As a classroom teacher in the early years of primary school, the researcher encountered students for whom “telling the time” was a challenge, but as the focus was on reading the hour and half hour times, it was assumed that the skills required to read the time to the minute would be learned in subsequent years. When the opportunity arose to work with students in Years 5 and 6, she was surprised to find that there were students nearing the completion of their primary schooling who were unable to confidently read half hour and quarter hour times on an analogue clock and could not solve problems relating to hours and minutes, despite undertaking lessons on time since they began school. As the researcher worked with these students, she noticed that they experienced some common difficulties when reading and interpreting the time displayed on the analogue clock face. The movements of the hour and the minute hands were not understood and a time such as 10 past 4 would be given as “2 past 4”, and “20 to 4” would be read as “8 to 4” or “4 past 8” (see Fig. 1). When asked to show a time on an analogue clockface, it was difficult for these students to recall where the hands would be placed to indicate “past” and “to,” and for many of these students, half past was also a challenge. They referred to the numbers on the clock but not the minute marks. Without an understanding of the relationship between hours and minutes on a clock-face, solving problems related to time such as converting between analogue and digital times or finding the arrival time of a trip when given the departure time and the duration of the journey, was challenging for these students.



*Figure 1.1* Errors made in clock reading by primary school students.

By Years 5 and 6, it appeared that these students had lost interest in trying to understand the reading of clocks as years of perceived failure had made them reluctant learners. The students' apparent lack of understanding led the researcher to question the curriculum and pedagogy for

the learning and teaching of time in the primary school. Questioning the curriculum prompted the researcher to consider how the teaching of time could be improved in primary schools so that many more students could experience success not only reading clocks and calendars, but also solving problems which require a deeper understanding of the concept of time.

## **1.2 The Research Problem**

Since the Industrial Revolution, time has been considered as a commodity, where time is money (Galison, 2000). Prior to this introduction of modern science, the perception of time was based around social and cultural meanings (Duncheon & Tierney, 2013). With the advent of western science based universal coordinated time (Duncheon & Tierney, 2013), we have become dependent on clocks and calendars to divide the day into sequential durations for school, work and even leisure activities. A more recent revolution, the invention of Information and Communication Technology (ICT) brought another temporal dimension, with its ensuing social media and the perception of a week as a 168 hour time period (Laguerre, 2004). Although conceptions of time can vary according to whether the user is considering time constructed in social and cultural contexts, clock time, or virtual time (Duncheon & Tierney, 2013), an understanding of key concepts of time is important. From the errors perceived when working with students in late primary school, and after discussion with teachers from Years 3 to 6, it became apparent that a number of students do not understand the key concepts of time. This apparent lack of understanding forms the basis of the research problem.

### **1.2.1 The importance of time**

Our knowledge of time enables us to participate in the present, plan for the future and simultaneously remember and appreciate what has gone before. Understanding and being able to read time measuring tools, experience social time, and communicate 24 hours a day in virtual time is crucial to our wellbeing and full participation in society. Given the current importance of understanding the passage of time and duration of events for our working and social lives, it is necessary that children develop and master the various components of time concepts and the measurement of time.

Although time cannot be seen, children become aware of time in their daily activities such as school time and bedtime (Buys & Veltman, 2005), and in recurring temporal patterns such as the rising and setting of the sun, the seasons and their birthdays (Friedman, 1990). The need to measure time has been a feature of our lives since the ancient Egyptians gave us the calendar and the 24 hour day (Hannah, 2005). Since the Middle Ages when mechanical clocks began to appear to denote prayer times and working hours (Barnett, 1998; Dohrn-van Rossum, 1996),

our time measuring tools have become more sophisticated. Time is still measured according to natural phenomena such as the day and the year but our need to measure time more accurately has seen the introduction of units of time to measure time segments from the very small, nanoseconds and milliseconds, to the immensely large, millennia, eons and eras (Barnett, 1998). Common time measuring tools in use today are the calendar, which is used to measure and record the time the Earth takes to revolve around the Sun, and the clock, which is used to measure the time the Earth takes to rotate once on its axis. As the Earth revolves around the Sun we experience seasons, and as the Earth rotates, day and night occur. Understanding these cyclic processes enables children to anticipate and plan for the future (Friedman, 2000; Hudson & Mayhew, 2011) and to remember the past (Friedman, 1991; Hudson & Mayhew, 2011).

Our reliance on time makes it an important topic in the mathematics curriculum as students need to develop a deep understanding of the relevant concepts to be able to interpret and use time measuring devices such as calendars and clocks effectively. Studies into the mathematics used by Australian adults in their everyday, non-occupational lives by Northcote and McIntosh (1999) and Northcote and Marshall (2016) have shown that calculations of time were the most common context for calculation; time calculations comprised 25% of all calculations in the 1999 study, rising to 30% in the 2016 study. While this deeper conceptual understanding of time is clearly part of a developmental process which occurs gradually from infancy to adolescence (Friedman, 2011; Piaget, 1969; Trosborg, 1982), it is important to note the distinction between telling the time and the concept of time. Children may be trained to read the dials on a timepiece, but still have difficulty in understanding the concept of time (Dickson, Brown, & Gibson, 1984).

### **1.2.2 Limitations of existing research**

Research interest in children learning about time has been evident from the middle of last century, but this interest has principally focussed on the psychology and development of temporal relations unrelated to units of time such as the hour and minute (Earnest, 2017). One of the first studies was undertaken by Piaget (1969) who investigated children's understanding of succession and duration. Piaget's study has been cited by later researchers despite its limitations which include using a small cohort of participants. Piaget's experiments have been repeated by other researchers who have formed conclusions not altogether in agreement with Piaget, although many of his results regarding time and speed have been validated by others (Levin, 1979; Levin, Israeli, & Darom, 1978; Lovell & Slater, 1960).

Further studies have been undertaken to ascertain what children understand about the passage of time and the language of time (Ames, 1946; Friedman, 1978, 2000; Friedman & Laycock, 1989), but there have been few studies which have investigated how children learn about time in the classroom or how many hours should be allocated to this topic. As an illustration of this, of the 1,630 plus research papers presented in the years 2005 to 2015 at the annual conferences of the International Group for the Psychology of Mathematics Education (IGPME), the major international conference on research into mathematics education, only *one* paper mentioned the topic of time (Doig, Williams, Wo, & Pampaka, 2006). Doig et al. collected responses to a test on measurement from 14,000 students, and in their paper reported on *one* item in the test on the attribute of time.

The language of time has been predominate in the research literature with studies focussing on the words children use (Ames, 1946), children's sense of the past and the future (Blything, Davies, & Cain, 2015; Friedman, 1977, 1986, 1991, 2000; Grant & Suddendorf, 2010; McCormack & Hanley, 2011; McCormack & Hoerl, 2007; Povinelli, Landry, Theall, Clark, & Castille, 1999; Weist, 1989), and children's judgements of duration, speed and distance (Levin, 1979; Siegler & Richards, 1979). Whilst the existing literature has extended our knowledge of what children know about some temporal relations, such as placing events in the past and the future, there has been little research on student learning and understanding of time symbols and notation (Burny, Valcke, & Desoete, 2009; Earnest, 2017; Friedman & Laycock, 1989), elapsed time (Kamii & Russell, 2012), or empirical studies on the learning of time published in the past two decades (Earnest, 2017).

Articles in teacher journals that relate to time tend to focus on giving teachers ideas and activities to assist children to learn to read the time on the clock face, with few activities to develop a deeper understanding of time (McMillen & Herdandez, 2008; National Council of Teachers of Mathematics, 2014). This brief overview of the existing research will be extended in Chapter 2.

### **1.3 The Purpose of this Study and the Research Questions**

The purpose of this study was to build on available knowledge on the development of time concepts in primary school students through the introduction of a Framework for the Learning and Teaching of Time, the development and implementation of assessment tools, and an eight-lesson intervention focussing on experiences and pedagogies for learning and teaching the concepts of time in a Year 3 and 4 classroom. Owing to the paucity of research on this topic (Burny et al., 2009; Earnest, 2017; Friedman & Laycock, 1989; Kamii & Russell, 2012), there

was a need to add to the research and professional learning literature on the teaching and learning of time. This research is important to the educational community as it aims to encourage researchers, curriculum writers and teachers to contribute to children achieving success in this important area. To add to our knowledge of children's developing understanding of time, this study investigated the following research question:

What are the major components of a clear understanding of time and how might these components be described, assessed and supported in the primary school classroom?

The following sub-questions assisted in answering the research question.

1. What are the major components of a clear understanding of time?
2. How can student learning and understanding of time be assessed?
3. What are middle year primary school students' understandings of time?
4. What classroom experiences and pedagogies might support student learning about time?

#### **1.4 The Key Steps in Investigating the Research Questions**

The key steps in investigating the research question and related sub-questions were as follows:

- the existing literature was used to structure an initial framework on major Components of time;
- a one-to-one, task based interview was designed to assess Year 3/4 students understanding of time;
- the interview data and the framework were used to develop an eight-lesson intervention focussing on aspects of time that appeared to challenge the students; and
- the Year 3/4 students were interviewed again to assess any growth in their understanding which could be attributed to the intervention.

#### **1.5 The Structure of the Thesis**

The thesis is divided into seven chapters. In Chapter 1, the introductory chapter, the researcher established the interest and impetus of the study, suggested a paucity of research in the relevant area, explained the purpose of the research and stated the research questions. The researcher gave a brief explanation of the key steps used to answer these research questions and explained the importance of the research to the educational community.

In Chapter 2 the literature related to the learning and teaching of time is examined. To place the measurement of time in context, the chapter commences with an examination of the tools used to measure time over the centuries. Insights into early time measurement emphasise how the measuring of time has been important to civilisations for centuries, and establishes the purposes for time measurement, the first step in identifying the major Components of time. With limited research on the learning of time, the learning of measurement concepts in general is outlined in detail and incorporates the learning of time concepts. Research on effective teaching is explored to underpin the pedagogical practice for teaching time, with sections on student learning and student assessment to ascertain optimal learning conditions for students.

In Chapter 3 the methodology used for the thesis is described. Design research is detailed and the context of the study is explained.

The results obtained from the study are presented in Chapters 4 and 5. The results leading up to the eight-lesson intervention are detailed in Chapter 4 with the results from the intervention and post-intervention assessment outlined in Chapter 5.

The responses to the four research sub-questions are provided in Chapter 6.

A summary of all the chapters and response to the main research question are provided in Chapter 7. Discussions of implications for teachers and researchers, limitations of the study and directions for future research conclude the chapter.

## **1.6 Summary of Chapter 1**

The background for the study was provided in this introductory chapter. The research problem was outlined with emphases on an explanation of the importance of time and existing research. The purpose of this study was outlined and the research questions were stated. The key steps undertaken to investigate the research questions were outlined. An outline of the structure of the thesis concluded the chapter.

A review of the literature on which this study is based is provided in Chapter 2.

## **CHAPTER 2. A Review of the Literature**

### **2.1 Introduction**

Although unseen, time plays an important role in our lives, directing us constantly throughout the day and night. Our use of time has changed over the centuries and continues to evolve. We have moved on from using the rising sun as our clock to awaken us each day and the setting sun to send us to bed to a reliance on very accurate time measuring tools. Due to the importance we place on time, there is a need for our students to be aware of, and to learn about the passage of time, time durations, sequences of time and how time is measured using and understanding time measuring tools.

To ascertain what is required in our mathematics curriculum and subsequently taught in our classrooms, it was considered important by the researcher to investigate the process by which adults have come to understand and measure time throughout history and the purpose for which time has been measured. An investigation into time measuring and tools and the reasons for their development was undertaken to validate the importance of measuring time, and to assist in identifying components of time that have endured for centuries.

The chapter begins with a reflection of humans' awareness, understanding, and measurement of time and the subsequent development of tools for this purpose. The concept of time and its relationship to other forms of measurement will be discussed along with the importance of students having a sound understanding of time.

### **2.2 The Sources of the Literature Discussed in this Chapter**

The literature discussed in this chapter falls into two major parts. The first category describes the measurement of time over the centuries, conceptualises time, identifies the major Components of time and concludes with a Framework for the Learning and Teaching of Time. A search of the literature was undertaken primarily through the Australian Catholic University's library collection using the library's system Alma/Primo supplied by Ex-Libris. A search through the books on the shelves and the 461 data bases to which the library subscribes was undertaken to gain an understanding of how we learn to measure time. Understanding the purposes for which time measuring tools were invented and used assisted in establishing the major Components for a clear understanding of time. Given the focus on the historical aspects of time, many of the references related to this section were relatively old. Searching education data bases such as A+ Education and ERIC using key words (examples, students, time,



measurement and learning) led to further articles which supported the process of identification of the major Components of time and informed the first sub-question posed in this dissertation. The second section discusses the curriculum, the learning and teaching of time and assessment. An overview of the literature selected for the latter part of the literature review and the process by which it was selected are explained at the commencement of the second part.

### **2.3 The Measurement of Time over the Centuries**

To establish what aspects of time could be considered major Components, it was deemed important to investigate how time was measured from early civilisations to the present day. Reviewing the tools developed over the centuries assisted in gaining an understanding of society's changing needs. Identifying the purpose behind each time measuring tool also assisted in the identification of the major Components of time.

Time has always been a part of Earth's existence. Although time cannot be seen, we experience a sense of time and we are time conscious. Time is still measured according to natural phenomena, the day, the lunar month and the year; in addition, constructed divisions or units of time have been introduced to measure time segments from the very small, nanoseconds, milliseconds and seconds, to the immensely large, decades, centuries, millennia, eons and eras (Barnett, 1998).

While early man would have been aware of the differences between periods of sunlight and darkness, day and night were regarded as different phenomena and not as a single entity (Barnett, 1998). It is likely that our early ancestors were aware of changes over time as animals and children aged, plants ripened and people died. By the time people started to cultivate crops, it would have been necessary to know the cyclical and successive nature of the seasons and to be aware of the best times to sow and harvest (Barnett, 1998; O'Neil, 1975).

The question of the universe having a beginning in time puzzled philosophers and scientists for centuries until scientific discoveries confirmed the creation dates of planets and stars, leading to a change in our understanding of time (Hawking, 1988). Newton (1642-1727) believed, like Aristotle (384-322 B.C.E<sup>1</sup>), in absolute time. "That is, they believed that one could unambiguously measure the interval of time between two events, and that this time would be the same whoever measured it, provided they use a good clock" (Hawking, 1988, p. 18). Although we still measure our daily lives based on Newton's concept of absolute time,

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<sup>1</sup> B.C. is an abbreviation for the years Before Christ and is used in many of the cited references. B.C.E., Before the Common Era, is also used in cited references and denotes the same periods of time. For consistency, I have used B.C.E. throughout.

unalterable and independent of external factors, Einstein showed ideas of space and time need to be reconsidered when comparing objects moving at or near the speed of light. With his theory of relativity, Einstein introduced relative time, where time and space are inextricably linked and distances in the universe are measured according to the speed of light (Barnett, 1998; Hawking, 1988).

The next sections give a brief account of how time has been measured and the purpose for which time was measured over the centuries.

### **2.3.1 The measurement of months and years**

Calendars, the oldest and most stable systems of recording time, have endured for centuries (Barnett, 1998). The use of calendars over such a long period demonstrates an ongoing need to measure and record the sequential ordering of days and months and the duration of a year.

Over one thousand years B.C.E, that is, well before the advent of any clocks to mark the hours of the day, the ancient Egyptians studied the heavens at night and connected the periodic regularity of the moon and the planets to time (Hannah, 2005; O'Neil, 1975; Weinert, 2013). The Egyptians used a lunar calendar for festival purposes, with months comprising 29 or 30 days based on the cycle of the moon and a civil calendar based on the movement of the sun (Hannah, 2005). The civil calendar had 12 months of 30 days, but as each year has 365 days, five epagomenal or intercalary days were added, usually at the end of the year (Hannah, 2005; O'Neil, 1975).

The Egyptians gave us the 24 hour day, although their hour was not a fixed length as we know it, but varied according to the length of the night and the change of seasons. To tell the time at night the Egyptians observed the rising of certain stars with the time between the rising of one star and the next being the Egyptian hour (Hannah, 2005).

The Greeks saw the earth as the centre of the universe, with the six known planets, the sun and the other stars orbiting it. Calculations based on the movement of the planets and the moon gave rise to the discovery of the number of days in a year and the advent of the Greek calendar (Hannah, 2005; Weinert, 2013). The Greeks found inconsistencies between the lunar and solar cycles and endeavoured to synchronise these cycles and to maintain alignment by intercalating a thirteenth month at irregular intervals (Hannah, 2005).

From its beginning, the Roman calendar was lunisolar but, like the Greeks, the Romans had difficulty in aligning the moon cycles with the sun. The Romans had a superstitious regard for odd numbers, so selected twenty-nine and thirty-one days for the months, with one month of

twenty-eight days (Hannah, 2005). Even with an intercalary month, a misalignment developed between the calendar and the sun. In 46 B.C.E., Julius Caesar is given credit for revising the calendar, making the length of the year three hundred and sixty-five and one quarter days. To account for the quarter day, one day was added to every fourth year, giving us our Leap Year (Hannah, 2005; O'Neil, 1975).

The calendar we use today is the reformed Julian or Gregorian calendar with overtones from the early Greek and Roman calendars (Hannah, 2005; O'Neil, 1975). With the exception of July and August, named respectively for two important leaders of the time, Julius Caesar and Augustus, the names of the months are derived from the calendar of the Roman Republic (Hannah, 2005).

The Gregorian calendar is named for Pope Gregory X111, who introduced this calendar in 1582 (O'Neil, 1975). The Gregorian calendar counts the years from the birth of Jesus, indicated by the letters A.D. meaning Anno Domini, the year of our Lord. The Gregorian calendar is a solar calendar relying on the movement of the earth around the sun to give us the length of each day and each year. The number of hours in a day is an artificial construct but the numbers of days in a year, along with the seasons of the year, are determined by our position in space in relation to our sun.

Although the calendar year comprises 365 days, the rotation of the earth around the sun takes 365.24219 mean solar days (Hannah, 2005). By the 16th century, an adjustment to the timing of Leap Years was required, whereby the century years in which the first two digits are not divisible by four (e.g., 1800, 1900, 2100) are not Leap Years.

There are other means of measuring a year. Our solar year is the *tropical* year, measuring the sun from one spring equinox to the next (Hannah, 2005). A *sidereal* year “measures the passage of the sun across a point among the stars, and comprises 365.2564 mean solar days” (Hannah, 2005, p. 12). Although the difference between a solar and a sidereal year is twenty minutes and twenty- three seconds, it would take one hundred years to be different by a day and a half, so in everyday life, we treat each of these years as the same (Hannah, 2005).

Early calendars, like the calendars of today, played a role in the smooth functioning of an ordered society such as the coordination of the natural progress of days and seasons with the planning for planting and harvesting of crops and other seasonal events (Hannah, 2005).

### 2.3.2 The measurement of hours

The sundial is the earliest known tool for measuring the succession and duration of daylight hours. As the sun moves across the sky, the shadows cast from the direction of the rays of light shorten from sunrise to midday, when the sun is directly overhead and the shadow is the shortest. As the sun continues on its path westward, the shadows lengthen until the sun sets. The first sundials were in use from the fifth millennium B.C.E. and consisted of a stake (a gnomon) placed into the ground to observe the sun's shadow (Barnett, 1998; Dohrn-van Rossum, 1996). By the second millennium B.C.E., cities and trade were established and the gnomon had been calibrated with lines to mark the changes in the shadows of the sun. The Egyptians divided the first half of the day into six sections. By turning the sundial around, the second half of the day could be measured. This allowed the day to be divided into twelve slots of time (Dohrn-van Rossum, 1996). As each day's available sunlight was divided into twelve, these divisions would have varied in length daily from summer to winter, giving rise to the hours being termed temporary hours (Barnett, 1998; Dohrn-van Rossum, 1996). While the accuracy of these early Egyptian sundials has been questioned, Greek and Roman sundials showed steady improvement, with sundials becoming prevalent throughout the Roman Empire from the 3rd century B.C.E. (Barnett, 1998). As people became aware of the differences in the length of the shadows across the Empire, changes were implemented to account for changes in latitude in different cities (Barnett, 1998).

Sundials measured the daylight hours but they were ineffective when there was little or no light. Although sundials were adapted to different seasons and different parts of the world due to the sun's angle differing from place to place, they had limited use. Nevertheless, sundials, with their temporary hours, were used in one form or another for one and a half millennia, from the late Roman period, through the Early Christian period and into the 14th century (Barnett, 1998).

The need for measuring time throughout the hours of darkness and shadow brought about the invention of the water clock or clepsydra (plural, clepsydrae). Water dripping from one container into another enabled equal blocks of time, or durations, to be measured (Dohrn-van Rossum, 1996). Clepsydrae have been found possibly dating back as far as 1500-1400 B.C.E with the first evidence of scaled vessels such as these found in Egypt (Dohrn-van Rossum, 1996). Although the Romans did not use water clocks until the 2nd century B.C.E., the Greeks were using them as early as the 5th century B.C.E (Barnett, 1998; Dohrn-van Rossum, 1996). Simple clepsydrae were used in Athenian courts and assemblies to limit the time for speeches, and by the Greeks and Romans for military watches and astronomical measurements (Barnett, 1998; Bedini, 1983). This invention indicated a need by ancient civilisations to progress from

recording sequences of time in varying durations as indicated by the sundial, to measuring equal durations of time.

Water clocks were not always reliable. The nature of water meant that when the weather was very hot, the water could evaporate, but when the weather was very cold, the water would freeze. The rate of water flow was dependent on the surrounding temperature (Barnett, 1998).

Sandglasses are still used today but have always been limited to measuring short periods of time (Barnett, 1998; Dohrn-van Rossum, 1996). While the sand had the advantage of not evaporating or freezing, the friction of the sand moving through the hole in the glass would erode the hole, thereby increasing the flow of sand. At the time of their greatest use, it was not possible to construct a sandglass that was large enough to last all night, further limiting their accuracy and use (Barnett, 1998).

While graduated candles and sticks of incense were in use to measure time in China during the Sung Dynasty (960-1279), it is the Saxon king, Alfred the Great (849-899) who is given credit for marking candles with horizontal lines to denote periods of time (Barnett, 1998). As candles and incense were not sufficiently large to burn throughout the night, the problem of measuring the passing of time during the hours of darkness was not solved with their use.

As the need for greater accuracy in time measurement became apparent, sundials, water clocks, sandglasses and candles to measure sequences and durations of time were replaced by the development of more sophisticated time measuring tools leading to modern day clocks and watches. The necessity for improved methods to measure sequences and durations of time is explained in the following section.

### **2.3.3 The need for increased accuracy when measuring time**

The Middle Ages were a time when most people were pious, with the Christian church being a dominant feature in the lives of many Europeans. Christian monks were guided by Saint Benedict (circa 480-543) and the Canonical Hours to pray seven times at regularly spaced intervals across the day and into the night (Barnett, 1998; Dohrn-van Rossum, 1996). To ascertain the necessary prayer times during the day, sundials and water clocks were used but at night the brethren in the monasteries relied on the stars (Poole, 1915; Southern, 1953).

In the high Middle Ages, although the majority of the population lived in rural communities and relied on the sun and the seasons to organise their farming activities, church bells were rung throughout the day to indicate times for work, meals and prayer for all members of the community (Barnett, 1998; Dohrn-van Rossum, 1996). Temporal hours were still in use in the

Middle Ages, making the measurement of the time difficult to ascertain exactly, resulting in some variations across seasons and across monasteries regarding the hours of worship (Dohrn-van Rossum, 1996).

For lay people who lived outside of the monastery, a Book of Hours was published which included the times for worship, religious tracts to be read at the appropriate prayer times, images which represented nature and rural tasks and honoured the saints, and gave a clear depiction of calendar time, thereby developing an awareness of a sense of time discipline within the population (Barnett, 1998). The need to measure hours more accurately throughout the day and the night led to the introduction of the first mechanical clock.

It is difficult to determine who was responsible for the invention of the mechanical clock, but it is believed that this type of clock appeared late in the 13th century (Barnett, 1998; Dohrn-van Rossum, 1996; Thorndike, 1941). Considered most likely to have originated in monasteries, the development of the mechanical clock changed the way time was measured by the population of Europe (Dohrn-van Rossum, 1996).

The first mechanical or wheeled clocks were not used to measure the hours, but were fitted with bells to awaken the monks for the nocturnal prayers (Barnett, 1998; Bedini, 1983; Dohrn-van Rossum, 1996). However, by the early 14th century huge clocks were being installed in cathedral towers (Barnett, 1998), giving the populace access to a regular counting of hours.

#### **2.3.4 Synchronisation of time**

The ability to synchronise time changed the face of industry and raised time consciousness of individuals (Barnett, 1998). Work bells rung to determine the beginning and end of the working day were in common usage in the 13th and 14th centuries, although the difficulty of determining what constituted a working day caused some conflict in factories. From the middle of the 14th century, the divisions of the day and the day's wage needed refinement. The construction and cloth industries introduced the communal clock which made the division of the day more precise, added new wage demands and gradually became the normal time giver for working hours (Dohrn-van Rossum, 1996).

Accuracy of clocks improved over the 17th century, with private ownership of clocks among the burgher class (Dohrn-van Rossum, 1996) and a profession of clockmakers becoming well established (Barnett, 1998). Factory owners installed clocks to determine the length of the working day. With more reliable clocks measuring equal hours, workers could now be paid for the hours they worked. The unit of work, which had always been the day, now changed to be

the hour. Where once the monasteries had been at the forefront of measuring time, now the merchants and factory owners needed to measure and record the time.

The move to equal hours occurred gradually throughout the 14th and 15th centuries, coinciding with the building of tower clocks in cities and towns where clocks were set to localised times according to the sun and the location of the town on the earth's surface (Barnett, 1998). Local times were adequate for the needs of the people as communication between towns was restricted; one either walked, travelling on average thirty kilometres a day, or used horses, which could average seventy to one hundred kilometres a day with a skilled horseman changing horses regularly (Dohrn-van Rossum, 1996).

In 1784, the mail coach system arrived in England (Barnett, 1998). The introduction of strict timetables made the use of local times difficult for travellers, and the development of the railway increased the need for coordination and synchronisation of clocks across England, Europe and the United States (Barnett, 1998; Dohrn-van Rossum, 1996; Galison, 2000).

By the 18th century, many people across Europe had clocks and watches to tell them the time; an asset when planning events throughout the day. While the introduction of the pendulum into clocks had increased their accuracy, town and cities still used their own local times. Germany, for example, had five different units of time (Barnett, 1998; Dohrn-van Rossum, 1996; Galison, 2000). With the introduction of the railways into Europe in the 1820s, the time taken to travel between towns and cities was significantly reduced, requiring the coordination of clock times. People began to expect punctuality and reliability (Dohrn-van Rossum, 1996). Local times became an inconvenience to passengers, who were likely to miss their trains (Barnett, 1998).

To overcome the problem, the railway companies incorporated their own railway time for consistency. In England, railway time matched Greenwich Mean Time, while France's railways used Rouen time (Barnett, 1998). In the 1870s, Germany and Austria were also discussing standardised times for their countries. Germany was keen to have a world time, based on the meridian of Greenwich. Many inventors put their efforts into the construction of a single central clock or master clock which would synchronise all other clocks, resulting in numerous patents being presented at the patents office (Galison, 2000).

The interest in constructing electrical distribution systems to connect distant clocks to a master clock became a challenge for scientists and inventors across Europe who wanted to establish a coordinated clock system, particularly for the railways. The idea of simultaneity was important, not only for the railways, but also for the clock industry and the military, who relied on transport systems (Galison, 2000). Many chronometric patents were submitted to the patents office in

Bern including patents for remote alarms, remote regulation of pendulums, telephonic and wireless transmission of time, and clocks indicating other time zones (Galison, 2000).

Albert Einstein had begun work at the patents office at Bern in 1902 and became interested in the patents being introduced to overcome the problems of clock coordination. Solutions to these problems were “exactly in his area of greatest concern and professional occupation: precision electromechanical instrumentation” (Galison, 2000, p. 388). Einstein wondered how two events could be judged simultaneous. While he could see that two events occurring at the same point, such as his watch indicating seven o’clock and the arrival of the train were simultaneous, he questioned whether two distant events would be simultaneous (Galison, 2000). As he addressed the problem of distant simultaneity, Einstein became engaged in a powerful and highly visible new technology that conventionalized simultaneity, synchronized train lines, set longitude, and then fixed time zones (Galison, 2000).

Einstein’s work on simultaneity brought him to the theory of relativity, where time is no longer considered absolute as Newton had envisaged. Relativity “has revolutionised our ideas of space and time” (Hawking, 1988, p. 21).

The measurement of time is now considered to be more accurate than the measurement of length, so that “in effect, the meter is defined to be the distance travelled by light in 0.000000003335640952 seconds, as measured by a cesium clock” (Hawking, 1988, p. 22).

### **2.3.5 Modern time**

Despite Einstein’s theory of relativity redefining ideas of time, on the surface of the earth we still define time in absolute terms in line with Newton’s ideas (Barnett, 1998). Our linear measurement of time has progressed over the centuries, becoming more and more accurate. The quartz crystal has redefined our timepieces as digital watches have no moving parts, being comprised of a small battery, a quartz crystal and some electronic circuitry with the wheel train in dial watches being all that remains of the mechanical clock. The quartz crystals vibrate creating a weak electrical current of the same frequency as its vibrations. The first clock using this technology was built by Marrison in 1928 with an accuracy of one or two thousandths of a second per day (Barnett, 1998).

The discovery of the laws of quantum mechanics by Bohr in 1913 led to the study of the behaviour of the nucleus of an atom. Bohr found that “the energy released or absorbed when an electron changes energy levels takes the form of radiation at a frequency unique to that energy level change in that particular atom” (Barnett, 1998, p. 166). This behaviour makes the atom the perfect timekeeper (Barnett, 1998). Although many different elements could have been



chosen for use in atomic clocks, the atom that defines the duration of a second is the isotope of the cesium atom, cesium 133 (Barnett, 1998; Taylor & Thompson, 2008).

### **2.3.6 A summary of the measurement of time over the centuries**

Since the days when time was measured by observing the Sun, the Moon and the stars, the tools to measure time have become more sophisticated, more precise and more accurate. Since the invention of the sundial, we have seen time measured with water clocks, sandglasses, candles, mechanical clocks and the atomic clock. While these discoveries have allowed us to measure time with greater accuracy, we still rely on linear and absolute measurements of time such as the calendar and the clock as our daily lives are connected to the earth's rhythms of day and night, and the yearly rotation of the earth around the sun (Moore-Ede, Sulzman, & Fuller, 1982). An investigation into the development of tools to measure time has assisted in the identification, and demonstrated the importance of, several aspects or Components of time, on which we rely for understanding: an awareness of the passing of time; the succession and duration of time events; and the measurement of time. The different measures of time relevant to today's society: the social construction of time, virtual time and measuring time with accuracy, and the importance of measuring time are discussed in the next section.

## **2.4 The Measurement of Time in Today's Society**

Time is measured constantly. Like other forms of measurement, time can be separated into units which are iterated to form longer periods. Time can now be measured in units as small as nanoseconds, and as large as eons. Despite scientific advances by Einstein and Bohr (Barnett, 1998; Dohrn-van Rossum, 1996; Hawking, 1988), the units of the day, week and month are still important features of daily lives (Moore-Ede et al., 1982). Calendars are used throughout the world with the Gregorian calendar generally adopted world-wide although other calendars, such as the Han calendar from China and the Jewish calendar are still used for traditional or religious purposes (Thorsen, 2017). While calendars measure the days and months in a year and our clocks measure the hours and minutes in each day with increasing accuracy, other forms of time are not measured in the same way. Socially constructed time appears to have been with us forever while virtual time is relatively new.

### **2.4.1 The social construction of time**

At the beginning of the 20th century, anthropologists and sociologists began to see time as a socially constructed concept (Duncheon & Tierney, 2013). Social time can be considered an abstract concept with notions of past, present and future varying across different cultures around

the world, characterised by activities, rituals, natural cycles and spiritual beliefs (Boroditsky & Gaby, 2010; Duncheon & Tierney, 2013; Silverman, 1997). Conceptions of time, and the language of time, vary across cultures as evidenced by studies of the Pormpuraaw people in Australia (Boroditsky & Gaby, 2010) and the Eastern Iatmul people of the Sepik River region in New Guinea (Silverman, 1997).

When the Europeans arrived in Australia, it was generally believed that the Indigenous people did not have any concept of time as the Australian Aborigines did not have words in their language to match the English words of temporality (Perkins, 1998). Nevertheless, the Aborigines had a strong temporal sense demonstrated not only by their connection to the ecology of the land, the seasons, and the natural cycles of animal life, but also by the important seasonal communication with other groups with whom they traded (Donaldson, 1996). The Dreamtime of the Aboriginal people demonstrates a connection of the present to the past by giving an explanation of the creation of the land, its features, and its animals (Donaldson, 1996; Perkins, 1998).

In socially constructed time, relationships, social factors and cultural factors take precedence over clock times; the quality of relationships being more important than the time spent on the relationship (Duncheon & Tierney, 2013). The social time of Indigenous communities is considered by Perkins (1998) to be resistant to clock times of the Europeans.

#### **2.4.2 Virtual time**

One of the greatest changes to our understanding of time has occurred since the adoption of computer technology. What is perceived as regular time, or the civil week, according to Laguerre (2004), is organised along several axes that give it stability: the separation of the workplace from the home, divisions of time for work and rest, dividing the work week from the weekend, working with people doing the same types of work, and face-to-face interaction with other workers.

The cyber week differs from the civil week in that real time is mixed with virtual time, several tasks can be completed at the same time, tasks can be compressed into shorter working periods or expanded into longer periods, and time can be selected from a range of different temporalities (Laguerre, 2004).

The cyber week can continue for 168 hours, activated through technological means (Laguerre, 2004), making people available all the time. The speed at which we can communicate with each other, complete tasks, and have instant access to world events, media and social connections

may be changing the way we perceive the linear construction of time. The past, present and future become blurred and synchronous (Duncheon & Tierney, 2013).

### **2.4.3 Measuring time with accuracy**

Clock time is defined as the linear representation of time; “a universal, measurable construct dictated by the clock and the Western calendar” (Duncheon & Tierney, 2013, p. 237). While the Gregorian calendar is based on the number of days the Earth takes to revolve around the Sun, the hours in a day are an artificial construct dating back to the Egyptians and temporary hours (Barnett, 1998; Dohrn-van Rossum, 1996). Dividing the day (including both daylight and night time) into 24 hours is steeped in history, but the divisions could easily have been different (Barnett, 1998). The definition of a second was originally defined as a fraction,  $1/86,400$  of the mean solar day, but due to irregularities in the rotation of the Earth, this definition was found not to be sufficiently accurate, resulting in a new definition being adopted. The second is now defined as “the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom” (Taylor & Thompson, 2008, p. 19). Despite the accuracy afforded to the second, had our early astronomers divided the day differently, we may well have had a different number of seconds, and consequently minutes and hours, in a day (Barnett, 1998). As it stands, this is the system we have adopted and adapted over the centuries to accurately inform us of a measured time of the day.

### **2.4.4 A summary of the measurement of time**

Socially constructed time takes into account rituals, natural cycles and spiritual beliefs, while virtual time makes us available to others anywhere in the world at any time. Time today has been shown to be measured with greater accuracy than any other period in our history. Our use of time measuring tools is dependent on understanding how time is measured.

The different aspects of time have been discussed and our need to measure the passage of time has been demonstrated. To gain an awareness of students’ understanding of time and developing knowledge of time measurement, and to place time in the context of measurement as it is in the *Australian Curriculum: Mathematics* (ACARA, 2016c), the next section is a discussion of the development of measurement concepts in general.

## **2.5 Measurement Concepts**

Measurement is used every day for activities such as cooking, noting distances when travelling, and shopping for clothes that will fit (Wilson & Osborne, 1992). Described by Smith and his

colleagues (Smith, Van den Heuvel-Panhuizen, & Teppo, 2011) as “the coordination of continuous quantity and number” (p. 617), measurement plays an important role in mathematics and science making it a foundation for all fields (Lehrer, 2003; Smith et al., 2011; Wilson & Osborne, 1992). Lehrer (2003) added “on the one hand, to measure is to do. On the other hand, to measure is to imagine qualities of the world, such as length and time” (p. 179). As measurement plays such an important role in our lives, it is important for children to understand the concepts of measurement including length, area, volume, mass, angle and time, as each forms a base for future learning (Lehrer, Jaslow, & Curtis, 2003; Outhred, Mitchelmore, McPhail, & Gould, 2003).

### **2.5.1 Development of measurement concepts in general**

The need to measure and record time is evident by the inclusion of aspects of time in the measurement section of the *Australian Curriculum: Mathematics* (ACARA, 2016c). To gain an understanding of the stages of development required to learn about time, and with few resources on time upon which to draw (Burny et al., 2009), the development of measurement concepts in general are discussed in this section leading to a discussion of the linkage between children’s conception of time and measurement.

Concern has been raised over the lack of understanding of conceptual principles of measurement by children, not only in primary schools, but also in secondary schools (Kamii, 2006; Outhred et al., 2003; Sarama, Clements, Barrett, Van Dine, & McDonel, 2011; Smith et al., 2011). A proportion of students have learned to use standard measuring tools and the procedures of measuring, without necessarily learning the underlying principles of measurement (Smith et al., 2011; Stephan & Clements, 2003).

Research into the teaching and learning of measurement attributes such as length, area, volume, and angle has shown that, despite some variation between the concepts identified, there is a general consensus among researchers that children need to develop fundamental concepts to have a thorough knowledge of measurement (Battista, 2006; Lehrer, 2003; Lehrer et al., 2003; McDonough, Cheeseman, & Ferguson, 2013; McDonough & Sullivan, 2011; Piaget, Inhelder, & Szeminska, 1960; Szilágyi, Clements, & Sarama, 2013; Wilson & Osborne, 1992).

Lehrer believed that a child’s conception of measure, rather than being a single concept, incorporates a collection of concepts, the understanding of which develops over the years the child is at school through everyday experiences and practices (Lehrer, 2003; Lehrer et al., 2003). Lehrer (2003) identified eight foundational measurement concepts including unit-attribute relations, identical units, standardisation of units and iteration that he considered

fundamental to a child's understanding in what he referred to as the child's *theory of measure*. The unit used for measuring is assigned the numerical value of one and must be compatible with the property of the object being measured (Wilson & Osborne, 1992). The counting of identical units will give the measure of the object (Lehrer, 2003; Wilson & Osborne, 1992) such that, for length or area for example, a count of five indicates five units of space (Stephan & Clements, 2003).

The iteration of units requires the knowledge that units are reused, units can be rearranged, a total of units can be subdivided (Lehrer, 2003) and the unit is a part of the whole object (Kamii & Clark, 1997). To implement correct unit iteration of length and area, units must be correctly positioned in line with each other so that there are no gaps or overlaps (Battista, 2006; McDonough & Sullivan, 2011; Outhred et al., 2003). Although unit iteration can vary between spatial properties with, for example, units of length being placed end to end in a line and units of mass being placed on digital or balance scales, for accurate measurement the size of the unit being used must be identical (McDonough et al., 2013; McDonough & Sullivan, 2011). The use of standard units for measurement gives consistency within the community as communication is enhanced when conventional units are adopted rather than arbitrary units (Lehrer, 2003).

Other concepts considered to be fundamental to a child's understanding of measure include additivity, in which the measurement of the parts are added together to equal the whole object (Lehrer, 2003; Wilson & Osborne, 1992); proportionality, the recognition that measurements made with different sized units will produce different quantities and the quantities will be proportional to the size of the units used (Lehrer, 2003); the zero point, for example, knowing the distance between 0 and 10 would be equal to the distance between 30 and 40 (Lehrer, 2003); and conservation of number that underlies the counting of units when measuring. Children need to understand conservation to realise that a distance or unit will remain unchanged if it changes position, is rearranged or subdivided (McDonough et al., 2013; Outhred et al., 2003; Stephan & Clements, 2003). An important stage in a child's understanding of measurement is knowing that the distance from A to B (AB) is the same as the distance from B to A (BA) (Piaget et al., 1960).

These fundamental concepts have been researched and identified for areas of measurement such as length, area, mass and volume (Battista, 2006; Lehrer, 2003; Lehrer et al., 2003; McDonough et al., 2013; McDonough & Sullivan, 2011; Piaget et al., 1960; Szilágyi et al., 2013; Wilson & Osborne, 1992). Many of these fundamental concepts are also appropriate for time such as unit, additivity, unit iteration, standardisation of units, origin or zero point and conservation.

However, insufficient studies have been conducted on the fundamental concepts of time to adapt these notions to the learning of time.

More recently, learning trajectories defined by Sarama and her colleagues as a description of “how concepts and skills develop over time” (2011, p. 668) have been developed for measurement areas such as length (Sarama et al., 2011) but there remains a paucity of research on the teaching and learning of time (Burny et al., 2009; Earnest, 2017; Friedman & Laycock, 1989; Kamii & Russell, 2012).

### **2.5.2 A summary of measurement concepts**

Fundamental concepts have been identified for an understanding of measurement. While these fundamental concepts align well with measurement attributes such as length, an examination of the literature indicated a lack of research literature on the teaching of time, reflecting the lack of research undertaken in this area, as evident in the lack of PME papers on time, discussed in sections 1.2.2.

The literature was also examined more specifically in light of the subject of the first research question, that is, the major Components of a clear understanding of time. While the research question is addressed more fully later in the thesis, initial insights from the literature which guided the development of assessment tools and data collection, are provided below.

## **2.6 Learning to Measure Time**

Time, like length, volume and area, is measured, but unlike these other attributes, time is not visible. Fraisse (1984) considered time as an intricate subject, being associated with world time and personal time. Friedman (1978) stated that time seemed “to be a physiological, perceptual, cognitive, and social, as well as a natural phenomenon” (p. 268), and more recently described time as “many things: recurrent sequences of events, natural and conventional time patterns, invariant causal sequences, logical relations between succession and duration, the past-present-future distinction and many others” (Friedman, 2011, p. 398). Time is defined by Burny et al. (2009) “as a component of a measuring system used to sequence events, to compare the duration of events and the intervals between them” (p. 481).

The teaching of time to children is more complex than teaching them to read clocks (Kamii & Long, 2003), as developing a knowledge of time is linked to space, distance and speed (Casasanto, Fotakopoulou, & Boroditsky, 2010; Piaget, 1969). When children are learning about time, many aspects of time need to be considered, such as duration and succession (Fraisse, 1984; Piaget, 1969; Vakali, 1991) and psychological time (Friedman, 1978; Vakali,

1991). While the reading of clock times is important for children, clock knowledge requires not only an ability to read the time from the clock face and to operate on these times to promote relationships, but also requires an understanding of where a time occurs within the day and what activities might be happening (Friedman & Laycock, 1989). Time related competences are “the competences and skills associated with measuring and recording the passage and duration of time e.g. clock reading, using calendars and timelines, measuring time intervals” (Burny et al., 2009, p. 481).

When reviewing the literature regarding the measurement of time, the tools developed for this measurement, and the fundamental concepts of measurement, it became clear that there were distinct categories about the understanding of time. Four major Components, that is, Awareness of time, Succession, Duration, and Measurement of time, were identified by the researcher as being required for a deep understanding of time. Drawing upon the literature, *The Framework for the Learning and Teaching of Time* (also referred to below as the Framework) was created based on these four major Components which are elaborated with key ideas.

Over the course of the study, the Framework was progressively modified, in light of data analysis and emerging literature, and the final version is provided and discussed in Chapter 6. For clarity of understanding however, the relevant literature is reviewed now under the headings of what proved to be the initial Framework, that is, the version prior to data collection. This initial version of the Framework can be found in section 2.7 (Figure 2.1). An explanation of each major Component is given in the following sections.

### **2.6.1 An understanding of Awareness of time**

Although time as a concept is intangible for children, it is present in their lives as they learn to be at school on time or are permitted to stay up later than their usual bedtime (Buys & Veltman, 2005). Over our lifetimes, we experience recurring temporal patterns (Friedman, 1990), daylight and darkness, months, seasons, and the anniversary of special events. There is a distinction between telling the time and a concept of time as children may be trained to read the dials on a timepiece but have difficulty in understanding a concept of time (Dickson et al., 1984). The understanding of time is a part of the developmental process which occurs gradually from infancy to adolescence (Friedman, 2011; Piaget, 1969; Trosborg, 1982). Four key ideas that further explain an Awareness of time have been identified and are explained in the following four sections.

### ***2.6.1.1 A point in time***

By being aware of time as a series of ordered events (McColgan & McCormack, 2008), we are able to measure the duration between two events by ascertaining the time of each event. The first event becomes the zero point (Lehrer, 2003) on the time continuum from which the time is measured up to the second point. In this way, any event on the time continuum can be used as a reference point. For example one's birth year can be the zero point from which the years are counted up to the present year, giving one's age in years.

### ***2.6.1.2 The language of time***

To gain an understanding of the development of a sense of time in children, Ames (1946) observed children between the ages of 18 months and 48 months as they engaged in spontaneous or directed play, and then asked these children questions relating to time, compiling a list of time-related words and phrases used by the children. The children in the study were described by the author as having a high average to very superior intelligence, although the reasons for this judgement were not clearly explained. From her study, Ames (1946) concluded that consistent trends in the development of time sense were evident with common concepts appearing at the same age and in a definite order, although complete mastery of each concept developed over time; at 18 months children were able to respond to time words, at 24 months the word or phrase could be used spontaneously; and by 42 months the child could answer questions relating to the concept. Although this is not a recent study, it demonstrates that the use of temporal words and phrases (e.g., next year, in a minute) by young children precedes the understanding of the particular time concept.

Other studies focussing on temporal words such as before and after (Blything et al., 2015), yesterday and tomorrow (Grant & Suddendorf, 2010, 2011), and the names of days and months (Friedman, 1991) found children's temporal vocabulary became more accurate around the ages of five to six. Intervals of time referred to by children under three years of age are less specific than the same words used by adults, such as that the word *yesterday* may refer to sometime in the past (Weist, 1989).

### ***2.6.1.3 Temporal patterns***

An understanding of divisions of time and temporal patterns allows adults to anticipate future events (Friedman, 2000; Hudson & Mayhew, 2011) and to have memories of times past (Friedman, 1991; Hudson & Mayhew, 2011). An understanding of the past and the future develops over many years. Friedman (1977) gave 62 children aged between four and 10 years



patterning tasks which included ordering days of the week, months of the year, regular holidays and seasonal activities. His results indicated increased ability to represent temporal cycles from the age of four to age 10. Other studies have shown that children have a sense of the relative order of past events by age four (Friedman, 1991; McCormack & Hanley, 2011), but do not have an understanding of the relative order of future events until age five (McCormack & Hanley, 2011). This anomaly may be due to many children requiring little understanding of the future as parents take on the responsibility of planning for weekends, preparing meals, and taking care of what happens to the children (Hayne, Gross, McNamee, Fitzgibbon, & Tustin, 2011; Suddendorf & Moore, 2011).

#### ***2.6.1.4 Psychological time***

Psychological time is our perception of time. When we are engrossed in a task, the time appears to pass quickly, but time will appear to move more slowly when we are not engaged or interested in what we are doing. For example, 10 minutes spent waiting for an appointment may seem to be longer than the 10 minute appointment. Psychological time is described by Piaget (1969) as lived time and is seen by Friedman (1978) as multifaceted, a natural phenomenon with physiological, perceptual, cognitive and social aspects which can be grouped into logical, conventional and experiential times. According to Friedman (1978), logical time is the flow of time which incorporates succession and duration. Conventional time is cultural with temporal cycles, sequences, and temporal words varying across societies, and experiential time “refers to the perception and memory of succession and duration in the absence of logical or conventional cues” (Friedman, 1978, p. 286).

Logical, conventional, and experiential time develop concurrently as shown by experiments conducted by Piaget (1969). Piaget studied children to determine whether they understood that age differences stay the same throughout their lifetimes or whether children believed that as they grew older and taller they would catch up to adults. He also investigated whether children understood the connection between their age and their order of birth. Piaget (1969) found that children up to the age of about six years were egocentric and were unable to determine the order of birth of two people despite knowing that one was older than the other, nor were the children able to determine who was the older when told which person was born first. By approximately age eight, children could determine order of birth, but still confused age with size, assuming that if one person is taller than another, then they must also be older, but by age nine the children in Piaget’s study demonstrated a complete understanding of order of births and colligation of ages. By the age of about nine, children could also differentiate between size and age as they followed comparable stages to the learning of succession and duration (Piaget, 1969).

## **2.6.2 An understanding of Succession**

Succession is the ordering of time in a sequential manner. To seriate times, that is, to arrange times in a series or order, and to iterate units of time requires an understanding of succession. Years are arranged by number, months appear on the calendar in the same order each year with January of the new year always follows December of the previous year. Likewise, days occur in rotation in sequential order. The understanding of the past, present and future rely on succession. Simultaneity and synchronisation have strong links to succession. Simultaneity is demonstrated when events occur at the same time and synchronisation, a coinciding and agreement in time, ensures regular periodicity.

Time incorporates succession and duration, both of which are important to our understanding of temporal qualities (Fraisse, 1984; Levin, 1977; Piaget, 1969). Friedman (2008) informs us that children as young as a few months can remember sequences and are sensitive to word order in sentences indicating a “biological head-start” (p. 346) to the adaption of time. Friedman (2008) adds that by eight months children respond differently to forward and backward versions of videotaped events.

The present study identified six key ideas from the literature deemed to be important for a deep understanding of succession. Each key idea is explained in the following sections.

### ***2.6.2.1 Defining Succession***

Succession “corresponds to the fact that two or more events can be perceived as different and organised sequentially ... based on our experience of the continuous changing through which the present becomes the past [while] the concept of duration ... applies to the interval between two successive events” (Fraisse, 1984, p. 2). Piaget (1969) claimed that young children did not perform well on sequencing tasks as the sequencing of events in time was connected to causality, linking causes and effects, and cognitive reversibility.

To analyse the child’s conception of succession and duration, Piaget (1969) undertook several experiments with children, the results of which were first published in 1946. These experiments, which were repeated by Lovell and Slater (1960) involved observing the flow of water from one flask into two flasks, toys racing along a track for the same amount of time but with different starting and finishing points, and the siphoning of water from one beaker to another beaker of the same capacity but of a different shape. After questioning the children on their observations, both teams of researchers concluded that children failed to appreciate the order of succession before the age of eight with serial correspondence being established by age ten (Lovell & Slater, 1960; Piaget, 1969). Piaget (1969) considered the reconstruction of two events required a

reversibility of thought, something he considered the children in his study were unable to achieve before the ages of seven or eight.

### ***2.6.2.2 Iterating units of time***

A deep understanding of the Measurement of time, like the measurement of length for example, requires both transitive reasoning and unit iteration (see section 2.5.1), but in addition children need to understand that time measuring tools such as clocks function at a constant speed (Kamii & Long, 2003). To assess understanding of unit iteration by elementary school students, Kamii and Long (2003) gave students in Kindergarten, Years 2, 4 and 6 two unit iteration tasks. The first task involved counting vials of water and the second task required the students to flip a 10 second sand timer as music was played. In each task the students had to determine which of two pieces of music played for the longer time. For accuracy, the units of time (vials of water and sand timers) had to be, like units to compare lengths, “placed” in sequential order without any gaps. The findings from these experiments showed an increase in successful outcomes between Years 4 and 6.

A succession of smaller units can be iterated to form a larger unit. For example, 100 centimetre units will form a metre. Likewise, 60 minutes will form an hour and 24 hours will form a day. To understand and use units of time, students need to appreciate the important part unit iteration plays in sequencing and succession.

### ***2.6.2.3 Simultaneous and synchronous events***

Simultaneous and synchronous events are particular cases of succession. Piaget (1969) considered the concepts of simultaneity (occurring at the same time), synchronisation (coinciding in time), isochronism (of equal time), and seriation (arranged in order) important elements to the understanding of duration, but believed each concept can also be closely linked to succession just as duration is linked to succession. When events occur simultaneously, they occur at the same time. Simultaneous events can be coincidental. Synchronous events are *made* to occur at the same time. For example, synchronised swimmers perform the same sequence of movements in the water at the same time as the others in their group. A sound track is synchronised to the actions of the actors when added to a film clip.

### ***2.6.2.4 Years are arranged in numerical order***

It is a worldwide practice to give each year a numerical name even though the calendar years may not match other calendars. For example, the Gregorian calendar counts this year as 2017 as last year was 2016 and next year will be 2018. The Chinese calendar marks this year as 4714

(between 4713 and 4715) and on the Hebrew calendar it is 5777. Children need to be able to represent time in terms of the regular patterns of weeks, months and seasons to be able to locate events in the past and future (Hudson & Mayhew, 2011). Friedman (1990) concluded that temporal orientation within a day occurs frequently during early childhood, but it is not until middle childhood that orientation within the week or year becomes more common. Friedman (1990) suggested that the rote learning of the days of the weeks and the order of the months in a year may delay the development of temporal operations.

#### ***2.6.2.5 Days, weeks and months are cyclical***

Although we consider time to be linear, particularly when we consider sequential ordering of time, some units of time are also cyclical. Temporal order is common to both linear time and cyclical time with cyclical time having the additional factor of recurrence (Friedman, 1977). Friedman (1977) distinguishes between the two forms of sequential time by noting that a series in linear time can have “earlier” or “later” relationships but in cyclical time “recurrence entails that there be no fixed earliest event ... because any member will recur if one continues in the “earlier” or “later” direction” (p. 1593). Days are cyclical as during each day we experience morning, afternoon, night in a 24 hour period. Each week has seven consecutive days which are repeated as are the 12 months of the year. Important changes occur between the ages of three and five, particularly in the way children consider time (McCormack & Hanley, 2011). By the ages of nine to ten, children develop an understanding of cyclical patterns of time such as weeks, months and seasons (Friedman, 1977, 1978, 2000).

#### ***2.6.2.6 The past, the present and the future***

Succession requires an understanding of the past, the present and the future as our conception of time “is populated by a series of chronologically ordered events stretching from the present in two different directions, into the past and into the future” (McColgan & McCormack, 2008, p. 1477). Numerous studies have been conducted to determine the ages at which children can remember and sequence past and future events, and recognise the causal links that past and future events have on the present (Busby & Suddendorf, 2005; Friedman, 1977, 1986, 1990, 1991, 2000; Friedman & Lyon, 2005; Grant & Suddendorf, 2010; McColgan & McCormack, 2008; McCormack & Hoerl, 2007; Povinelli et al., 1999). In general, the research indicated that although very young children had some understanding of temporal sequencing, improvements in this area were evident from the ages of five to six. Experiments conducted by Fivush and Mandler (1985) demonstrated that for children aged between four and six years, events in forward order were the easiest to sequence, followed by unfamiliar events in forward order,

familiar events in backward order with unfamiliar events in backward order being the most difficult to sequence.

### **2.6.3 An understanding of Duration**

Duration is the passage of time, with each duration requiring a starting and a finishing time (Fraisse, 1984). While the precision by which duration can be measured today is evident with one second being measured at an atomic level (Taylor & Thompson, 2008), the duration of periods of time can also be measured with sandglasses, counting and handclaps. A duration of time can be very short (nanoseconds which are one thousand-millionth of a second) or very long (a millennium is one thousand years) and can be measured with formal units (hours, minutes and seconds) and informal units (a little while). Other elements related to an understanding of duration include simultaneity (being or happening at the same time), synchronisation (keeping time together), isochronism (performed in equal times), and seriation (arranged in order).

Although children perceive succession and duration from an early age, research suggests they are unable to combine the two ideas until they reach the stage of logical thought, around the ages of seven to eight (Fraisse, 1984; Piaget, 1969). Piaget's (1969) claim that succession and duration develop at the same time is disputed by Levin (1978) who found that duration was a more difficult concept for children and consequently developed later. Judgements of duration by young children are influenced by cues such as distance and speed (Levin, 1979; Levin et al., 1978; Trosborg, 1982). Children under the age of seven confuse space and time believing that a body moving for a longer duration must go further (Casasanto et al., 2010; Levin, 1977; Piaget, 1969) and a body moving faster will take a longer time to cover a given distance than a slower body (Lovell & Slater, 1960; Piaget, 1969). Further studies by Siegler and Richards (1979) confirm the idea that children understand the concept of speed well before the concept of time. Additional confusions occur when the same language is used for both space and time, such as long and short, and distances are measured in a few minutes, as in "the shop is just a few minutes down this road" (Casasanto et al., 2010).

The present study identified six key ideas from the literature deemed to be important for a deep understanding of duration. Each key idea is explained in the following sections.

#### ***2.6.3.1 Defining Duration***

When we follow the Newtonian understanding of time, we view time as being on a continuum with all events placed in order, with durations being the intervals of time between points on the

continuum (Friedman, 1978). To understand the concept of time, children need to understand that a series of events occur in a temporal order and the intervals between these events are durations (Piaget, 1969). Duration is the interval of time between two separate events and cannot exist without succession (Fraisse, 1984).

### ***2.6.3.2 Adding, subtracting, multiplying and dividing units of time***

The *Australian Curriculum: Mathematics* indicates that children at Level 4 (Year 4) learn to convert between units of time (ACARA 2016c). To effectively convert between units requires an understanding of the duration of each unit and the interconnectedness of the units measuring durations of time.

### ***2.6.3.3 Simultaneity, synchronisation, isochronism and seriation***

The notions of simultaneity, synchronisation, isochronism and seriation were identified by Piaget (1969) as important elements of duration. A deep understanding of time would require children to be aware that although we see time as linear, events can overlap. Events that occur simultaneously occur at the same time. For example, the school bell may ring at the same time as a child hits a cricket ball. When events are synchronal, they are *made* to coincide in time, just as the orchestra plays and the performer sings. Isochronal events occur for the same period of time, that is, they are equal in duration, whereas seriation is the ordering of events in a series.

### ***2.6.3.4 Duration is continual***

Trosborg (1982) conceived time as being subdivided into punctual and durative aspects, the punctual aspect being a point in time while the durative aspect is continual. To appreciate duration, children need to understand that any given period of time, be it measured using a formal unit (e.g., an hour) or informal (e.g., the time to cross the road), the duration is an unbroken period of time from one point on the time continuum to another. There can be no gaps or spaces as the flow of time is continual.

### ***2.6.3.5 A unit of time is constant***

The idea of a unit of time is closely connected to 2.6.1.1, *A point in time*. Formal units of time have a predetermined duration that is measured from one point to another point on the time continuum. Children need to understand that, for example, the duration of an hour is the same for every hour that they experience whenever it occurs. For example, the duration of time between 10 o'clock and 11 o'clock will be the same as the duration of time between 11:30 and

12:30. This constancy applies to every unit from the very small (e.g., nanosecond) to the very large (e.g., year).

#### ***2.6.3.6 Measuring Duration***

Durations of time can be measured in formal units. Due to the accuracy of time measuring devices such as the atomic clock, very small units of time can be measured such as milliseconds, nanoseconds and microseconds. Units can be added and multiplied to form larger units such as months, years and decades. There are more units of time than the familiar units found on a clock: the second, the minute and the hour.

#### **2.6.4 An understanding of Measurement of time**

A deep understanding of time requires a knowledge and understanding of the Measurement of time, that is, how time is measured. To measure time according to the conventions of the hour, minute and second it is necessary to have a sound knowledge and understanding of specific units of time and time measuring tools. Although the learning and teaching of units and tools for measuring time is specified in the *Australian Curriculum: Mathematics* (ACARA 2016c) the reading of tools to measure time appear to focus primarily on determining the current point in time such as the date on a calendar or the time on the clock. Students need to understand that a clock measures how much time has elapsed in two 12 hour periods, the first period from 12 am to 12 pm (half a day) and the second 12 hour period from 12 pm to 12 am (the second half of the day). These 24 hours of a day relate to the rotation of the Earth on its axis. When reading the time on a clock we are recording the measurement of time from twelve o'clock. When the clock indicates ten minutes past 8, we are informed that eight hours and ten minutes have elapsed since twelve o'clock (duration), and that we have moved into the ninth hour (succession). A calendar which measures the days, weeks and months of the year is related to the 365 $\frac{1}{4}$  days the Earth takes to revolve around the Sun. The Earth's position in relation to the Sun also determines the seasons (succession and duration).

Each measurement attribute incorporates the use of a calibrated scale as a measurement tool. Rulers are used to measure length, calibrated weighing scales can be used to measure mass, and clocks are used to measure time. Studies of children identifying time on an analogue clock have shown it to be a difficult accomplishment for children up to ten years of age, requiring a range of previously learned skills such as counting forwards and backwards and understanding the relationship between the hands and the numbers on the clock face (Vakali, 1991). Reading the time from a clock is a "complex symbol system" (Friedman & Laycock, 1989, p. 357) which Friedman and Laycock (1989) identified as having three components: the different processes

for reading digital and analogue clock times, understanding operations of clock times such as the addition of intervals, and knowing where the time on the clock and regular activities fit into the day.

The present study identified six key ideas from the literature deemed to be important for a deep understanding of the Measurement of time. Each key idea is explained in the following sections.

#### ***2.6.4.1 The passage of time is measured in specific units***

Studies have identified that children learn clock times first to the hour, followed by the half hour, with times to the minute being the most difficult (Boulton-Lewis, Wilss, & Mutch, 1997; Friedman & Laycock, 1989). While the reading of digital time has been shown to be easier than analogue time, children who can read the numbers may not fully understand what they have read (Boulton-Lewis et al., 1997). Boulton-Lewis et al. (1997) emphasised the need to continue instruction on clock reading through to Year 6 as children at this year level cannot be assumed to have maintained skills for reading and recording the time. Challenges occur for teachers when making decisions on when to teach the order of days of the week, clock time and the order of the months, as children learn to order these aspects of time from the ages of four to 10 years (Friedman & Laycock, 1989).

#### ***2.6.4.2 Units of time are based on natural phenomena***

The movement of the Earth and the moon in space create fundamental units of time. The time the Earth takes to revolve once around the Sun is measured as either a sidereal year of 365 days, six hours and nine seconds or more often, a tropical year of 365 days, five hours 48 minutes and 46 seconds (see 2.3.1). The length of a calendar year (based on the tropical year) is reliant on the natural phenomena of the revolution of the Earth. The Earth revolves on its axis. This rotation takes one full day and includes the daylight hours when our location on the Earth faces the Sun and night time hours when our location faces away from the Sun. The 23 degree tilt of the Earth towards the Sun creates the seasons experienced on Earth.

#### ***2.6.4.3 Manufactured units***

While the length of the year and the duration of the day are reliant on the rotation and revolution of the Earth around the Sun, other units of time have been created. Although the second is now measured with great precision (Taylor & Thompson, 2008), the number of seconds in a minute, the number of minutes in an hour and the number of hours in a day were developed by ancient civilisations when they needed to break the day into smaller, measurable units. These



manufactured units, handed down to us from civilisations such as the Egyptians, the Babylonians and the Romans, are still in use today (Hannah, 2005).

#### ***2.6.4.4 A meaningful point in time***

A point in time, for example a day or a specific time, becomes more meaningful when we understand the position of the particular event on the time continuum. The time continuum includes the past, the present and the future. An explanation of children's understanding of the past and the future can be found in section 2.6.1.3.

#### ***2.6.4.5 Time measuring devices***

Since the earliest devices for measuring time were developed, the measurement of time has become increasingly sophisticated. Seconds are measured by the amount of radiation emitted from a cesium atom (Taylor & Thompson, 2008). The atomic clock is extremely accurate and will not lose one second in 300 million years.

#### ***2.6.4.6 Time in the measurement curriculum***

Time is a form of measurement, although unlike length, volume and area, time is not able to be seen. Nevertheless, foundational concepts in measurement also apply to time. For example, transitive reasoning and unit iteration, two important concepts which need to be understood when measuring length (Lehrer, 2003), also apply to time. For a child to measure time, he or she also must know that the time measuring instrument operates at a constant speed, that is, a child must have an understanding of conservation of speed (Kamii & Long, 2003). Data from studies of children from Kindergarten to the sixth grade<sup>2</sup> by Kamii and Long (2003) suggested that conservation of speed develops gradually in children, with the majority of children developing “the notion that the speed of the instrument must be constant and is independent of their own actions” (p. 176) from Years 4 to 6. Kamii and Long (2003) suggested that as transitivity and unit iteration develop first with respect to length, then volume, and then time, it may be beneficial for students to have regular experiences with time, such as asking them if they have time for a story before lunch, making decisions regarding activities to be completed in the available time and making their own timing devices, rather than activities that have a narrow focus. Developing a sense of time and experiencing activities that help children

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<sup>2</sup> In Australia, students commence school in the Foundation year with the following years being Year 1, Year 2, etc. up to Year 12. In the United States of America, students commence school in Kindergarten then progress through Grades from 1<sup>st</sup> Grade to 12<sup>th</sup> Grade.

understand the passing of time is an important stage of a child's development (Buys & Bokhove, 2005).

### **2.6.5 A summary of the development in learning to measure time**

The importance of children developing a sound understanding of the foundational concepts of measurement attributes, including time, has been discussed. The major Components for an understanding of time have been identified as an Awareness of time, Succession, Duration and Measurement of time. Key ideas that support each major Component have been explained to further explain each Component.

The next section introduces the Framework for the Learning and Teaching of Time with an explanation of the design.

## **2.7 A Framework for the Learning and Teaching of Time**

The development of a framework that could lay a firm foundation for the learning and teaching of time was considered necessary as Australian mathematics curriculum documents were found to lack underpinning concepts considered important to the learning and teaching of time (ACARA, 2016c), and the research literature did not offer a research-based framework. The framework developed by the researcher, the Framework for the Learning and Teaching of Time, juxtaposed the key underlying ideas of the concept of time: Awareness of time, Succession, Duration and the Measurement of time (see Fig. 2.1), drawing upon the works of Fraisse (1984), Friedman (2011), Kamii and Long (2003), Trosborg (1982) and Vakali (1991).

The development of the Framework was an iterative process in line with design research (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). The identification of major components of time formed the initial theory on the learning and teaching of time. The initial Framework was constructed after an extensive review of the literature to identify the major Components and key ideas. The final Framework, discussed in Chapter 6, was the result of a further review following data collection.

### **2.7.1 Major Components of the Framework**

While the Framework may appear to be a linear model, further explanation shows that this model is in fact, far more complex. The major Components, Awareness of time, Succession, Duration and the Measurement of time are clearly not discrete, but linked by double-headed arrows that are fundamental to the reading of the Framework (see Figure 2.1).

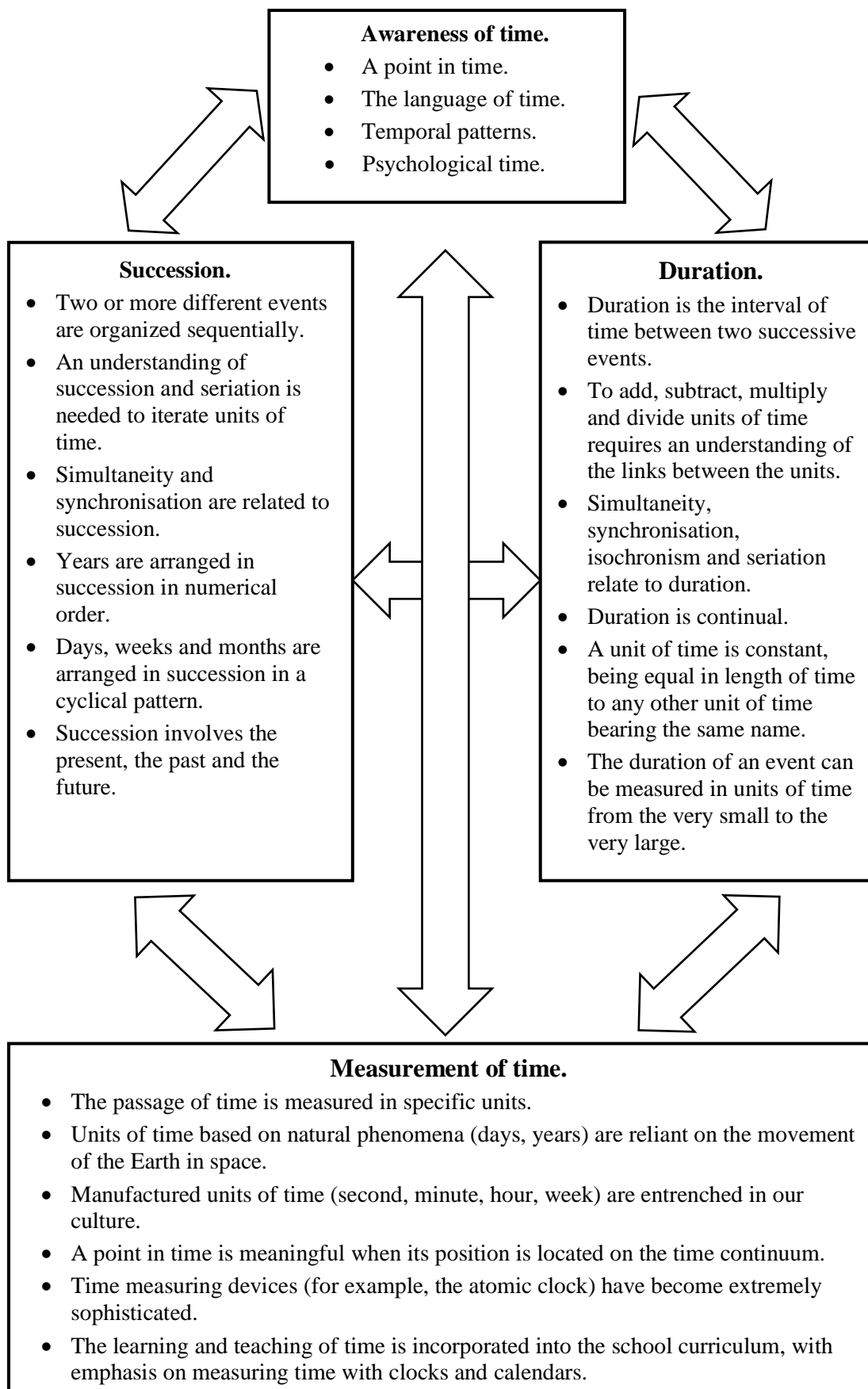


Figure 2.1. The initial Framework for the Learning and Teaching of Time.

The first box is labelled Awareness of time, as being aware of time seems to be a natural starting point to understanding the concept of time (Ames, 1946; Friedman, 1977, 1990). The boxes on either side of the diagram indicate the need for students to understand the concepts of Succession and Duration (Burny et al., 2009). Without an understanding of Succession and Duration, the reading of clocks and calendars may be meaningless, as the students fail to put the time into context. The Measurement of time is crucial to the understanding of time. Measuring time requires a knowledge of specific units of time and time measuring tools.

The Framework demonstrates how notions of time are not learnt in sequence, nor at the same time. To promote a deeper understanding of the concept of time, each major Component is linked to every other major Component by carefully positioned double-headed arrows.

As different elements embedded in for example, succession, are learnt over a sustained period of time, a deeper understanding of duration is also occurring. The arrows indicate that at the same time that a student is developing an understanding of Succession and Duration, his or her Awareness of time and its significance to his or her own life, and an understanding of why Measuring of time is undertaken in particular ways depending on the context, is also expanding and deepening (Thomas, Clarke, McDonough, & Clarkson, 2016).

As explained earlier, this initial version of the Framework was current during the data collection period. After analysis of data and consideration of recent emerging literature, the Framework was revised. The final version can be found in Chapter 6 (Figure 6.9).

### **2.7.2 A summary of the Framework for the Learning and Teaching of Time**

In the discussion above, the development of the Framework for the Learning and Teaching of Time was explained and the initial Framework introduced. A detailed explanation of each major Component and key idea was given. The inclusion of the double-headed arrows into the design of the Framework was explained.

### **2.8 The Sources of the Literature Discussed in the Remainder of this Chapter**

The remainder of the chapter reviews the literature that informs the addressing of the other three sub-questions. To address the assessment of students' understanding of time, students' learning about time, and pedagogies the researcher reviewed the literature on the curriculum, effective teaching and learning of mathematics, student understanding, and assessment of students. The discussions on the above areas were based on the sources of literature that were found in the library. At the commencement of the study, the Australian Catholic University's library collection with access to 461 data bases, as stated in section 2.1.1., was used to find any

literature related to the topics in this part of the dissertation. Education data bases such as A+ Education and ERIC were also accessed separately. Key words in the searches included curriculum, time, teaching time, the development of time concepts, effective teaching and assessment. The initial search was a general search on the teaching and learning of time as the supervisors of this study were not aware of any particular literature that would guide the researcher. Unlike the first part of this chapter that relied on books for information, the second part was informed by peer reviewed articles that were blind refereed. When an article of interest was found in a peer reviewed journal, the researcher searched through the reference list for other suitable articles from peer reviewed journals and peer reviewed chapters in books. As the search expanded, an overlap of authors was sought. The specific literature on time was scant although the more general literature on teaching and learning was extensive. The researcher was directed by her supervisors to some key studies such as the Early Numeracy Research Project (ENRP; Clarke et al. 2002) and Askew's study (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997) and international conference proceedings, with which they were familiar.

Finding scant research on the learning and teaching of time, the search was extended to published research papers from other well-known international conferences. The difficulty in finding up-to-date literature meant that this study is reliant on some older material that is nevertheless relevant.

A comparison was made to the curricula of three other countries as one means of determining if the expectations of Australia's curriculum were in line with learning goals in other countries.

## **2.9 Curriculum Expectations for the Teaching of Time**

Measurement and geometry are an important part of the Australian mathematics curriculum commencing in the Foundation year and continuing to Year 10. In the student's first year of school (aged 5-6), it is recommended that children make direct and indirect comparisons of objects, use appropriate measurement language such as tall and taller, and learn the days of the week. By the end of Year 10 (aged 15-16), students solve problems involving surface area, volume, develop geometric reasoning and apply formulas such as Pythagoras' Theorem to solve problems (ACARA 2016c). Curricula from England (Department for Education, 2014), Singapore (Ministry of Education Singapore, 2014b), and the United States of America (Common Core State Standards Initiative, 2014) also recommended that the formal learning of measurement begins when children commence school. To illustrate that the *Australian Curriculum: Mathematics* (ACARA, 2016c) is in line with international curricula with regard

to the ages at which aspects of time are introduced, a summary of the expected learning outcomes for primary aged children is given in the following section.

### **2.9.1 Time in the Australian curriculum**

The Australian curriculum is the responsibility of the Australian Curriculum, Assessment and Reporting Authority (ACARA) which was established in 2008 to introduce and oversee a national curriculum from Foundation to Year 12, a national assessment program aligned to the national curriculum, and collection and collation of assessment data. ACARA is under the direction of the Australian Government and state and territory ministers for education (ACARA 2016b).

The Australian curriculum introduces time as a learning outcome in the Foundation year of school as shown in Table 2.1. Students at this year level are generally five to six years of age. In this first year, students are introduced to the days of the week, connect the days of the week to familiar events, sequence events in order and compare and order the duration of events. In a student's second year of school, aged six to seven it is anticipated that students will learn to describe duration using months, weeks, days and hours, and be able to tell the time on an analogue clock to the half hour. When students are aged seven to eight, clock reading to the quarter hour and the appropriate language of 'past' and 'to' are listed in the curriculum along with months and seasons in order. It is envisaged that students at this age learn to read a calendar to determine the date and the number of days in each month. By the ages of eight to nine it is anticipated students tell the time to the minute and recognise the relationships between units of time such as the minute and hour with am and pm notation being introduced the following year, when children are aged nine to ten, along with the challenge of solving simple time problems (ACARA, 2016c).

The underlying assumption is that a complete knowledge of all aspects of time has been achieved around ages nine and ten, enabling students to use their knowledge to solve problems and read timetables. So in the final two years of primary school, students are expected to be ready to move to solving problems regarding time, such as being able to read and interpret timetables, and compare time systems of 12 and 24 hours (ACARA, 2016c). Research has indicated that the learning outcomes introduced into the first five years of school may be challenging for some children as the learning of different aspects of time may continue through to the end of primary school (Boulton-Lewis et al., 1997; Friedman & Laycock, 1989).

## 2.9.2 Time in other national curricula

In Singapore, students are not required to commence formal schooling until age six (Ministry of Education Singapore, 2014a). In their first year of school, Singaporean students are taught to tell the time to the hour and half hour. The following year when aged six to seven they are taught to tell and write the time to five minutes, use abbreviations of h for hour and min for minute, and use am and pm notations (see Table 2.1). Aged seven to eight, children are taught to tell the time to the minute, use the terms 'past' and 'to', measure and convert time in hours and minutes, find the durations of time intervals and solve word problems which involve adding and subtracting time in minutes and hours. By the age of ten, it is anticipated that children will learn to measure time in seconds, and solve problems using a 24 hour clock (Ministry of Education Singapore, 2014b).

The Department of Education in England requires students to attend school from the ages of five to sixteen (Department of Education, 2014). It is anticipated that students in England learn the language of dates, days, weeks, months and year, tell the time to the hour and half hour, and become familiar with an analogue clock face in their first year of school, aged five. At the ages of six to seven, English students compare and sequence time intervals, are taught to tell the time to five minutes, and learn the number of minutes in an hour and hours in a day. Reading the time to the nearest minute, a knowledge of 12 and 24 hour times, seconds, leap years and the comparison of durations of events are anticipated when the students are aged seven to eight. An understanding of analogue and digital clocks, conversion of hours to minutes and vice versa, years to months and weeks to days are anticipated to be achieved by the ages of nine to ten (Department for Education, 2014).

The United States of America introduced the Common Core State Standards Initiative (Common Core State Standards Initiative, 2014) as a curriculum guide for all states. In the United States, students commence school at age five beginning in Kindergarten. Although measurement is introduced in Kindergarten, the first mention of time, telling and writing the time in hours and half hours using both digital and analogue clocks, is at age six to seven. It is expected that students aged seven to eight learn to tell the time from digital and analogue clocks to the nearest five minutes, and write such times using am and pm notation. By the ages eight to nine, the expectation is for students to be able to tell and write the time to the nearest minute, and add and subtract time intervals in minutes. By the end of the following year, students should have a knowledge of all measurement units, including the hour, the minute, and the second, and be able to solve word problems relating to time (Common Core State Standards Initiative, 2014). Table 2.1 illustrates the similarities in curriculum between Australia, Singapore and the

Table 2.1

*Expected Learning Outcomes for Time, with Approximate Ages, from Australian and International Curricula*

<b>Learning outcome</b>	<b>Australia</b>	<b>Singapore</b>	<b>England</b>	<b>USA</b>
Compare and order the duration of events.	5-6			
The days of the week.	5-6		5-6	
Tell the time to the hour/half hour.	6-7	5-6	5-6	6-7
Draw hands on the clock to show time.		6-7	5-6 6-7	7-8
Use abbreviations <i>h</i> and <i>min.</i>		6-7		
Describe duration using months, weeks, days, and hours.	6-7			
Tell the time to the quarter hour.	7-8		6-7	
Use the language of <i>past</i> and <i>to</i> .	7-8	7-8		
Name and order months and seasons.	7-8			
Use a calendar to identify the date.	7-8			
Tell the time to 5 minutes.		6-7	6-7	7-8
Tell the time to one minute.	8-9	7-8	7-8	
Recognise relationship between units of time, e.g., 60 minutes in one hour.	8-9	7-8	6-7	8-9
Measure time in hours and minutes.		7-8		8-9
Convert between units of time.	9-10		8-9	10-11
Use am and pm notation.	9-10	6-7	7-8	7-8
Solve simple time problems.	9-10	7-8	8-9 9-10	8-9
Measure time in seconds.		8-9	7-8	9-10
Compare 12 and 24 hour systems.	10-11	8-9	7-8 8-9	
Interpret and use timetables.	11-12			
Relationship between distance, time and speed.		10-11		



United States of America. Although this is a small comparative sample of countries, it does demonstrate that Australia is in keeping with other English speaking countries<sup>3</sup> with its focus on reading clocks and calendars and the ages in which these concepts are introduced to the students. Having established the curriculum requirements for teaching time in Australia, it is important to ascertain the achievement of the students and to determine what problems might exist within the curriculum for teachers and students. To do this requires an understanding of current assessment of the Components of time. The next section discusses national assessment results.

### **2.9.3 Student success in relation to expectations**

The Australian NAPLAN tests (ACARA 2016a) are held annually and assess a wide range of mathematics knowledge. Items from the NAPLAN tests that focussed on time were identified. Results from 2008 to 2016 (see Appendix A) indicated that while up to 85% of students in Year 3 (age 8-9) could read clocks to the half hour, reading time to the quarter hour and comparing times on digital and analogue clocks was more challenging. The use of a calendar also appeared to be problematic for many of the students in Year 3. By Year 5 (age 10-11), students present as more capable when reading analogue and digital clocks, although many students in Year 5 had difficulty selecting the correct response to problems which required calculations between minutes and hours. Students in Year 7 (12-13), the first year of secondary education, demonstrated a lack of understanding of time comparison such as time intervals, time zones, analogue and digital conversion, minutes to seconds, and am to pm. These results may indicate a mismatch between Australian curriculum expectations and student learning which is worthy of investigation.

### **2.9.4 A summary of the curriculum expectations for the teaching of time**

To place the teaching and learning of time into the context of the educational system, the curriculum expectations for the teaching and learning of time in Australia were outlined above. Comparisons were drawn with curricula from Singapore, England, and the United States of America to illustrate the commonalities in expected learning outcomes that exist across countries. The anticipated learning outcomes for each country mentioned are similar, demonstrating that the Australian curriculum is in line with several other English speaking first world countries. Students are introduced to clocks and calendars in early primary school with mastery of these time measuring tools anticipated by the middle of primary school. Results

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<sup>3</sup> Singapore has four official languages: English, Malay, Mandarin, and Tamil

from nationwide assessment of students from Years 3, 5 and 7 undertaken in Australia have indicated that a number of students fail to master the use of clocks and calendars by the middle years of primary school.

In light of the fourth research sub-question, which related to what classroom experiences and pedagogies might support student learning about time, an investigation of research into effective teaching was undertaken. As the eight-lesson classroom intervention, during which the researcher took on the role of teacher as well as researcher, was a major source of data collection for this study, relevant literature could potentially act as a guide for the planning and implementation of the researcher's intervention lessons, as well as assist in the identification of possible reasons for the level of performance of students in relation to time. The next section is a discussion of literature related to effective teaching with particular reference to effective teaching of *mathematics*.

## **2.10 Effective Teaching**

All educational systems, principals and teachers desire that teaching be effective, but effective teaching can be defined in many different ways. Teachers who encourage their students to try new strategies, discuss their findings, and promote a positive attitude to mathematics in the classroom may be defined as effective. Teachers whose students make cognitive advances may also be seen as effective. Effective teaching could be teaching which leads to children enjoying their work, or teachers enjoying their work, or student success on standardised tests, such as NAPLAN (ACARA 2016a). Such success could be measured at one point in time, or seen as growth over time. In considering research on effective teaching, we need to consider how the researchers defined and measured effectiveness. The next section details key research on effective teaching of mathematics, and pedagogical strategies that have been shown to be related to the effective teaching of mathematics.

### **2.10.1 Studies in effective teaching of mathematics**

Studies identifying skills of effective teachers are widespread, including many in the relation to the teaching of mathematics. In the mid-1990s, the British Government instigated a National Numeracy Strategy from recommendations based on research evidence (Brown, Askew, Baker, Denvir, & Millett, 1998). In their review of the literature from which the recommendations came, Brown et al. (1998) noted that international observations had shown that there were teachers' strategies which correlated with high student attainment in mathematics. These included the use of higher order questions that require thought more than practice, emphasising connections between mathematical ideas, and collaborative problem solving.

Askew, Brown, Rhodes, Wiliam and Johnson (1997) undertook a study in England over two school terms during 1995 and 1996 to identify the knowledge, beliefs and practices used by effective numeracy teachers in primary schools and to identify strategies that could be applied more widely. Askew et al. (1997) identified three approaches to mathematics teaching: a connectionist orientation, where teachers stressed the links within the mathematics curriculum; a transmission orientation, whereby teachers demonstrate procedures and formulas to children for them to practise; and a discovery orientation, which encourages children to create their own methods for finding solutions to problems. Although most of the teachers studied used strategies from all approaches, the students who were taught by teachers who were identified as strongly connectionist were most likely to show the greatest improvement over the two terms of the study (Askew et al., 1997).

The Early Numeracy Research Project (ENRP) (Clarke et al., 2002) was conducted in Victoria from 1999 to 2001. This was a major project between Australian Catholic University, Monash University, The Victorian Department of Employment Education and Training (now known as the Department of Education and Training), the Catholic Education Office, Melbourne (now known as Catholic Education Melbourne), and the Association of Independent Schools Victoria (now known as of Independent Schools Victoria). A part of the ENRP study was an investigation into the effectiveness of teachers of early numeracy. Clarke et al. (2002) reported that effective teachers of early numeracy demonstrated particular behaviours and beliefs regarding numeracy teaching. Examples of these behaviours and beliefs were selecting tasks that engaged the children and maintained involvement, building on children's mathematical ideas and strategies, and having high, but realistic expectations for all the children.

Skills for effective teachers were also identified through the synthesised data from the research of others (including meta-analyses). Anthony and Walshaw (2007) investigated 660 pieces of research to report key findings relating to effective mathematics teaching and learning in New Zealand. Hattie (2003, October) synthesised over 500,000 studies on effective teaching, although not specifically of mathematics, and found that while the students themselves, their homes, schools, principals, and peers had an impact on learning, it was the teachers, by their knowledge, actions, and concerns, who accounted for about 30% of the variance of achievement by students.

Similarities exist between the findings of these studies. For example, effective teachers are confident in their knowledge of the mathematics they are teaching. Their lessons are planned to be engaging, include challenging tasks, and give opportunities to students to discuss findings and make connections. Effective teachers structure assessment to assist with planning further

lessons. Teachers' personal attributes, such as their beliefs and understanding of numeracy have also been shown to play a significant role in their students' success (Clarke et al., 2002). Teachers who respect, care and have a high regard for their students as learners seek to break down barriers to learning (Hattie, 2003, October).

When reviewing the teaching of mathematics for the Australian Council for Educational Research, Sullivan (2011) drew on international and Australian research findings to identify six key principles for the effective teaching of mathematics: articulating goals, making connections, fostering engagement, differentiating challenges, structuring lessons, and promoting fluency and transfer. These six principles were found to summarise the skills and behaviours identified by the aforementioned studies and incorporate the skills and strategies to be implemented into the planning and delivery of the intervention lessons to be conducted as part of this study. The intention of the lessons in this study was to ascertain what classroom experiences and pedagogies might best assist children's development when learning about time (sub-question 4). The six key principles identified by Sullivan will be discussed in the following sections with reference to the research mentioned in the previous section.

#### ***2.10.1.1 Articulating goals***

Teachers need to be clear when explaining their goals to students. The most effective teacher feedback guides students to where they are going, how they are going and what they are going to be doing next (Sullivan, 2011). Effective teachers have high but realistic expectations of their students, allowing them opportunities to question the reasons for, and the outcomes of, the tasks they are completing (Anthony & Walshaw, 2008). Effective teachers of numeracy in the ENRP conducted in Victoria, Australia, explained to students the purpose of the mathematics lesson, set goals for the students, and informed the students of the correct mathematical terminology (Clarke et al., 2002).

#### ***2.10.1.2 Making connections***

Teachers need to make connections by building on the knowledge and experience that the students bring to the classroom (Sullivan, 2011). Student learning is enhanced when connections are made from previous lessons or experiences (Clarke et al., 2002), different areas of mathematics are connected by way of words, symbols and diagrams (Askew et al., 1997), and students are given constructive feedback when articulating their thinking (Anthony & Walshaw, 2007). Askew et al. (1997) identified particular traits in teachers who had a connectionist orientation. The connectionist teachers made connections between numbers and methods which promoted efficiency and effectiveness, emphasised links between different

aspects of the mathematics curriculum, encouraged students to draw on their prior knowledge to solve problems, promoted the development of reasoning and justification, and believed in dialogue between teachers and students. Although no teacher in the study had all the listed qualities of a connectionist teacher, teachers who were strongly connectionist were “more likely to have classes that made greater gains over the two terms” (Askew et al., 1997, p. 28) than teachers who were identified as more strongly allied to discovery or transmission orientations.

#### ***2.10.1.3 Fostering engagement***

Effective teachers engage their students in a variety of rich and challenging tasks which foster decision making and engagement in mathematics (Anthony & Walshaw, 2008; Sullivan, 2011). When identifying factors relating to teacher effectiveness, Askew et al. (1997) investigated the response of the students within lessons and student engagement with activities as important factors alongside what the teacher did during each lesson. The ENRP also found that their effective early numeracy teachers structured purposeful tasks which fostered the use of different strategies and chose tasks that engaged children (Clarke et al., 2002).

#### ***2.10.1.4 Differentiating challenges***

Sullivan (2011) reported that effective teachers encourage interactions, including questions and answers, between students and teachers as a way to support students who need assistance and to further challenge other students as they engage in mathematics experiences. This is in part borne out by the 1997 study by Askew et al. which identified strategies used by their highly effective teachers such as, encouraging questions and discussion between students, selecting methods and strategies that were efficient and effective, and emphasising the development of mental strategies. Effective early numeracy teachers in Victoria were found to use a variety of questioning styles which promoted thinking, listening, sharing, and reasoning (Clarke et al., 2002).

#### ***2.10.1.5 Structuring lessons***

Effective lessons are well-structured, allowing for individual and group activities, reporting of students’ learning, and the teacher’s summary of key mathematical ideas (Sullivan, 2011). Successful early numeracy teachers demonstrated well-planned lessons that incorporated the use of a range of materials, engaged the children with an introductory whole group focus activity, drew out critical components during each lesson, used a variety of structures during the body of the lesson, and included lesson conclusions where children reflected on their learning (Clarke et al., 2002). Highly effective teachers in England emphasised the efficiency

of problem solving by using mental skills, written or part-written calculations and electronic tools (Askew et al., 1997) while expert teachers in the United States were more likely to seek feedback on the effectiveness of their teaching and instructional strategies, anticipate, and improvise as required (Hattie, 2009).

#### ***2.10.1.6 Promoting fluency and transfer***

Sullivan (2011) emphasised the importance of developing mental skills which can be drawn upon for automatic responses. While fluency can be enhanced by practice and reinforcement of learnt skills, it is important that automatic responses are developed through relational understanding, described by Skemp (2006) as the students knowing what they are doing and why they are doing it. Effective teachers emphasise the use of mental skills to build connections between mathematical ideas (Askew et al., 1997), and encourage children to listen to, evaluate and explain mathematical thinking and ideas (Anthony & Walshaw, 2009; Clarke et al., 2002). The development of mental skills is enhanced through problem solving, a strategy which promotes a deeper understanding and connection of mathematical concepts (Lambdin, 2003).

#### **2.10.2 A summary of effective teaching**

The elements required for teachers to be effective in their classrooms have been identified by studies in England, New Zealand and Australia. It can be seen from Australian and international studies and research that questions requiring higher order thinking, dialogue between students and teachers, making connections between different mathematical concepts and thought provoking tasks are significant factors in effective mathematics classrooms. Effective teachers display attributes that engage their students and promote effective learning. Fostering engagement was an important first step in the teaching intervention part of this study. A variety of tasks were planned to promote student interest in their learning with opportunities given for self-reflection. The Framework is structured to illustrate the connections between each major component thereby guiding the researcher as teacher to give the students every opportunity to make connections between prior knowledge and new learning.

### **2.11 Student Learning for Understanding**

Given that effective teaching of mathematics should lead to student understanding, the next section includes a discussion of student learning for understanding, types of understanding, constructivism and the learning of time for understanding. Included in the following section is background information that informs the response to the second research sub-question which asks how students' learning and understanding of time can be assessed.

An important part of this study was the development of an assessment tool that would give teachers and researchers a clear picture of each student's understanding of the major Components of time. To inform the development of this assessment tool, the researcher required knowledge of what is meant by *understanding*, including types of understanding, how students construct meaning, and how students learn for understanding. The subsequent stage in the development of the assessment tool was to establish an understanding of the meaning, the purpose, and types of assessment. The following sections explain each of these topics in turn.

### **2.11.1 Types of understanding**

Skemp (2006) was concerned about the concept of understanding and the ramifications for students of the different interpretations of the word. He described two such variations in the meaning of understanding, relational understanding and instrumental understanding. Relational understanding was described by Skemp as the real meaning of understanding as it means knowing both what to do and why what is done is done in a particular way. Relational understanding is more adaptable to new problems as students know why a particular method works, makes concepts easier to remember when they are interrelated, and is more satisfying to students (Skemp, 2006). Skemp did not consider instrumental understanding to be understanding at all, despite the view of many teachers to the contrary, as this understanding is what he considered to be "rules without reasons" (p. 89). Instrumental understanding requires less knowledge on the part of the students as they are only required to learn a rule to have a page of correct answers. Skemp noted that teachers aim for their students to have both relational and instrumental understanding as a deep understanding of the process is important to mastery of the process. He noted that many students prefer the quickest and easiest way get a desired solution and are content to only have instrumental understanding.

Hiebert and Carpenter (1992) regarded understanding as being composed of external representations which comprise written symbols, spoken language, and physical objects, and internal representations which explain how the ideas are represented in the mind of the learner. Internal representations consist of mental networks providing a framework of connecting ideas which can be based on similarities and differences between ideas, and subsumption and inclusion of ideas. To completely understand mathematical concepts, the ideas need to be incorporated into an internal network.

A mathematical idea or procedure or fact is understood if it is part of an internal network ... the mathematics is understood if its mental representation is part of a network of representations. The degree of

understanding is determined by the number and the strength of the connections. A mathematical idea, procedure, or fact is understood thoroughly if it is linked to existing networks with stronger or more numerous connections. (Hiebert & Carpenter, 1992, p. 67)

Learners are continually building mental networks through making connections between relationships (Hiebert & Carpenter, 1992). Two such relationships suggested by Hiebert and Carpenter (1992) are similarities and differences, and inclusion. Similarities and differences exist throughout mathematics as one can compare different ways to solve algorithms, or compare shapes, for example. As students create relationships between parts and a whole, networks are built based on inclusion.

The development of a deep understanding of mathematics is promoted by the understanding of the Big Ideas in mathematics, defined by Charles (2005, p. 10) as “a statement of an idea that is central to the learning of mathematics, one that links numerous mathematical understandings into a coherent whole.” Big ideas are central to the learning of mathematics as connections are developed and expanded across the school years. Making connections and the building of knowledge internally is viewed by researchers as a constructivist way of thinking or constructivism (von Glasersfeld, 1995b).

This section has defined understanding and discussed briefly the relationship between understanding and learning. To develop the concept of understanding further, the following section explores the role of constructivism and the impact constructivism has on the learning process.

### **2.11.2 Constructivism and learning**

Von Glasersfeld’s work on constructivism has played a significant role as a theory of learning since the early 1980s, its inception stemming from Piaget’s cognitive-development psychology (Steffe & Kieren, 1994). Reality is constructed in an individual’s mind by linked and interdependent experiences through processes of assimilation, that is, fitting an experience into a pre-existing conceptual structure, and accommodation, that is, developing new schema to accommodate new ideas and knowledge (von Glasersfeld, 1995b). Learning is no longer viewed in behaviourist terms of a stimulus-response mechanism but “requires self-regulation and the building of conceptual structures through reflection and abstraction” (von Glasersfeld, 1995a, p. 14). Brown and his colleagues (1989) considered learning to be achieved through activity and situations with knowledge being constructed like language, as the following excerpt explains.



All knowledge is, we believe, like language. Its constituent parts index the world and so are inextricably a product of the activity and situations in which they are produced. A concept, for example, will continually evolve with each new occasion of use, because new situations, negotiations, and activities inevitably recast it in a new, more densely textured form. So a concept, like the meaning of a word, is always under construction. (Brown et al., 1989, p. 33)

Constructivists believe learners build knowledge by active creation or invention rather than passive absorption, by reflection on their actions, and by communication through social discourse (Clements & Battista, 1990), with knowledge of the world being constructed from their perceptions and experiences and incorporated into their previous experiences (Simon, 1995). Pre-existing knowledge is the base upon which all subsequent learning is added; the learner constructs the knowledge internally from their personal experiences (Ernest, 2006). Simon (1995, p. 115) described learning as “the process by which human beings adapt to their experiential world.” Students construct knowledge by listening, by practising, and by reflective thinking (Clements, 1997). Since its inception, constructivism has developed into different versions such as radical constructivism and social constructivism, each with its own set of meanings and interpretations, although the metaphor of construction and building remains the same, with new knowledge being added to pre-existing structures.

Von Glasersfeld coined the term radical constructivism as he considered it to be “a *radical* rebuilding of the concepts of knowledge, truth, communication, and understanding...[which]...cannot be assimilated to any traditional epistemology” (von Glasersfeld, 1995b, p. 19). Through their actions and reflections, individuals construct their own reality and determine their own knowledge (Steffe & Kieren, 1994). Critics of radical constructivism interpret the explanation of individual learning, based on a personal representation of reality, to neglect the social aspect of learning through communication (Ernest, 2006). In his rejection of constructivism, Lerman (1996) emphasised the role of consciousness, occurring in social life, as the essence of human functioning. He believed radical constructivism did not adequately explain intersubjectivity, leading radical constructivists to consider social construction to explain the effects of enculturation. In their response to Lerman, Steffe and Thompson (2000) emphasised the role of individual interactions with the environment in engendering interactions within the individual.

Social constructivism, originating in sociology and philosophy, appeared in mathematics education in the late 1980s and although the term is used to describe different interpretations, a

commonality exists, described by Ernest (1994, p. 65) as “the notion that the social domain impacts on the developing individual in some formative way, and that the individual constructs (or approximates) his or her meanings in response to his or her experiences in social contexts”. The mind is not socially isolated, with conversation, both internal and external, playing a significant role in learning (Ernest, 2006). Social constructivists value the role of the cultural environment of the individual and the impact of language and interpersonal relationships to the learning process. The learning and teaching processes are interactive, involving “implicit and explicit negotiation of mathematical meanings...[elaborating on]...the taken-as-shared mathematical reality” (Cobb, Yackel, & Wood, 1992).

In the classroom, teachers who adhere to a constructionist philosophy of learning will listen to and question their students, while giving them opportunities to solve problems, to work in small groups, to reflect on mathematical tasks, to participate in classroom discussions, and to be involved in social interaction (Brown et al., 1989; Clements, 1997; Confrey, 1991; Steffe & Kieren, 1994). Students, with guidance from their teachers, should become self-motivated and independent, creating more complex understandings of, and an ability to communicate, mathematical concepts (Clements & Battista, 1990; Cobb, 1988). Cobb (1988, p. 89) considered that a primary responsibility of teachers was “to facilitate profound cognitive restructuring and conceptual reorganisations”. Confrey (1991, p. 118) endorsed this view when she stated that “knowledge is not the accumulation of information; it is the construction of cognitive structures that are enabling, generative and proven successful in problem solving”. To foster this learning environment Steffe and D’Ambrosio (1995) emphasised that mathematics teachers should be adept at posing situations for students, and encouraging reflection and interactive communication of mathematics. As a theory of learning, constructivism assists teachers to understand their students by giving them a conceptual framework for learning (Simon, 1995).

### **2.11.3 A summary of student learning for understanding**

An appreciation of the importance of and the process by which students learn for understanding has been established as a background for the development of a tool for student assessment that effectively assessed the students’ learning and informed planning. Such an appreciation also contributed to the development of the intervention lessons in this study as the activities for each lesson were selected to promote learning for understanding.

## **2.12 Student Assessment**

To determine whether students gained a deep understanding of the major Components of time presented in the intervention lessons, the most appropriate assessment methods needed to be

utilised. To inform the selection or design of the assessment in this study, different aspects and types of student assessment are defined and discussed in this section.

Much of a teacher's work is involved in the assessment of the students. Assessment can be used for a wide range of purposes from informing teachers to help them to assist students, to assisting in the development of national curricula (Webb, 1992). Assessment should not only be used as a data gathering exercise, but should also be a worthwhile learning experience, with the tasks and problems given to the students being meaningful and directed towards learning (Messick, 1994).

### **2.12.1 Definition of assessment**

Assessment can be defined as any activities or processes undertaken with the purpose of collecting evidence of learning in a planned and systematic way, which is then used to make a judgement about student learning (Harlen & Deakin Crick, 2002). Education integrates activity and reflection, with the reflective function embodied by assessment (Clarke, 1996). Webb (1992) defined mathematical assessment as "the comprehensive accounting of an individual's or group's functioning within mathematics or in the application of mathematics" (pp. 662-663). Although not a definition as such, Wiliam's (2010) statement that assessment "functions as the bridge between teaching and learning" (p. 137) illustrates the importance of assessing students.

### **2.12.2 Purposes of assessment**

One purpose of assessment is political. Schools are accountable to governments, who are accountable to their community; teachers are accountable for the effectiveness of their teaching; and in the classroom, students are accountable (Clarke, 1996). While aggregated assessment results can be used inside the classroom to determine the effectiveness of the instruction, the data are also used outside the classroom for accountability, management decision making, and policy formation. Assessment data provide information to decision and policy makers, who make judgements about the effectiveness of the educational program and individual teachers, as well as providing information on the effectiveness of the national educational system (Webb, 1992). Assessment reflects the learning outcomes valued by the school and community, which define the curriculum, as what is assessed determines what is taught (Clarke, 1996).

A second purpose of assessment is to determine advancement into higher education, work placement and employment. In most Australian states and territories, a student's final two years of secondary education, Years 11 and 12, are heavily influenced by assessment through subject-

based examinations, and vocational education and training examinations (Santiago, Donaldson, Herman, & Shewbridge, 2011).

The third and major purpose of assessment is evident at the classroom level. Assessment is a tool used by teachers to gain evidence and provide feedback on what the students know and are able to do, and express what is valued regarding the capabilities of the students (Webb, 1992). Clarke (1996) considered the three fundamental purposes of assessment were to model, monitor and inform. Successful mathematics assessment models value performance and educational practice, monitor the students' display of capabilities, and effectively inform interested parties. Teachers need assessments to give them an understanding of a student's behaviours and achievement, cognitive processes, learning potential, and motivation (Ginsburg, 2009). The Victorian Department of Education and Training (2017) defined assessment as an ongoing process in which evidence is gathered, analysed and reflected upon so that informed and consistent judgements can be made to improve future student learning.

### **2.12.3 Assessment practices**

The Department of Education and Training in Victoria views assessment as ongoing having the aim of assisting student learning. Three types of assessment predominate: assessment of learning, when teachers assess a student's learning to ascertain the progress the student has made in relation to goals and standards; assessment for learning, when teachers assess students' progress to inform their teaching; and assessment as learning which occurs when students reflect on their own progress (Department of Education and Training, 2017). Assessment of learning can be considered as either summative assessment or formative assessment (Department of Education and Training, 2015; Ginsberg, 2009). The next two sections detail summative and formative assessment.

#### **2.12.3.1 Summative assessment**

Summative assessment is assessment *of* learning. Assessment tasks that are designed with the aim of evaluating student learning to find out what students have learnt are summative (Santiago et al., 2011). Examples of summative assessment are tests, diagnostic tasks, projects, and examinations which show the students' knowledge and skills. In primary schools, common assessment methods which provide evidence of achievement using outcomes include

observing and recording student achievement as it occurs, mapping progress through the collection of student work samples over a period of time, tasks that incorporate the application of understandings and learning processes in

a set project and analysis of non-print based work samples. (Santiago et al., 2011, p. 51)

NAPLAN tests (ACARA, 2011) which are administered annually in Years 3, 5, 7 and 9 in both government and non-government schools to monitor student progress (Santiago et al., 2011), can be classed as summative. There are both advantages and disadvantages of summative assessment. In his list of approaches to mathematics assessment, Webb (1992) considered the benefits of one form of summative assessment which he termed a special case approach. Webb demonstrated the occasional need for teachers to assess a student's knowledge or skills, or knowledge on a particular procedure. However, students who are given insufficient time to explain their understanding, students who can demonstrate their understanding orally or physically but are restricted to writing their responses, and students who have language difficulties, could be disadvantaged by this type of assessment (Clarke, 1996).

### ***2.12.3.2 Formative assessment***

Assessment *for* learning has also been described as formative assessment. Formative assessment has been defined as assessment used to guide the teaching of students (Ginsburg, 2009), occurring within the context of teaching and learning (Santiago et al., 2011), and described by Black and Wiliam (1998) as “encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged” (pp. 7-8). Feedback is a key feature of formative assessment, playing a large part in the performance of the student, particularly when designed to promote the correction of errors (Black & Wiliam, 1998; Wiliam, 2010). The information gained from the assessment is used to plan effective learning activities and tasks for the individual student (Ginsburg, 2009). Ginsberg (2009) considered formative assessment to cover four main areas: the student's behaviour and achievement (performance), the student's cognitive processes (thinking and knowledge), the student's readiness to learn (learning potential), and the student's willingness to learn (affect and motivation).

Examples of formative assessment include tasks or tests which allow the teacher to determine strategies used, active observations of a student in which the teacher may manipulate situations to gauge responses, and a clinical interview in which the interviewer makes interpretations of the student's learning by listening to what the student says and by observing what the student does (Ginsburg, 2009). Disadvantages of this type of assessment can be the time required to prepare tasks and assess each student.

#### **2.12.4 Assessment tools**

Nationally, the Australian Curriculum, Assessment and Reporting Authority (ACARA), with representatives from all states and territories and non-government school sectors, is responsible for the National Assessment Program (NAP) that oversees the formative assessment testing termed the National Assessment Program - Literacy and Numeracy (NAPLAN). Since 2008, NAPLAN tests have been conducted annually for students in Years 3, 5, 7 and 9 to assess their essential skills in Literacy (reading, writing and spelling) and Numeracy (ACARA 2016a). Items are largely multiple choice. Owing to the nature of the assessment, questions are determined to be either correct or incorrect based on choices or what is written for open-response tasks, as there is no opportunity to ask a student to explain his or her thinking. Some items from this national testing program will be used in this study.

Another form of formative assessment that will be useful in this study is the diagnostic or clinical interview. Questioning children in a one-to-one interview allows a teacher to elicit a child's thinking and to follow his or her thought processes (Ginsberg, 2009). One particular task-based one-to-one interview was developed as part of the Early Numeracy Research Project (ENRP), a three-year Prep (first year of school) to Year 2 research project which was conducted from 1999 to 2001 (Department of Education and Training, 2013). The use of this interview to assess children's thinking and learning has been demonstrated to have many advantages over written tests. Teachers reported that they gained improved insights into each child's mathematics understanding, developed an appreciation of what the 'quiet achievers' in their classroom know, improved their knowledge of the subject matter and become aware of strategies used by the student to solve problems, and become aware of common problems and misconceptions in children (Clarke, Clarke, & Roche, 2011). Interviewing children allows teachers to not only record a child's answers to a question, but to also observe the child's actions and responses when solving a problem, and to make notes regarding the explanation of mental strategies used to reach a conclusion (Clarke et al., 2011). By questioning children one-on-one, teachers increase their knowledge of how children learn mathematics (Bobis et al., 2005), gathering information on the "most powerful strategies that a child accesses in a particular domain" (Clarke, 2013, p. 20). Although the ENRP Interview did include a section on time, due to the dearth of research available at that time regarding the learning of time, the parts of the interview relating to time were not particularly research-based (D. Clarke and A. McDonough, personal communication, May 9, 2017). For all of these reasons such an assessment tool will be fruitful to use in assessing students' understanding the Components of time.

Classroom assessment is designed to improve learning and develop deep understanding and requires a range of assessment practices. Assessment tools also depend on the purpose of the assessment and can include observations, interviews, portfolios and asking questions (Stenmark, 1991). For the purposes of this research, one-to-one task based interviews, NAPLAN tests, rich assessment tasks, student's self-reflections, and informal assessments were selected as assessment tools. Each form of assessment has advantages and disadvantages. Reasons for this selection are given in the following sections following a description of each form of assessment.

#### ***2.12.4.1 One-to-one task based interviews***

A process approach such as interviewing the students, identifies problem solving skills and higher order thinking strategies, and allows teachers to develop a deeper understanding of the students' thought processes (Webb, 1992). More information can be gained from a student about their strategies and cognitive processes during an interview than can be gained by observations or tasks (Ginsburg, 2009). Through the interview process with students, teachers are able to determine whether a student has made a simple error or is lacking in conceptual knowledge, diagnose misconceptions, and assess a student's ability to express mathematical knowledge verbally (Huinker, 1993). An advantage for teachers of students in the early years of schooling is that issues with reading and writing are somewhat overcome with a face-to-face interview as children respond verbally (Clarke, 2001). A good interview is supported by thought provoking questions, so teachers need to consider the type of questions to be asked. Questions such as 'How did you work that out?' and 'Could you solve that another way?' encourage students to become more reflective and analytical and less dependent on the interviewer's prompts (Clarke & Clarke, 2004).

While the one-to-one interview is "a source of rich information regarding ...[students] ... thoughts, understandings, and feelings about mathematics" (Stenmark, 1991, p. 28) one disadvantage expressed by Huinker (1993) is the time required for the assessment and the interpretation of results. However, Huinker believed that with careful planning, this obstacle could be removed. As a researcher, the time required to interview the students was not an issue as arrangements were made for each student to meet the researcher at a convenient time.

One example of a one-to-one task based interview is the mathematics interview, developed for use with students from the Foundation year to Year 4 that was a major feature of the Early Numeracy Research Project (ENRP). The Early Numeracy interview provides information about the big ideas, or growth points, in nine domains of mathematics as children are given

opportunities to demonstrate their mathematical understandings and preferred strategies for solving problems (Clarke et al., 2002). The interview consists of around 60 tasks ranked in order of complexity. A student's level of understanding is deemed to be reached when the student is no longer able to respond correctly to tasks.

Interviews have been introduced for other areas of mathematics such as fractions and decimals and for areas in English such as reading, writing, speaking and listening. For convenience, the interviews are now accessed by teachers online as diagnostic assessments of children for example, commencing primary school (Santiago et al., 2011).

The one-to-one task based interview was developed as an assessment tool for this study as it allowed for the researcher to ask for more information as necessary to clarify a student's understanding, and permitted the students to ask for an item to be repeated. By encouraging students to say what they were thinking when unsure of the correct response, the interviewer was able to assess a partial understanding as well as a full understanding of an item. Having described the importance of the one-to-one interview, the next section will discuss the advantages and disadvantages of NAPLAN tests.

#### ***2.12.4.2 NAPLAN tests***

While tests have been conducted in classrooms to determine knowledge of facts and skills, questions have been raised about the reliability and validity of pen and pencil short answer tests to assess mathematical understanding (Clements & Ellerton, 1995). Nevertheless, there are some advantages to using this type of test. The annual NAPLAN tests provide a measure of individual student performance of learning compared with state and national norms. Used extensively throughout Australia, there are data on thousands of students against which the performance of these students can be compared. There is potential to act on the data provided but the delay of several months between the test and the performance data arriving at the school limits this potential. The NAPLAN data does not give any indication by which the students solved the problems given, furthering limiting the value of this type of assessment.

#### ***2.12.4.3 Rich assessment tasks***

Traditional mathematics teaching has involved repetition of facts to develop fluency and procedural efficiency but a more progressive approach has been for teachers to use open-ended, non-standard problems which allow learners to be inventive and creative (Foster, 2013). Foster (2013) conceded that many teachers may use a combination of both of these approaches and suggested that this combination could be successful in developing proficiency whilst at the



same time promoting creativity and exploration of problems. Authentic tasks that require students to use multiple problem-solving strategies, contain important and relevant content, promote conversations within groups, and allow students to discuss mathematics meaningfully (Slavit, Bornemann, Haury, Knott, & Evitts, 2009).

To cater for a workplace that demanded workers be decision makers, assessment of mathematics changed during the 1970s and 1980s to incorporate assessment tasks that were more authentic; tasks that allowed students more time and flexibility to demonstrate their understanding and skills than examinations could offer were introduced (Brown & Hodgen, 2010). Assessment tasks were designed to reflect the rich, authentic tasks in the classroom and could be either formative or summative in their design. Clarke (2000), in a summary of ideas from teachers on rich assessment tasks, compiled a comprehensive list of characteristics that define this style of assessment. Rich assessment tasks were described as activities that

- Connect naturally to what has been taught
- Address a range of outcomes in the one task
- Are time-efficient and manageable
- Allow all students to make ‘a start’
- Engage the learner
- Can be successfully undertaken using a range of methods or approaches
- Provide a measure of choice or ‘openness’
- Encourage students to disclose their own understanding of what they have learned
- Allow students to show connections they are able to make between the concepts they have learned
- Are themselves worthwhile activities for students’ learning
- Provide a range of student responses, including a chance for students to show all that they know about the relevant content
- Help teachers to decide what specific help students may require in the relevant content areas
- Authentically represent the ways in which the knowledge and skills will be used in the future (Clarke, 2000, p. 4)

Rich assessment tasks not only provide teachers with valuable information about their students and their capabilities, but help to guide their teaching (Clarke, Stephens, Beesey, Clarke, & Sullivan, 1997). The use of rich assessment tasks as an assessment tool during the eight-lesson intervention provided additional information for the researcher such as the student’s response

to the task, the steps taken by the student to complete the task, and the connections made by each student to other concepts.

This section has shown that rich assessment tasks are a valuable assessment tool for teachers to assist them to diagnose misconceptions and problems, and to plan strategies for student learning.

#### ***2.12.4.4 Self-reflections***

Alongside assessment *of* learning (summative assessment) and assessment *for* learning (formative assessment), a third style of assessment is encouraged within Australian schools, that is, assessment *as* learning. Assessment as learning involves the students monitoring their own learning, asking questions, and assessing what they know to guide them in their future learning. A benefit of involving the students in their own assessments and reflecting on their learning, is the opportunity for the students to consider the characteristics of quality performances (Clarke, 1996). Examples of this form of assessment would be student constructed tests, and student journals and portfolios in which students can list what they know, and record their feelings and concerns. Black and Wiliam (1998) reported that with this type of assessment opportunities arose for students to understand the learning goals, become familiar with the assessment criteria, and reflect on their work. Assessment as learning can be summative and formative.

Self-reflections were selected as a form of assessment for this study as the researcher could gain additional insights into how students solved problems, the difficulties or challenges faced by the students, and the students' feelings about the activities planned for their learning by setting aside several minutes at the end of each lesson for the students to write.

Informal assessment is another valuable assessment tool used by teachers. The next section describes examples of informal assessment that were used in this study.

#### ***2.12.4.5 Informal assessment***

Although informal assessment sounds like it is something that occurs casually in the classroom, informal assessment has a significant role to play in understanding a student's learning. Informal assessments can be anecdotal records including observations made by the teacher as students work on tasks, checklists which record observations and comments, journals in which students reflect on their knowledge and skills, video or audio tapes of students as they solve problems, and students' self-assessments.

As one of the main purposes of assessment is to inform teaching, the teacher, who is in the best position to interpret the curriculum in terms of needs and capabilities of the students, is also the best person to interpret the students' responses from assessments (Clarke, 1996). Clarke (1996) stressed that the important principles of assessment were to "facilitate the exchange of information ... optimize the students' expression of their learning ... have instructional value ...[and]... anticipate action" (p. 337). Clarke argued that students can also share the responsibility of assessment as "it is the student's learning we aim to facilitate, and the student's actions we seek to inform" (p. 333). Self-assessment methods by students such as construction of their own test items, selection of their own portfolio items, completion of journal entries, and the completion of regular self-assessment procedures give teachers a deep insight into the students' knowledge and understanding (Clarke, 1996).

Observations of students as they work can give the teacher valuable information on the student, particularly students who may have difficulty with written or oral language, or may be reticent to share their ideas openly to the whole group (St. Clair, 1993).

The eight-lesson intervention was planned and implemented by the researcher who became the teacher. Working in the classroom allowed for observations to be made of for example, the students' working habits, the ways in which students solved problems and the different conclusions reached.

### **2.12.5 Summary of assessment practices**

This section defined different types of assessment and discussed the many purposes of assessment. Assessment strategies (one-to-one task based interviews, rich assessment tasks, self-reflections and informal assessments) were explained in detail with the reasons given for their selection for use in this study.

### **2.13 Summary of Chapter 2**

The researcher began this chapter with a brief history of our understanding and measurement of time from the development of calendars based on the cycles of the sun and the moon, through the development of the sundial, water clocks and sandglasses, to the introduction of clocks to accurately measure hours, minutes and seconds. The importance of the different ways time is measured, that is, social time, clock time, and virtual time, were explained. The development of measurement concepts was discussed followed by an overview of key concepts of time which students need to develop. A Framework for the Learning and Teaching of Time was presented based on the purposes for which time has been measured over the centuries and up to the present

day. National and international curricula were compared to illustrate the expected outcomes for primary aged children learning about time, and data were presented on Australian students' achievement in relation to time items on national assessments. An emphasis was placed on student learning with sections on effective teaching, student learning for understanding, and current assessment methods including the one-to-one interview, rich assessment tasks, self-reflections and informal assessment, all of which made important contributions to the development and implementation of the one-to-one task-based interview, and the intervention lessons.

In Chapter 3 the researcher details the methodology behind this study.

## **CHAPTER 3. Methodology: The Design and Context of the Study**

### **3.1 Introduction**

The focus of this chapter is the epistemology, the methodology, and the methods used in the research. The reasons behind the types of data that were collected are given together with an explanation of how the different data were analysed.

As a reminder of the research questions introduced in Chapter 1 and explored through the literature discussed in Chapter 2, the purpose of the study and the research questions are briefly restated in the following sections.

#### **3.1.1 Purpose of the study**

As demonstrated in Chapter 1 and Chapter 2, time is an important attribute of measurement. Over the centuries our measurement of time has become more precise; our lives are measured in fractions of a second and our work and leisure time has become influenced by virtual time as our pursuits in these areas has become more global. To develop an awareness and understanding of time, students need to learn about succession and duration, be aware of social and virtual time, make calculations using 24 hour time, interpret timetables, and be able to read and understand the different time measuring devices in use today.

In Chapter 2 it was highlighted that few researchers have delved deeply into the learning and teaching of time as evidenced, for example, by the lack of research papers on this topic presented at the annual conference of the International Group for the Psychology of Mathematics Education (IGPME), the major international conference on research into mathematics education. The purpose of this study was to build on available knowledge on the development of time concepts in primary school students through the introduction of a Framework for the Learning and Teaching of Time, the development and implementation of assessment tools, and an eight-lesson intervention focussing on experiences and pedagogies for learning and teaching the concepts of time in a Year 3 and 4 classroom.

#### **3.1.2 Research questions**

Time is measured continually, making this measurement attribute an important one in the mathematics curriculum. During her years as a classroom teacher, the researcher became aware that despite the ever-present nature of time, some students found this concept challenging. The researcher's experiences in primary school classrooms and interest in mathematics led her to

question how children develop an understanding of this unseen measurement attribute, time. This interest led to the following research question to be examined in this study:

What are the major components of a clear understanding of time and how might these components be described, assessed and supported in the primary school classroom?

This question has three aspects worthy of examination: the identification and description of the major Components of time that need to be understood; assessment of children's understanding of time; and the identification and recognition of classroom experiences and pedagogies that support learning of time in the classroom. These three aspects gave rise to the following sub-questions:

1. What are the major components of a clear understanding of time?
2. How can student learning and understanding of time be assessed?
3. What are middle year primary school students' understandings of time?
4. What classroom experiences and pedagogies might support student learning about time?

The methodology and methods used to answer the research questions is explained in this chapter. To begin to answer the sub-questions, the major Components of time were identified and explained (actually undertaken in Chapter 2), and an assessment tool was developed to assess students' understanding of time. To investigate classroom experiences and pedagogies that might support students' development when learning about time, an eight-lesson intervention on the topic of time was planned and implemented by the researcher acting as teacher. The study was guided by the philosophical stance explained in the next section.

## **3.2 Philosophical Stance**

The philosophical stance taken in this study is discussed in this section. The constructivist epistemology, the design research methodology and methods used to collect data are briefly outlined in Figure 3.1 and explained in greater detail in the following sections.

### **3.2.1 Epistemology: Constructivism**

Epistemology is "the study of the nature of knowledge and justification" (Schwandt, 2015). Crotty (1998) defined epistemology as our views on what constitutes human knowledge and what is "entailed in knowing ... how we know what we know" (p. 8). Although there are several epistemological positions from which research can be conducted, Guba and Lincoln (1989)

considered the constructivist paradigm as the most appropriate when considering inquiries into humans in contrast to what they described as a conventional or positivist paradigm. A brief explanation of positivism is given here as a comparison to constructivism, the epistemology behind this study. Positivists believe that knowledge is founded directly on experience with laws that govern science and society (Schwandt, 2015), hypotheses can be tested, facts can be collected and studies are value free and objective (Bryman, 2004). Positivism “offers assurance of unambiguous and accurate knowledge of the world” (Crotty, 1998, p. 18). Positivists believe research into social science should be value-free and objective, and guided only by empirical evidence (Neuman, 2011).

Epistemology	Constructivism
Theoretical Perspective/Methodology	Design research
Methods	<p>Mainly qualitative methods with some quantitative methods using the following data collection tools:</p> <ul style="list-style-type: none"> <li>• One-to-one interviews</li> <li>• NAPLAN items</li> <li>• Rich assessment tasks</li> <li>• Students’ self-assessment</li> <li>• Informal assessment</li> </ul>

Figure 3.1. The approach to this study.

In contrast to this view, constructivists believe that meaning is not discovered as such, but constructed by each individual according to their experience with particular phenomena, illustrated by different people viewing the same phenomena and developing different meanings (Crotty, 1998; McKenney & Reeves, 2012). Unlike social constructionism in which knowledge is believed to be constructed through social interchange and language (Flick, 2006) constructivism is the belief that the mind is active in the construction of knowledge (Schwandt, 2015). Neuman (2011) described a constructionist orientation as “an orientation toward social reality that assumes the beliefs and meaning that people create and use fundamentally shape what reality is for them” (p. 102). Individuals create their own meaning from their experiences, interactions with other people, and their environment (Hartas, 2010). Crotty (1998) defined *constructionism* as focusing on “the collective generation [and transmission] of meaning” (p. 58), distinguishing this philosophy from *constructivism* which he defined as “focusing

exclusively on the meaning-making activity of the individual mind” (p. 58). This active creation of knowledge is evident in the mathematics classroom that has a culture of explanation, negotiation, sharing and evaluation enabling students to create new mathematical knowledge through their reflection of physical and mental actions (Clements & Battista, 1990).

As an experienced teacher, the researcher observed children in the classroom over many years. Her observations led her to believe that children learn through their experiences, gradually building concepts and developing understanding. While classrooms can be seen as places of social learning, in this study the researcher was interested in the students as individuals. The researcher’s observations seem to knit with Crotty’s (1998) suggestion that meaning is constructed by people as they interpret the world around them and engage with it. Hence this study is guided by the paradigm of constructivism. Constructivism is explained in detail in section 2.11.2.

### **3.2.2 Theoretical perspective/ Methodology: Design research**

Design research in education emerged in the 1990s (Anderson & Shattuck, 2012) following the work of Brown (1992) who had moved from studying student learning in the laboratory to working with students in the classroom. Her seminal work in design research led the movement (Collins, Joseph, & Bielaczyc, 2004). Brown’s design experiments were developed with two objectives: a theoretical aim which would contribute to a theory of learning, and an intervention which would contribute to practice. Conducting research in the classroom had advantages over more scientific approaches as insights could be gained and practical solutions could be developed when researchers were working in the real world (Brown, 1992; McKenney & Reeves, 2012).

Collins, Joseph and Bielaczyc (2004) stated that design research was developed to address issues regarding the study of learning. Collins et al. (2004) identified four issues that could be addressed by design research: theoretical questions regarding learning attended to in context; learning studied in the real world away from the laboratory; researchers widening their measurement of learning; and research findings being derived from formative evaluation. Collins et al. (2004) added that design research is based on theoretical principles developed from prior research which need to be addressed for the research to be effective.

Rather than being seen as a single approach to research, design research is a series of approaches in a natural setting aimed at producing new theories and practices for teaching and learning (Anderson & Shattuck, 2012; Barab & Squire, 2004). The systematic and iterative nature of the research enables the researchers to extend their knowledge about innovative learning



environments by addressing questions from prior research (Design-Based Research Collective, 2003), and developing solutions to educational problems with the aim of informing the work of others (McKenney & Reeves, 2012). Each design is built on a collaborative partnership between researchers and practitioners and focusses on the testing of a significant intervention using mixed methods (Anderson & Shattuck, 2012). Design experiments are seen by Cobb, Confrey, diSessa, Lehrer and Schauble (2003) as “both ‘engineering’ particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them” (p. 9). For the present study, the following definition of design research from Plomp (2007) was adopted:

The systematic study of designing, developing and evaluating educational interventions (such as programs, teaching-learning strategies and materials, products and systems) as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them. (p. 13)

While design research is usually conducted through an intervention in the classroom, it encompasses more than interactions between teachers, learners and researchers exploring innovations and testing interventions. Interventions are supported by theoretical claims from prior research about teaching and learning, with researchers working towards understandings that connect the theory with designed artefacts and practice (Design-Based Research Collective, 2003). Interventions are developed by researchers in collaboration with practitioners and implemented into the classroom where successive versions of the intervention are studied and reviewed for effectiveness (Plomp, 2007).

Cobb et al. (2003) listed five features of design research which were: developing theories about the process of learning; having a highly interventionist methodology, creating conditions for developing theory that can form potential pathways while at the same time being reflective with the possibility of several levels of analysis; having an iterative design with cycles of invention and revision; and being pragmatic and accountable to the design. Building on earlier work, Van den Akker, Gravemeijer, McKenney, and Nieveen (2006), described design research as: interventionist, with an intervention in the real world; iterative, incorporating design, evaluation and revision; process oriented, focussing on understanding and improving interventions; utility oriented, having a design that is practical for users; and theory oriented, being based on theory with the testing in the field building on the theory.

The features of design research that are important for this study were adopted from the work of Van den Akker et al (2006). This study was based on theory that supported an intervention in a local classroom and incorporated an iterative cycle of design, test and review that focussed on improving the intervention lesson content and pedagogy. The iterative cycle was particularly important to this study. The importance of iteration to design research was emphasised by Cobb et al. (2003) who described the process of iteration as “developing an initial design, conducting the experiment, and carrying out a systematic retrospective analysis” making it a “crucial determinant” in any type of design experiment (pp. 11-12).

Although design research is a powerful tool for research into learning, challenges exist for the researchers. These include that the design plan cannot specify all the details as constant decisions have to be made regarding the participants (Collins et al., 2004). The number of decisions to be made regarding the participants is dependent on the number of participants. Throughout the intervention, decisions were made regarding activities for each lesson that were suitable for the 27 students. The researcher is the designer, implementer and evaluator and subsequently may be subject to bias (Anderson & Shattuck, 2012; Barab & Squire, 2004; McKenney, Nieveen, & van den Akker, 2006; Tabak, 2004). To overcome possible bias, several strategies were implemented. These strategies are explained in section 3.9.1.4.

The findings from design research are not generalisable to a larger universe (Plomp, 2007). While lack of generalisability is a challenge, this research aimed to make a difference for the individual teachers and schools involved in the intervention (Anderson & Shattuck, 2012). Comparing across different designs may be difficult (Collins et al., 2004). Evaluation is dependent on many variables, such as the participants’ needs, interests, and abilities (Collins et al., 2004).

Difficulties may arise from the complexity of the real world (Collins et al., 2004; McKenney et al., 2006). Working in a classroom which is the domain of another teacher can present additional challenges such as student behaviour, noise level, and distractions for the students. When planning both the pilot study and the intervention, consideration was given to any difficulties or challenges which could arise with steps taken to reduce or eliminate them. Large amounts of data may be collected needing a large number of resources for collection (Collins et al., 2004). As the data for this study were collected, appropriate and suitable storage was addressed in line with the university guidelines. The temporal bounding of a project may be influenced by multiple iterations of the study (Anderson & Shattuck, 2012). This study had temporal bounding built into the project, thereby reducing the number of iterations possible.

There are particular advantages to using design research (Shavelson, Phillips, Towne, & Feuer, 2003). Shavelson et al. listed strengths of design research as the testing of theories in the place of practice, researchers working with practitioners to co-construct knowledge, researchers adapting instruction to suit the daily problems which affect teaching and learning, the recognition that the theory has limits, and the adaption of the theory through iteration. Design research has been shown to make a difference for individual teachers and schools involved with small-scale interventions (Anderson & Shattuck, 2012).

The methodology for this study, design research, guided the researcher to the methods to be used in this study. As the research is accountable for the function of the design in authentic settings (Design-Based Research Collective, 2003), the methods to be used for data collection in this study were school based. Plomp (2007) listed the functions of research as “to describe ... to compare ... to evaluate ... to explain or to predict ...[and]... to design and develop (p. 11). In this study, actions of the participants were described, the strategies used by the participants were compared, the data from the rich assessment tasks were evaluated, future learning was explained or predicted, and the Framework for the Learning and Teaching of Time was designed, developed and refined as was the intervention. The methods used to collect the data to answer the research questions are detailed in the next section.

### **3.2.3 Methods: Qualitative and quantitative**

As noted in Figure 3.1, a combination of methods was used following the philosophical stance outlined in the two preceding sub-sections. A more detailed explanation of the methods is given in this section. Following the design research features of design, test and review meant that several types of data were collected and analysed. Each method of collection impacted on the later collection tools in sequence. For example, the data collected from the first interviews impacted on the design of the lessons as is appropriate for design research studies. The nature of the data collection in design research led to this study being described overall as using mainly qualitative methods with some quantitative methods. Interviewing, participant observation and interpretive analysis, three of the many methods that come under the category of qualitative research (Denzin & Lincoln, 2000), were used in this study. As some aspects of quantitative research were also incorporated into the data analysis, such as the statistical analysis of the interview data, it is tempting to describe this study as *mixed methods* (Creswell, 2005). Creswell describes mixed methods research as encompassing the following criteria.

An approach to research in the social, behavioural, and health sciences in which the investigator gathers both quantitative (closed-ended) and

qualitative (open-ended) data, integrates the two, and then draws interpretations based on the combined strengths of both sets of data to understand research problems. (Creswell, 2015, p. 2)

However, for a study to be considered a fully integrated mixed methods study, “interaction between the qualitative and quantitative strands occurs at all stages of the study” (Creamer, 2018, p. 19). This was not the case in this study.

The remainder of this chapter details the context and the methods of data collection used in this study: one-to-one interviews, NAPLAN items, rich assessment tasks, students’ self-reflections and anecdotal notes made by the researcher.

### **3.3 Context of Study**

In this section, the overall context for this study is described. A description of the participating schools, student participants and teacher participants is given along with an explanation of the criteria used to select the schools, students, and teachers involved in the study. All required university ethics procedures were undertaken in line with guidelines from the university’s Human Research Ethics Committee (HREC) (See Appendix B for the Human Research Ethics Committee letter of Approval). The role of the researcher in the context of the study is described to inform the reader of the relationships between the researcher, the school, the teachers, and the students during the data collection phase.

#### **3.3.1 Overall context**

To answer the research question and the four sub-questions, data were collected from Year 3 and 4 students in a regional government primary school. Prior to the main data collection, a pilot study was conducted in another government school in the same regional city. The first school where the pilot study was conducted is hereafter called *the trial school* and the second school where the main study was conducted is hereafter called *the main school*. Prior to approaching the schools, approval was gained from the Department of Education and Training to conduct research in Victorian government schools (see Appendix C).

#### **3.3.2 Participating schools**

A pilot study to trial the central data collection tool, the one-to-one task based interview, was conducted in the trial school. Data collected from the participants in the trial school gave rise to an improved data collection tool used at the main school. As the researcher lives in a regional Victorian city with 34 government schools and 14 non-government schools, the primary schools

selected as trial and main schools were within this provincial city. A description of each school is given in the next section with an explanation of the criteria used to select the schools.

### ***3.3.2.1 The trial school***

The trial school was a government school with an enrolment of approximately 290 students at the time of the study. This school is situated in an urban area approximately nine and a half kilometres from the centre of the city, within close proximity to community amenities such as a large shopping centre, sporting facilities, public transport and a bushland reserve. This school is close to an established residential area but had become a growth area for housing in recent years. The range of housing options near the school meant students came from a diverse range of socio-cultural backgrounds. Visual and Performing Arts feature in the school curriculum with instrumental music tuition available and an annual school production. The school catered for students from Prep (Foundation) to Year 6 with a curriculum that was consistent with the Australian curriculum (Australian Curriculum Assessment and Reporting Authority (ACARA), 2013).

The trial school was selected for two reasons. Firstly, the students enrolled at this school came from diverse backgrounds and, according to their teachers, exhibited a range of mathematical skills from low to high achievement. Secondly, the researcher was familiar with the school and its culture as she had worked there for several years, but had left before the current students were enrolled. The researcher approached this school to be a part of the study as she knew some of the staff, but was unfamiliar with the students and their families. Being known by staff members for her confidentiality and diplomacy assisted with an acceptance of the study, which may not have been as forthcoming in an unfamiliar school. Trialling the interview with students who did not know the researcher promoted professional teacher/student interactions that were beneficial to the interview trials.

Prior to trialling the interview, in line with guidelines from the university's Human Research Ethics Committee (HREC) information letters and permission/assent forms were distributed to the school principal, teachers, parents and students (see Appendix D) who wished to participate in the study. All students who participated in the study had submitted signed parent permission forms and had signed assent forms.

### ***3.3.2.2 The main school***

The main school accommodated the major data collection and intervention program. For consistency, this school was selected as it had a similar student enrolment and socio-economic

status to the trial school. The main school is in a similar urban location to the trial school. It is five kilometres from the centre of the same regional city. It had a student population of approximately 300 at the time of the study. With this number of students, the classroom teachers were supported by specialist staff who taught art, music and a language. As with the trial school, the main school catered for students from Prep (Foundation) to Year 6 with a curriculum that was consistent with the Australian curriculum (Australian Curriculum Assessment and Reporting Authority (ACARA), 2013).

The main school was selected for two additional reasons. Firstly, the students enrolled at the school came from similar backgrounds to the students from the trial school and, according to their teachers, had similar achievements in mathematics. Secondly, the principal was very supportive of the project in general. His enthusiasm came from two perspectives: the prospect of additional assistance in mathematics for his students and respect for the researcher's study. The researcher had voluntarily assisted in this school twice-weekly for three years, working with a small group of Year 5 and 6 students who were experiencing difficulty with Year 5 and 6 mathematics. Familiarity with the staff due to regular attendance at the school was favourable to an acceptance of the idea of student interviews and intervention lessons. The researcher did not know any of the Year 3 and 4 students, as she had only assisted the students in Years 5 and 6 who had since left the school to attend secondary school.

Prior to undertaking research and data collection in the main school, in line with guidelines from the university's Human Research Ethics Committee (HREC) letters of introduction, information and permission/assent forms were distributed to the school principal, teachers, parents and students (see Appendix E) who wished to participate in the study. All students who participated in the study had submitted signed parent permission forms and had signed assent forms.

### **3.3.3 Student participants**

To acquire student participants, information packs and permission forms were sent to students' parents in Years 3, 4, 5 and 6 in the pilot school and students from one Year 3 and 4 class in the main school. The *Australian Curriculum: Mathematics* listed telling the time to the minute as a Level 3 objective (Australian Curriculum Assessment and Reporting Authority (ACARA), 2016c), so students were selected from Year 3 and above for this research project. This section informs the reader how the students were selected for the study and why they were selected.

### ***3.3.3.1 The trial school***

Sixteen students were involved in the pilot study. Three girls and four boys were in Year 3, four girls and three boys were in Year 4, and two girls were in Year 5. The number of participants was dependent on the return of signed permission forms from the students' parents or guardians, informed consent from the students, and an informal discussion with the classroom teacher. The students were reported by their classroom teachers to have a range of mathematical outcomes, ranging from low achievement to high achievement. Interview times were arranged to reduce any inconvenience for the teachers and to keep disruption to the classroom to a minimum. In accordance with ethics guidelines, a pseudonym was allocated to each participating student to ensure that neither the student nor the school could be identified.

### ***3.3.3.2 The main school***

The main school had three classes of Year 3 and 4 students. The principal of the school selected one class for the study after a discussion with the teachers of the three classes. The researcher was invited into the class to meet the students who were given information about the purpose of, and their role in, the study. The classroom teacher's assessment of her students showed a range in their mathematical achievement from low achievement to high achievement. Prior to the intervention, the classroom teacher planned her mathematics program with the other teachers in the Year 3/4 unit. In the previous year these students, who were then in Years 2 and 3, had experienced no more than five to six weeks on the topic of time spread across the year through both formal teaching of time and incidental teaching experiences. Lessons focussed on reading and writing the time using an analogue clock and converting between units of time such as seconds to minutes and days to weeks. Key words listed by the teachers included second, minute, hour, day, week, fortnight, month, year and decade. It appeared that the greatest emphasis in this teaching was on the Measurement Component of time. In the year of the intervention, in keeping with other years, a total of four weeks had been allocated to the teaching of time prior to the intervention. With the introduction of the intervention in Term 4, the classroom teacher did not plan any additional lessons on time for the remainder of the year.

Each student in the combined Year 3 and 4 class was given an information pack containing details of the study for the parents/guardians and students, and permission/assent forms, in line with the guidelines from the university's Human Research Ethics Committee (HREC). Of the 30 students in the class, 27 students returned the forms giving parental permission and student assent to be a part of the study. In accordance with ethics guidelines, a pseudonym was allocated to each participating student to ensure that neither the student nor the school could be identified.

The participating students ranged in age from eight years and 10 months to 11 years and one month. The breakdown in ages and Year levels can be seen in Table 3.1.

Table 3.1

*Ages (in Years and Months) and Year Levels of the Participating Students*

Year 3 boys	Year 3 girls	Year 4 boys	Year 4 girls
8:10	8:11	9:11	9:10
8:10	9:1	10:0	9:11
9:11	9:4	10:1	9:9
9:3	9:5	10:4	10:2
9:3	9:9	10:7	10:2
9:4		10:7	10:4
9:5		11:1	
9:5			
9:8			

### ***3.3.3.3 The main school sample group***

To gain more specific pictures of individual students' participation and learning throughout the eight-lesson intervention while not making the reporting unwieldy, six students were selected based on their results from their pre-intervention interview to represent a broad range of achievement by the class group. The interview scores for the whole group were ranked and the lowest and highest scores were excluded. From the remaining list, every fourth score was selected commencing with the lowest score, resulting in a group of three girls and three boys. These students, identified by the coded pseudonyms 03G3, 05G3, 07G4, 13B3, 18B4, 24B3 scored 54, 91, 122, 79, 99 and 109 from a maximum possible score of 138. The six selected students will henceforth be referred to as the sample group. Work samples described in each lesson are, where appropriate, from the sample group, with selected work samples for the entire class provided in the designated Appendix section.

### **3.3.4 Teacher participants**

Teacher participants selected for the study were required to give informed consent and be willing to follow guidelines and directions from the researcher. For the pilot study, teachers across Year levels 3 to 6 were given the opportunity to be involved. Three teachers, with classroom experience ranging from 10 to 40 years, gave permission for their students to be involved in the trial.

The teacher in the main study was the regular classroom teacher of the combined Year 3/4 classroom. The teacher in the main school had less than five years' teaching experience. The class was divided into groups for mathematics lessons to allow her to cater for the individual differences of the 30 children in the room. In accordance with ethics guidelines, a pseudonym



was allocated to the participating teacher to ensure that neither she nor the school could be identified.

### **3.3.5 Role of the researcher**

Although the principal role was as collector and analyst of data gathered during the research project, the role of the researcher was manifold. As well as collecting data for this study, the researcher took on the role of classroom teacher for the eight-lessons, becoming a teacher-researcher with the responsibility for teaching and audio recording each lesson. While the researcher and classroom teacher had many teaching strategies in common, the teacher-researcher incorporated some classroom experiences and pedagogies into the lessons that differed from the mathematics experiences previously offered by the classroom teacher, as reported by that teacher. These experiences were based on the teaching style of the teacher-researcher, the Framework Components, the results from the one-to-one interviews, the literature focussing on best practice, and the intended focus of each lesson.

### **3.4 The Pilot Study**

A pilot study gave the researcher an opportunity to trial the data collection tools and their procedures prior to the main study. Piloting such tools ensures participants can understand the items and allows changes to be made if necessary (Bell, 2005; Creswell, 2005), and helps to maximise the validity and reliability of the study (Lodico, Spaulding, & Voegtle, 2010). The pilot study gave an opportunity to trial the one-to-one interview items to assess their suitability and effectiveness for Years 3 and 4. It also provided the added advantage of increasing the effectiveness of the researcher as her skills as an observer and interviewer were further developed and her knowledge of data analysis improved.

The pilot study trialled 66 items from the first version of the one-to-one task based interview. Several interview items were modified in consultation with the supervisors of this study. Alterations were made to items for the reasons shown in Table 3.3.

One important change after piloting the interview tool was the method of scoring each item, in order that it could be used more easily by another teacher or researcher. The statements used to assess each item were written to clearly define a score of two, one or zero points.

For example, item two required the students to explain when the day commenced. The original statements to demonstrate a full understanding, a partial understanding or did not demonstrate any understanding were as follows:

Today is Wednesday\*. When did Wednesday\* start? \*State the actual day you are talking to the student.

- Starts at midnight or 12 o'clock in the night/night-time. (2 points)
- Gives a time that is within an hour of midnight or 12 o'clock (between 11pm and 1am). (1 point)
- Gives a time that is more than one hour from midnight or did not know. (0 points)

To eliminate any misinterpretation, the dot points were changed to read:

- Starts at midnight or 12 o'clock in the night/night-time or 12am. (2 points)
- Gives a time that is within an hour of midnight or 12 o'clock (between 11pm and 11:59pm inclusive; or between 12:01am and 1:00am inclusive) OR says 12 o'clock without specifying when the 12 o'clock occurs. (1 point)
- Other incorrect response OR no response. (0 points)

Another example of the changed wording occurred in the following item:

Put your head on the desk\* for one minute and look up when you think one minute is up. \* Allow the student to choose whether to put their head down, close their eyes or turn away from the interviewer. Record the time in seconds that the student's head is down. Record any response from the student (physical or verbal). Number of seconds.....

- 50 to 70 seconds.
- 40- 50 seconds or 70-80 seconds.
- Less than 40 seconds. More than 80 seconds. Did not participate.

Changes to the dot points eliminated any confusion with 50 and 80 seconds.

I am going to get to estimate one minute. When I say 'Go', put your head on the desk.\* When you think one minute is up, you have to say 'Stop'. \*Allow the student to choose whether to put their head down, close their eyes or turn away from the interviewer. Record the time in seconds that the student's head is down. Record any response from the student (physical or verbal). Number of seconds.....

- 50 to 70 seconds, inclusive.
- 40- 49 seconds inclusive or 71-80 seconds inclusive.
- Less than 40 seconds. More than 80 seconds. Does not participate.

Table 3.2  
*Examples of Changes to Interview Items*

Reason for change to item	Item example/s	Outcome/Change in item
Item was too difficult or challenging.	Can you explain daylight saving to me?	Deleted from interview.
	Tell me what happens to make one year.	What can you tell me about the rotation of the Earth?
	Without looking at a clock, tell me what time you think it is.	Deleted from interview.
Item was confusing for the interviewee.	Two cards showing 6:15 and 6:45 as seen on an analogue clock. Which card shows the time closest to 6:20?	Deleted from interview.
Item did not clearly demonstrate its purpose making it difficult to assess.	What is something that takes a long time to do? What is something that takes a very long time to do?	Items were combined to make the item assess comparative durations.

As the changes to the interview resulted in the deletion, or combination, of some items, the final interview needed to be checked to ensure that each key idea for each major Component was assessed by as near to the same number of items as possible. Having a balanced number of questions for each key idea allowed for a comparative assessment to be made of each aspect of the Framework.

### 3.5 Data Collection Methods

A design experiment is conducted in a learning environment (Collins et al., 2004) as the research must be accountable for the function of an authentic setting. The data for this research project were collected from Year 3/4 students in a regional Victorian government primary school with the researcher taking the roles of the interviewer and teacher. The principal source of data came from the pre-and post-intervention interviews. Additional data were gained from the results of six NAPLAN test items, rich assessment tasks, the students' self-reflections and informal assessment undertaken during the lessons. Each data collection method is explained in the following sections.

This section gives a description of the methods used in the study and an explanation of how these methods align with the philosophical stance described in the previous section. The tools used to obtain the data are explained and reasons for the selection of each tool are given.

### **3.5.1 Overall parameters**

To answer the research questions, the following tools were used to collect data. The researcher developed and utilised one-to-one interview items and selected past NAPLAN items to assess the students' knowledge before and after the intervention. Classroom artefacts from rich assessment tasks, self-reflections and informal assessments, such as documented observations and field notes, were used to further assess the students' learning. The collection and analysis of the data during the intervention were instrumental in the development of the forthcoming lessons in line with design research. Each of these tools was discussed in Chapter 2. They are based on the premise that children develop their own understanding and knowledge of the world by constructing concepts and then building on their conceptual understandings as they gain further experience. This clearly links to the constructivist epistemological stance in which this study is located.

The methods used are discussed in detail in the next section.

### **3.5.2. One-to-one interviews**

The one-to-one interview was the principal form of assessment in the main study. To interpret the students' interview responses the researcher could request further information or a clarification of a student's response. Accurately transcribing the audio recording of each interview allowed for a deeper reflection on the understanding the student had demonstrated as the recording could be replayed as often as necessary to ensure each spoken word was clearly understood. The students were interviewed twice; the first interview was conducted before the intervention and the second interview was three weeks after the completion of the lessons. This section gives a detailed account of the reasons for the interviews, the type of interview and the interview questions. One-to-one interviews are discussed in section 2.10.4.1. The crucial point for this study is that by talking to students in a one-to-one interview, teachers (and in this instance the researcher) are able to develop a deeper understanding of the students' thought processes (Webb, 1992), strategies and cognitive processes (Ginsberg, 2009) and hence are better able to diagnose misconceptions and assess a student's ability to express mathematical knowledge verbally (Huinker, 1993).

Although the students had given informed consent, the purpose of the study was reiterated to the students before the interview commenced. The students were informed that they could leave at any time, but all of the participants chose to remain until the end of the interview.

Asking good questions is important for collecting good data (Merriam, 2009). While one-to-one interviews enable researchers to collect rich data, there are some disadvantages which

needed to be considered. Interviews may be considered “time-consuming and resource intensive” (Savin-Baden & Major, 2013, p. 371), recording the interview may be regarded as intrusive by the interviewee (Scott & Usher, 2011), and the responses may be biased by the researcher, and difficult to analyse and compare (Mertens, 2010). To overcome these problems, the questions were trialled and interviewing techniques practised by conducting pilot interviews at the trial school (Merriam, 2009); the interviews were conducted by the researcher who had time available for the purpose; the interviewees were put at their ease and interviews conducted only after assent was given; bias was reduced to a minimum as the researcher did not know any of the students before the interviews began; and the scoring format of the interview was carefully constructed for consistency of analysis.

### ***3.5.2.1 The type of interview questions***

Interview questions can be highly structured using predetermined questions, semi structured with more open-ended questions and fewer structured questions, unstructured and informal allowing the researcher to ask questions arising from the context to learn more about a phenomenon, or a combination of any or all of the above (Lodico et al., 2010; Merriam, 2009; Savin-Baden & Major, 2013). This study used a predetermined interview format with the inclusion of open-ended questions encouraging students to explain their thinking. For consistency, predetermined questions ensured all participants were asked the same initial question, while the addition of verbally expressed more open questions by the researcher such as ‘Can you tell me how you worked that out?’ allowed for more detailed data to be gathered. The role of the researcher/interviewer was to pose questions and to keep the conversation flowing, but it was also important for the researcher as interviewer to listen carefully to the responses of the participants (Lodico et al., 2010).

### ***3.5.2.2 The interview items***

The 69 items of the one-to-one task based interview were structured to assess three major Components of the Framework for the Learning and Teaching of Time (see sections 2.6 and 2.6.1); Succession, Duration and the Measurement of time. An Awareness of time, the fourth Component, was deemed to be present in all items. For example, students needed to understand the language of time to respond to items relating to morning, afternoon, calendars and units of time. A one-to-one task based interview designed for children in their first or second year of school would require items specifically aimed to assess Awareness of time. The students were informed at the outset of the interview that the interviewer wanted to find out what each student had learned about time and measuring time and they were to answer each item the best way that

they could. They were informed that some of the items may be easy, some of the items may be hard because they may not have learned about that item yet, and some of the items may make them think about time in a way that they had not done before. The students were also told that it was not a test, although their responses would be audio recorded for later analysis. Students were encouraged to ask for an item to be repeated if necessary for clarification, or to say ‘pass’ or ‘I don’t know’ if an item proved to be too difficult.

The major Components of the Framework are divided into key ideas which focus on important elements that explain and clarify the major Component (the dot points under each Component in Figure 2.1, in section 2.6.1). Each item of the one-to-one interview was formulated to ascertain the students’ knowledge and understanding of these key ideas. Three key ideas related to Succession were each assessed by four interview items, with the other three Succession key ideas each assessed by five interview items. The Duration key ideas were each assessed by five interview items. As Measurement of time included not only reading and writing analogue and digital times, but also an understanding of units of time and the passage of time, each Measurement key idea was assessed by eight items. Each interview item was identified as belonging to at least one key idea from the Framework. However, the concept of time is complex and so many of the items were listed as belonging to more than one key idea. Therefore, although the complete interview consisted of only 69 items allowing for some items linking to more than one key idea, there were 28 items that were classed as Succession items, 31 items as Duration, and 49 items relating to the Measurement of time (see Appendix F for a tabulation of this distribution). As noted above, all items were considered to incorporate an Awareness of time, so this major Component was not assessed separately.

Each item had a range of anticipated responses. All responses which demonstrated a full understanding of the item were given a score of two points with responses which demonstrated a partial understanding of the item being awarded one point, as indicated by the pre-determined response on the interview sheet. Incorrect responses or responses that indicated no understanding were recorded in written form verbatim for analysis of the student’s understanding. A zero score was given for students who gave no response to the item, who said, “I don’t know” or “Pass,” or shrugged their shoulders, or gave any other incorrect response or answer.

The complete interview, including questions and directions, can be found in Appendix G.

### **3.5.3 Past NAPLAN questions**

As noted in the literature review, some data were available at the national level as to students' performance on NAPLAN items dealing with time (see Appendix A). It seemed useful to use at least some of these items in the study. The author obtained approval from the Australian Curriculum, Assessment and Reporting Authority (ACARA) to access and use past NAPLAN numeracy test papers for the purposes of this research and to publish up to six (6) test items in this research project.<sup>4</sup> The six multiple-choice NAPLAN items included both words and images. Copyright for two of the images was owned by another party, so for these two items the text remained and the researcher introduced her own images that were analogous to the originals.

The six NAPLAN items were given to the students on two occasions; at the commencement of the eight-lesson intervention (15 October) and again four weeks after the conclusion of the lesson intervention (30 November). On the first occasion, the NAPLAN items were presented to the class at the end of the first intervention lesson. Timetabling the NAPLAN items at this time occurred due to the difficulty in gaining access to the whole class prior to the intervention, whereas the interviews were conducted at negotiated times. The positive relationship between the researcher and the classroom teacher allowed a compromise to be reached. On the second occasion, the NAPLAN items were presented to the class at the end of a regular mathematics lesson at a mutually convenient time for the classroom teacher and the researcher. Student performances on these NAPLAN items are discussed in detail in sections 4.5 and 5.3.

### **3.5.4 Rich assessment tasks**

Rich assessment tasks were discussed in section 2.12.4.3. The rich assessment tasks and lessons used in this project were developed and informed by the pilot data and the first round of interviews in line with the design research approach of assessment and review. The tasks are placed in this section as they are a part of the methodology and are described more fully in

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<sup>4</sup> The following note needs to be included as part of the permission given by ACARA to use any NAPLAN items. 'ACARA does not endorse any research paper that uses ACARA's material or make any representations as to the quality of such paper. Any paper that uses ACARA's material should not be taken to be affiliated with ACARA or have the sponsorship or approval of ACARA. It is up to each person to make their own assessment of the research paper.'

Chapter 5, the post-intervention results chapter. The rich assessment tasks were used in the intervention as another means of reviewing student understanding of lesson content. During the intervention, students were given tasks that allowed them time and flexibility to demonstrate their skills and understandings (Brown & Hodgen, 2010) with the use of open-ended, non-standard problems promoting inventiveness and creativity (Foster, 2013). Clarke (2000) listed several advantages to using rich assessment tasks to assess learning including the engagement of the learner, the use of a range of methods and approaches which encourage students to demonstrate their understanding of their learning, and the use of one task to assess a range of outcomes.

#### ***3.5.4.1 Rich assessment tasks incorporated into lessons***

An outline of the rich assessment tasks incorporated into four of the lessons, how they were developed, why they were used, and the benefits/disadvantages of each one are described in the next few paragraphs. Details of each lesson can be found in Chapter 5.

The first task was a ‘think, pair, share’ activity. There were three stages to this task, the first of which was thinking. The students had think about time and what they knew about time. They began with the phrase, ‘*Time is*’ and either finished the sentence or wrote some words they knew about time. The second stage involved the students forming pairs to read their sentence or words to a partner. The final stage was to share. The paired students shared their thoughts (words and phrases) with the whole class. Working in small groups, the students sorted their words and phrases into groups with a degree of commonality.

This task was developed to determine the students’ prior knowledge of the language of time. Other benefits included observing the students as they worked and allowing them the opportunity to talk amongst themselves to discuss their findings, although this benefit was tempered by the culture of a quiet classroom where students were encouraged by their classroom teacher to work quietly without much noise.

Throughout the intervention, the students were encouraged to review their knowledge and understanding of new words, such as succession and duration, by reading classroom displays of words, participating in discussions of past lessons, and using the words in their classroom conversations. To ascertain whether the students’ knowledge of the language of time had increased during the intervention, a post-intervention assessment task using the same stimulus of ‘think, pair and share’ was completed. As one review of the students’ learning, a comparison was made between the numbers of words written on each occasion. To compare the students’ prior knowledge of time words with their final list, a chart listing each student’s words under



the headings Succession, Duration, Measurement and Additional words was compiled for both lessons.

The second rich assessment task was the stimulus for a lesson to encourage the more capable students to use their knowledge from earlier lessons to measure and record 15 minutes. (A review of the previous lessons indicated that not all students were yet able to measure minutes.)

The students who undertook this rich assessment task were introduced to the expression “15 minutes of Fame.” They were informed that everyone in the classroom could become famous for 15 minutes. At first the students had to work in pairs to consider how they could measure fifteen minutes. Focus questions, including the following examples, were designed to stimulate their thinking.

- How many different ways can you measure 15 minutes? Hint: There are a lot of different starting points.
- Will everyone have their chance to be famous on the same day?
- What time will you start the ‘famous day’?
- Will some people be famous together or will everyone be famous on their own?
- What can a student do in 15 minutes to be famous?
- Will your timetable give the teachers 15 minutes of fame?

This task was developed to capture the interest of the students to measure and count intervals of 15 minutes. Becoming famous is often seen as attractive by this age group. Ideally, all the students would have been given this task but due to the limited number of lessons, half of the class were involved in a different activity that met their needs at this time. Working in small groups permitted a lot of discussion and ideas to circulate but meant that the assessment of the students was as a group.

The third rich assessment task was given to the students as a means of assessing their learning over the intervention period. At the conclusion of the intervention, each student wrote a letter to an adult of their choosing to explain what the students had learned during the classes on time. Allowing the students to select the recipient of their letter encouraged personal reflections to be made on their letter as each student was writing to a person who had not been in the classroom during the intervention. This task was selected to gain an insight into the elements of the intervention that the students considered important and to ascertain what they had remembered. A selection of letters from the sample group of students can be found in section 5.2.7.5.

### 3.5.5 Self-reflections

Self-reflections were written by each of the students at the conclusion of each lesson. These reflections gave the researcher an additional opportunity to review the students' learning and make changes to the ensuing lesson in line with design research. To develop interest in writing a self-reflection on their learning, prompts were given as a starting point to writing. Writing their thoughts at the end of a mathematics lesson was a novel concept for the students with several students being challenged by the task and hence writing very little. Nevertheless, what the students did write was of benefit for the researcher in assessing the outcomes of each lesson in that together the self-reflections supplemented the information gained from listening to the students' discussion as they undertook tasks.

#### 3.5.5.1 Self-reflection tasks

An outline of the self-reflection tasks incorporated into the eight lessons followed by an explanation of how they were developed, why they were used, and the benefits or disadvantages of the self-reflection tasks is given in the next few paragraphs. The self-reflections differed from day to day and were planned to help the students incorporate their ideas and learning from the just-completed lesson with previous lessons.

##### Lesson 1

- Write 4 new words you learned today.
- Write one thing you didn't know before today.
- Write the most interesting idea or thing you learned today.

##### Lesson 2

Complete the following sentences.

- Today I learned ...
- To help me understand time, it is important to know ...
- The most interesting thing in today's lesson was ...
- I would like to know more about ...

##### Lesson 3

Words or phrases were listed under each heading at the beginning of the lesson with additional words added at the conclusion of the lesson in a different colour.

- Words or phrases that we use when we talk about a long time. eg., ages, too long,
- Words or phrases that we use when we talk about a short time. eg., quickly, at once
- Words or phrases that we use for measured durations of time. eg., minute

Any additional thoughts and ideas that you think should be included relating to duration.

#### Lesson 4

This task is named 3, 2, 1.

- List 3 things you remember from this lesson.
- Give 2 examples of what you learnt.
- Write 1 question you have or something you are confused about.

#### Lesson 5

This task is a PMI.

- P = Plus. A Positive comment about your learning or the lesson.
- M = Minus. A negative aspect of the lesson. Something difficult or challenging for you during the lesson .
- I = Interesting. What was interesting or new for you during the lesson?

#### Lesson 6

Students have a few minutes to write what they have learned today. This can be in the form of a diary entry or dot points. Self-reflection may include:

- A new word or idea
- A realisation or clarification
- A different way of solving a problem

#### Lessons 7 and 8

The self-reflections were written into the letters to adults that reflected on the intervention and were used as a rich assessment task (See section 3.5.4).

Each self-reflection task was developed to make the students think about their learning; to consider what they had learned. For the researcher, tasks were designed to find what the students found to be new, interesting or challenging and were used as feedback from the students when the lessons were reviewed. The students' responses were beneficial not only when reviewing the lesson, but what they would like to know was useful information when considering further lessons and discussions. To make the tasks interesting and thought provoking, each self-reflection was presented as a new way to consider their learning. Giving specific directions, such as sentence beginnings, focussed the students' responses to the information being sought. The instructions were designed to be straightforward with only brief responses required, enabling the task to be completed in a few minutes. This was advantageous as each lesson was 90 minutes and at the conclusion of the lesson, the students were keen to have their lunch.

### 3.5.6 Informal assessment

Informal assessment was discussed in section 2.12.4.5, with examples given to demonstrate the usage of this mode of assessment by teachers in the classroom. As described in Chapter 2, teachers assess their students informally in a number of ways, such as anecdotal records, observing the students as they complete tasks, and recording notes in checklists and journals.

While the assessment in this study largely involved one-to-one interviews with additional assessment provided by rich assessment tasks and self-reflections, teacher/researcher observations were also taken as an informal form of assessment. The purpose of the observations was to gather information about processes operating in the classroom (Mertens, 2010; Patton, 1987), including the students' work habits, their engagement with the classroom teachers and peers, and their response to the researcher. Observations became important sources of data including descriptions of activities and people participating in the research, and the meanings attached to these activities gained through first-hand experience (Patton, 1987). The students' responses to tasks gave the researcher both an insight into the ways each student was constructing knowledge and valuable information for planning the next lesson.

The degree to which the teacher/researcher interacted with the participants as an observer varied. Lodico et al. (2010) identified four ways in which an observer can observe a group, some of which were not possible for this research: Neither becoming a *complete participant* who is secretly immersed in the group to gain an insider's viewpoint, nor a *participant as observer* actively participating in a group which is aware of the observer's role was possible as the teacher could not pose as a student. However, as a teacher, the researcher was able to be an *observer as participant* restricting the number of interactions with the participants, as observations were noted during small group and individual activities when the teacher/researcher discussed the students' actions and responses with them or a *complete observer* remaining as uninvolved and detached as possible while observing the students as a whole group, in small groups or working individually.

Regardless of which role was selected, there were advantages to gathering data by way of observation. By being in the field, the researcher as observer and teacher knew and understood the context, gained direct experience, became aware of events and situations that may not be obvious to the participants, familiarised herself about matters that participants were unwilling to discuss, moved beyond the selective perceptions of others, and added to her resources personal knowledge and direct experience (Patton, 1987).

### ***3.5.6.1 Informal assessment undertaken***

Observations included behaviours and comments of several students as they undertook tasks and activities and the researcher/teacher's behaviours and comments in response (Lodico et al., 2010). It was not considered necessary to make observational notes on every student during every lesson, but for some students additional information was gained from observing them as they attempted and completed tasks, asked questions or displayed reluctance to respond to a given task. As the researcher undertook the role of the teacher she became an observer as participant with limited interactions with the students or a complete observer observing the students as they completed tasks. All the interactions with students were audio-recorded with notes being made at the end of the lessons when the audio-recordings could be re-played.

To give more context to these informal assessments, some examples from just three lessons are given here.

#### **Example 1. Lesson 3**

Students were given small battery clocks to explore. They were instructed to watch the clock to observe the measurement of one second (and later one minute) and to experiment with what they could do in one second (and one minute). The use of working clocks enabled the students to observe and appreciate the passing of time, and to be more engaged in the task. This task was designed as an assessment as learning in which students could reflect on their own progress (see section 2.12.3). Observations were made regarding the students' responses to questions about the working clocks to ascertain their familiarity with these tools.

#### **Example 2. Lesson 4**

Measuring hours on a timeline. Each student was given a prepared timeline of a 24 hour day with each hour of the day shown on the timeline. Each student was required to complete their timeline by placing the events that occurred during their day above the times written across the length of the day, including the hours of sleep. This task gave the students an opportunity to talk about their learning. Audio recordings of students comparing, for example, the number of hours in a day they spent at school including after school care, and the number of hours they spent sleeping were transcribed for further consideration.

#### **Example 3. Lesson 5**

Building a clock on the floor. The students who had experienced difficulty with clock times were given the task of constructing a clock on the floor as a more meaningful task than drawing a clock. The students were able to assist each other to place the numbers and minute lines in

position. The numbers were on laminated cards, coloured pencils were used as the minute lines and adjustable walking sticks became the hands. The researcher was able to observe the students who were experiencing difficulty more closely when working on the floor with them.

### **3.5.7 Data collection methods that were available but not selected**

There are always additional methods for collecting data that may have been selected but were not considered appropriate by the researcher. In this study, pencil and paper tests additional to the NAPLAN tests could have been used as pre or post assessments during lessons. While the six NAPLAN items given to the students brought out some information regarding the knowledge children have of temporal concepts, there is evidence to suggest that at least some students can give correct answers in mathematics tests but actually have limited understanding of the concepts being measured (Clements & Ellerton, 1995). To answer the research questions, it was important to delve deeper into the children's understanding. In this study, the use of further pencil and paper tests was considered limiting in the information that would be gained from the students when compared with a one-to-one interview, rich assessment tasks, self-reflections and informal assessments tasks.

### **3.6 The Eight-Lesson Intervention**

The eight-lesson intervention was consistent with design research methodology in which theoretical principles contribute to learning and classroom lessons contribute to practice (Brown, 1992; Design-Based Research Collective, 2003). The principal of the school supported the intervention with lessons planned in collaboration with the classroom teacher. The intervention, consisting of eight lessons of 90 minutes (11:30 am until 1:00 pm), was implemented in the classroom during the regularly timetabled period for mathematics.

It was intended that four lessons would be taken per week, allowing the eight lessons to be completed over a two week period, but the inclusion of extra-curricular school programs such as swimming lessons and the Year 4 school camp into the school week extended the intervention by several days (see Table 3.2).

Each lesson was planned and implemented by the researcher taking the role of the classroom teacher in the students' classroom. The classroom teacher was present as an observer during each lesson, taking the role of assistant to the researcher when required. In her role as an assistant, the classroom teacher could supervise a small group as a task was completed, but the giving of instructions for each task, the implementation of the task, and the assessment were the responsibility of the researcher/teacher. Details of the eight lessons are given in section 5.2.

Table 3.3  
*Classroom Intervention Timetable*

Date	Lesson
Thurs 15/10/15	1. Talking about time.
	Swimming lessons. Fri 16/10/15
Mon 19/10/15	2. Round and round we go.
Tues 20/10/15	3. Tick. Tock.
	Grade 4 camp. Wed 21/10/15 - Fri 23/10/15
Mon 26/10/15	4. Make my day.
Tues 27/10/15	5. Fifteen minutes of fame.
	Swimming lessons. Wed 28/10/15
Thurs 29/10/15	6. Many happy returns.
Fri 30/10/15	7. Tomorrow is another day.
Mon 2/11/15	8. From time to time.

The class comprised 30 students. Three students did not participate in the study as informed consent was not obtained from their parents. These three students participated in mathematics lessons in another Year 3 and 4 classroom during the intervention lesson times. Thus 27 students participated in the lessons and participated in the one-to-one interview before and after the intervention. The participants comprised 14 Year 3 students (five girls and nine boys) and 13 Year 4 students (six girls and seven boys).

### 3.7 Data Collection Tools

A listing of the data collection tools, with a brief outline of the data collected and the focus of the data, matched to the research questions, is provided in Table 3.4.

#### 3.7.1 Audio-recording

Each interview was audio-recorded to ensure accuracy when transcribed. Audio-recordings were downloaded to confidential computer files that could be re-played as necessary. The date and time of each recording was matched to the hard copy of interview and coded with the student's pseudonym to maintain confidentiality.

The wearing of the audio-recorder by the researcher as teacher allowed for anecdotal data to be collected, although the recordings of students as they worked was limited to the students who were near to the researcher/teacher as the time of the recording. Despite the limitations of the recordings of lessons, important data were collected and downloaded onto the computer to be re-played for analysis after the lessons.

Table 3.4

*A Summary of Data Collection Tools and Data Collected in This Study*

Research sub-questions	Data collection tool	Data collected	Focus
What are the major Components of a clear understanding of time?	Literature review	Peer reviewed articles identifying major Components and key ideas of time.	Peer-reviewed research on the development of time concepts.
How can children's developing learning and understanding of time be assessed?	One-to-one interview	Recorded responses from participants to items on the one-to-one interview.	Student's responses to items (verbal and physical, e.g., pause before response given, shrugging of shoulders.)
	Past NAPLAN questions	Responses to six NAPLAN items.	How many items are correct? Which items are correct?
	Rich assessment tasks	Students' writing and drawings. Recorded conversations with students.	Written and verbal responses to activities undertaken by the students during lessons.
	Self-reflections	Each child's self-reflection. Student letters describing their learning.	Responses to self-reflection stimulus questions for each lesson. Time words in letters.
What are middle year primary school students' understandings of time?	Informal assessment. Observations taken as the participants work in the classroom.	Anecdotal notes. Work samples/ classroom artefacts. Recorded dialogue between students and teacher.	Motivation, attitude to tasks, suitability of tasks.
	One-to-one interviews. Past NAPLAN items.	Recorded questions by the interviewer and responses from participants.	Analysis of each student's interview responses.
What classroom experiences and pedagogies might best assist children's development when learning about time?	Lesson plans, field notes. Intervention lesson review. Audio recording of intervention lessons. Notes made during and after each lesson.	Lesson plans, field notes. Notes on lessons. Transcription of recorded data from lessons. Classroom observations and field notes.	Children's literature. Physical involvement. Manipulative resources. Language/terminology. Group work/discussion Self-reflections.



### **3.8 Data Analysis**

“Data analysis is the process of making sense out of the data” (Merriam, 2009, p. 175). While several guidelines exist for the interpretation of qualitative data, no single procedure determines the process, leaving the researcher to be guided by their own perspective to interpret and analyse the data (Creswell, 2005). In keeping with qualitative studies, the data collection for this study was varied and continual. It is recommended that data be analysed simultaneously with the data collection, with iterative phases of collection, and analysis (Creswell, 2005; Lodico et al., 2010; Merriam, 2009; Mertens, 2010). This was the case for this study, as data were analysed as they were collected from the two interviews with the students and the eight-lesson intervention. The following sections detail how the data were analysed to answer the research questions.

#### **3.8.1. One-to-one task based interviews**

The first set of data to be collected came from the one-to-one task based interviews. As explained in section 3.4.2.3, each child’s response to an item was coded as 2, 1, 0. Each student’s score for each item was then entered onto a spreadsheet with each student listed horizontally across the top and each interview item listed vertically down the left side. Scores were tallied for each student (vertically) and for each item horizontally. These tallies enabled comparisons between students and between items. Separate spreadsheets were also constructed for all the Succession items, the Duration items and the Measurement of time items, so that comparative scores could be analysed for each major Component. After the post-intervention interview, spreadsheets were constructed as above using the data from both interviews.

In order to determine whether changes in students’ performance from the pre-intervention interview to the post-intervention interview were statistically significant, several statistical tests were conducted. As these data were not normally distributed, non-parametric tests were utilised.

#### **3.8.2 Past NAPLAN items**

For each NAPLAN item a student’s response was graded as either correct or incorrect. This enabled tallies to be made for individual items and individual students. Once again, appropriate statistical tests were used to determine the significance of these differences. As the data did not meet normality requirements on either occasion (Shapiro Wilk statistics .862 and .827,  $p = 0.003$  and  $p = 0.001$ , respectively), a Wilcoxon Signed Ranks Test was used to determine whether there were significant differences in performance from October to November. Results of the statistical tests can be found in section 5.5.

### **3.8.3 Rich assessment tasks, self-reflections and informal assessment**

While data from rich assessment tasks, self-reflections and informal assessment were not as substantial as the interview data, they nevertheless complemented those data. As an example of the analysis of data arising from a rich assessment task, the lists of words and phrases compiled by the students after the ‘think, pair, share’ activity (referred to in 3.4.4.1.1) in lesson 8 were compared to the list of words and phrases compiled in lesson 1. Responses to the self-reflections such as the letters written by the students in lesson 7 were coded for references to the major Components and key ideas of the Framework. In each case differences in the students’ writing, from early in the teaching sequence to later in the teaching sequence in terms of the sophistication of their understanding of the major Components, were noted.

### **3.8.4 Summary of data analysis**

Data were analysed both quantitatively and qualitatively as indicated in Figure 3.1. Non-parametric tests were used to determine the statistical significance between the pre- and post-intervention interviews, and between the first and second NAPLAN results. Pre-intervention interview results were compared with post-intervention interview results as a means of assessing student growth in learning over the period of the intervention. In addition, correlations between the variables were computed, in order to examine a measure of association between the variables. Table 3.5 details how the data collected from this study were analysed.

## **3.9 Trustworthiness**

Researchers need to explain the steps taken throughout their study to check for accuracy and credibility of their findings (Creswell, 2014; LeCompte & Goetz, 1982) in order to produce valid and reliable results (Merriam, 2014). Maxwell (2005) describes this process as “looking for evidence that could challenge your conclusions or make the potential threats implausible” (p. 109). Internal validity, external validity, reliability and objectivity, appropriate criteria to ascertain trustworthiness in quantitative research, have been described as unworkable for constructivist approaches (Guba & Lincoln, 1989; Lincoln & Guba, 1985). With various types of quantitative research being undertaken, alternative criteria to describe validity and reliability have emerged (Flick, 2006; Merriam, 2009). For this study, the concerns regarding trustworthiness have been addressed under the criteria suggested by Lincoln and Guba (1985), namely credibility, transferability, dependability, and confirmability. These criteria, discussed in detail below, were developed to parallel the conventional criteria of internal validity, external validity, reliability and objectivity with adjustments made to suit the requirements of constructivist epistemology (Guba & Lincoln, 1989).

Table 3.5  
*Analysis of Data*

Data	Analysis
Responses to one-to-one task based interview items in relation to the Framework.	<ul style="list-style-type: none"> <li>• Each student’s responses scored according to the criteria for each item: two points for a response that demonstrates a full understanding, one point for a response that demonstrates a partial understanding and zero points for a response that indicates no understanding.</li> <li>• Spreadsheet of results from all students showing the number of 2, 1, and 0 scores for each item for all items.</li> <li>• Spreadsheet of results from all students showing number of 2, 1, and 0 scores for each Succession item.</li> <li>• Spreadsheet of results from all students showing number of 2, 1, and 0 scores for each Duration item.</li> <li>• Spreadsheet of results from all students showing number of 2, 1, and 0 scores for each Measurement item.</li> <li>• Statistical analysis of all interview items with additional analyses of succession, duration and measurement items using Shapiro Wilks test and Wilcoxon signed ranks test.</li> <li>• Spreadsheet showing comparison scores from interviews 1 and 2.</li> <li>• Spreadsheets showing comparison scores from interviews 1 and 2 for succession, duration and measurement.</li> </ul>
Past NAPLAN items.	<ul style="list-style-type: none"> <li>• Spreadsheet showing scores for each item for all students.</li> <li>• Spreadsheet showing comparison scores from NAPLAN 1 and NAPLAN 2.</li> <li>• Statistical analysis of scores using Shapiro Wilks test and Wilcoxon signed ranks test for NAPLAN 1 and 2.</li> </ul>
Rich Assessment tasks Task 1. Lessons 1 and 8. This task was a ‘think, pair, share’ activity. Time is... Task 2. Lesson 5. Students were introduced to the expression “15 minutes of Fame”. Task 4. Lessons 7 and 8. Letters to an adult.	<ul style="list-style-type: none"> <li>• Assessment of vocabulary.</li> <li>• Class list of known words compiled.</li> <li>• Individual word lists compared at end of lessons.</li> <li>• Words listed relating to succession, duration etc.</li> <li>• Collected timetables.</li> <li>• Notes on timetables re: how timetables were arranged. Looked for starting and finishing times. (on the hour?)</li> <li>• Accuracy of timetables.</li> <li>• Listed key words from letters.</li> </ul>
Self-reflections Lessons 1 to 8.	Record responses to self-reflections. <ul style="list-style-type: none"> <li>• Responses indicating new learning.</li> <li>• Responses indicating challenges.</li> </ul>
Informal assessment.	Record: <ul style="list-style-type: none"> <li>• Responses indicating new learning.</li> <li>• Responses indicating challenges.</li> </ul>

### **3.9.1 Credibility**

The credibility criterion is seen as parallel to internal validity by Lincoln and Guba (1985) and is concerned with matching the research findings to reality (Merriam, 2009). Merriam (2009) described qualitative research as an investigation into how people construct reality to understand the world; with the researcher accessing this reality through observations and interviews. Internal validity emphasises the truthfulness of the research report (Lewis, 2009). There are several techniques to ensure findings are credible, including prolonged engagement and persistent observation in the field, triangulation, peer debriefing and reflexivity (Lincoln & Guba, 1985; Merriam, 2009).

#### ***3.9.1.1 Prolonged engagement and persistent observation***

Prolonged engagement aims to overcome the effects of misinformation and distortion, to establish a rapport, to build trust and facilitate immersion into the culture of the site (Guba & Lincoln, 1989). Spending prolonged time in the field can assist the researcher to develop an in-depth understanding of the phenomenon (Creswell, 2014; Lewis, 2009). The week prior to the commencement of the interviews, a meeting was held with the classroom teacher. The first interviews began 2 September, 2015 before the eight-lesson intervention with the second interviews completed 27 November, 2015. The researcher was in the school for over 12 weeks meeting with the classroom teacher, conducting interviews and teaching the eight lessons of the intervention and reinterviewing the students. In this time, she became a familiar figure within the school and an accepted member of the school community.

#### ***3.9.1.2 Triangulation***

Triangulation is the cross checking of data collected at different times or at different places (Merriam, 2014), reducing the distortions that can arise from using only one method (Maxwell, 1998). The essential idea of triangulation is to find multiples sources to draw upon to confirm a conclusion (Willis, 2007). Multiple sources can take the form of different methods such as interviews, observations and testing (Lincoln & Guba, 1985). Willis (2007) noted that although methodological triangulation involved across three data collection methods such as interviews, observations and life histories, triangulation “can also be done across sources of information ... across settings ... across theories ... across researchers, and across studies” (p. 219).

To provide an admittedly limited comparison, the overall percentage scores of the Year 3 and 4 students to the first one-to-one task based interview were compared to the students’ responses

to six past NAPLAN items and to the State and National scores for NAPLAN items from 2008 until 2015.

### ***3.9.1.3 Peer debriefing***

Guba and Lincoln (1989) describe peer debriefing as engaging with a disinterested peer, with no contractual interest in the situation. Aspects of the inquiry are explored, such as biases, meanings and interpretations (Lincoln & Guba, 1985; Maxwell, 1998), and questions are posed to assist the researcher (Guba & Lincoln, 1989).

This study has been overseen by three supervisors who have guided the development of the Framework, the interview and the lessons. They have also been instrumental in the researcher submitting three conference papers to an Australasian conference.

Aspects of this project has been externally reviewed by nine or ten independent reviewers. Two papers based on this study were peer reviewed and accepted for presentation at the 2016 annual conference of the Mathematics Education Research Group of Australasia and publication in the conference proceedings (MERGA) (Thomas, Clarke, et al., 2016; Thomas, McDonough, Clarkson, & Clarke, 2016). A third paper was peer reviewed and presented at the 2017 annual conference of MERGA as the winner of the Beth Southwell Practical Implications Award, an award granted jointly by MERGA and the Australian Association of Mathematics Teachers (AAMT) (Thomas, Clarke, McDonough, & Clarkson, 2017).

### ***3.9.1.4 Reflexivity***

Reflexivity, or the researcher's position, is the process of the researcher reflecting critically on their role as a researcher "to explain their biases, dispositions, and assumptions regarding the research to be undertaken" (Merriam, 2009, p. 219). The nature of this study made it open to bias as the researcher was the sole interviewer, the teacher and the assessor of the students' responses to interview items and classroom activities. As the researcher has a teaching background, it was not possible to eliminate her theories and beliefs, but identifying the ways in which the researcher's values and expectations could influence the study assisted in avoiding any negative conclusions (Maxwell, 2005). Clarification of any bias by way of self-reflection "creates an open and honest narrative that will resonate well with readers" (Creswell, 2014, p. 202). Strategies were put into place to reduce the possibility of bias toward any student such as:

- The responses for each interview item that would score 2, 1 or 0 were reviewed by the researcher and her supervisors several times to ensure that a student's response could only match one of the three statements.

- As the teacher, the researcher developed a rapport with the students in the classroom but at the same time maintained an appropriate professional distance from the students. The intervention lessons were enhanced by the students responding to the teacher/researcher in the same manner as their classroom teacher.

### **3.9.2 Transferability**

A naturalist or constructivist inquiry is dependent on the time and context of the study making the generalisability of the results difficult to specify (Lincoln & Guba, 1985). A strategy used to establish a degree of transferability is for the researcher to provide a thick description; “an extensive and careful description of the time, the place, the context, the culture in which those hypotheses were found to be salient” (Guba & Lincoln, 1989, pp. 241-242).

A rich, thick description of the findings aims to give the reader an understanding of the setting and to share the experiences with the reader by providing a detailed picture of the investigation (Creswell, 2014; Lewis, 2009; Maxwell, 1998). Detailed descriptions of the setting, the participants, the interview and the lessons are given earlier in Chapter 3. The findings from the study are described in depth in Chapters 4 and 5.

### **3.9.3 Dependability**

Dependability parallels reliability and is concerned with the stability of the data over time as changes in the methodology are indicative of a maturing inquiry (Guba & Lincoln, 1989). Reliability “refers to the extent to which the research findings can be replicated” (Merriam, 2014, p. 220). Reliability is less applicable to qualitative studies than to quantitative studies due to the changeability of human behaviour. In qualitative research reliability is based more on dependability and consistency (Lincoln & Guba, 1985) and asking “whether the results are consistent with the data collected” (Merriam, 2014, p. 221). Strategies that can be adopted to ensure reliability are triangulation, peer examination/review and an audit trail (Creswell, 2014; Lewis, 2009; Merriam, 2014; Willis, 2007). The technique for documenting the dependability of a study is the dependability audit through which the process of the inquiry is examined (Guba & Lincoln, 1989; Lincoln & Guba, 1985). Triangulation has been discussed in section 3.9.1.2, with a description of the peer examination and review undertaken for this study detailed in section 3.9.1.3. Audit trail is discussed under Confirmability, section 3.9.4.

### **3.9.4 Confirmability**

The confirmability of an inquiry is also achieved through the auditing process, but where the dependability audit looks at the process, the confirmability audit examines “the data, findings,

interpretations, and recommendations-and attests that it is supported by data” (Lincoln & Guba, 1985, p. 318). The confirmability and dependability audit were combined in this study and are referred to as the audit trail.

#### ***3.9.4.1 Audit trail***

An audit trail is the documentation and recording of all the raw data, observations and the refinements and changes made throughout the study (Merriam, 2014; Willis, 2007). Throughout this study records were maintained on the following:

- The Framework for the Learning and Teaching of Time. Several versions were compiled before the final version was completed. All versions were retained for reference.
- The one-to-one interview. The first version of the interview was altered several times as items were refined or deleted. All versions were retained electronically. Detailed records, all audio recordings, and the transcribed recordings of all interviews were filed.
- The eight-lesson intervention. Detailed lesson plans were developed, changes to lessons noted and reviews written after each lesson that reflected on the effectiveness of the lesson.

### **3.10 Ethical Considerations**

Qualitative research undertakes the study of people. The participants rely on the ethical standards of the researcher to maintain ethical practice when collecting the data and disseminating the findings (Merriam, 2009). The participants in this study were students from Years 3, 4 and 5 from two primary schools. The researcher strictly adhered to the guidelines of the university’s Human Ethics Research Committee as detailed in section 3.3. All participants in the research were identified only by a pseudonym with the original documents such as permission forms locked in a safe. Information held on the computer is password protected. Permission to conduct research in Victorian government schools was approved by the Department of Education and Training once approval had been gained from the university’s Human Ethics Research Committee (see Appendix C).

### **3.11 Summary of Chapter 3**

In this chapter, the researcher restated the purpose of the study and the research questions. The philosophical stance was outlined and supported by descriptions of the epistemology (constructivism), and methodology (design research). The methods used in the research were

detailed under the heading, Data collection methods. A description of the data collection and analysis was given, and included sections on the pilot study as well as the main study, the collection of the data and the analysis of the data. The credibility, transferability, dependability, and confirmability of the study were clarified. Important ethical considerations were discussed, which included reference to the requirements of the university's Human Research Ethics Committee (HREC) and relevant attachments.

In the next chapter, Chapter 4, the researcher details the results from the study prior to the eight-lesson intervention, with the results of the intervention and data collected after the intervention detailed in Chapter 5.



## **CHAPTER 4. Pre-Intervention Results**

### **4.1 Introduction**

The results from this study are reported in two chapters. This chapter includes data collected prior to the eight-lesson intervention, an explanation of the ways in which these data informed the intervention, and a brief summary of the lessons which formed the intervention. Each section includes a brief explanation of the process by which the data were collected and the reason for the particular data collection, although more detail for this was presented in Chapter 3. Chapter 5 includes data from the intervention and post-intervention student assessments.

Before the commencement of the eight-lesson intervention, two sets of data were collected to evaluate the students' prior knowledge and understanding of concepts of time. The first set of data consisted of the students' responses to NAPLAN items from past years and the second set of data was collected through a one-to-one task based interview.

### **4.2 The Research Questions**

Although detailed earlier, the research questions which gave the reason and context for the data collection and analysis, are for convenience repeated here. The overarching research question is as follows:

What are the major components of a clear understanding of time and how might these components be described, assessed and supported in the primary school classroom?

The research sub-questions are as follows:

1. What are the major components of a clear understanding of time?
2. How can student learning and understanding of time be assessed?
3. What are middle year primary school students' understandings of time?
4. What classroom experiences and pedagogies might support student learning about time?

Prior to the commencement of data collection in the main study, The Framework for the Learning and Teaching of Time was developed and then used to inform the interview development and, subsequently, the planning of the intervention. The Framework is briefly outlined in the next section as it is not only integral to the discussion of the results of the data collection, but is in itself, a result of this study.

### **4.3 The Initial Framework for the Learning and Teaching of Time**

A lack of research into the deep learning and teaching of time was instrumental in the decision to develop a theoretical framework to draw together ideas underpinning the concept of time. The major Components identified from the literature were: an Awareness of time; Succession, the sequential ordering of time; Duration, the passage of time; and the Measurement of time which requires a knowledge of specific units of time and time measuring tools (see Figure 4.1). Double-headed arrows illustrate the inter-connection between each of the four major Components. The dot points listed under each major Component are the key ideas. Each key idea has been identified from the literature as an important aspect of the Component under which it has been placed (see section 2.6).

The development of The Framework for the Learning and Teaching of Time (also referred to as “the Framework”) was integral to the development of the one-to-one interview, as each item in the interview was aligned to one or more major Components in the Framework. Results from the interviews provided information on each student’s understanding of three of the major Components: Succession, Duration and Measurement of time. It was assumed that students in Years 3 and 4 had already developed an Awareness of time and hence this Component was not specifically assessed. Nevertheless, all the items in the interview were in some way related to an Awareness of time.

As the lynchpin of this study, the development of the Framework was an ongoing process, resulting in two major iterations: the initial Framework and the revised and final Framework. Figure 4.1 shows the initial Framework at the time of the interviews and the intervention. A detailed explanation of this Framework can be found in Section 2.6.1, with the revised Framework explained in Chapter 6.

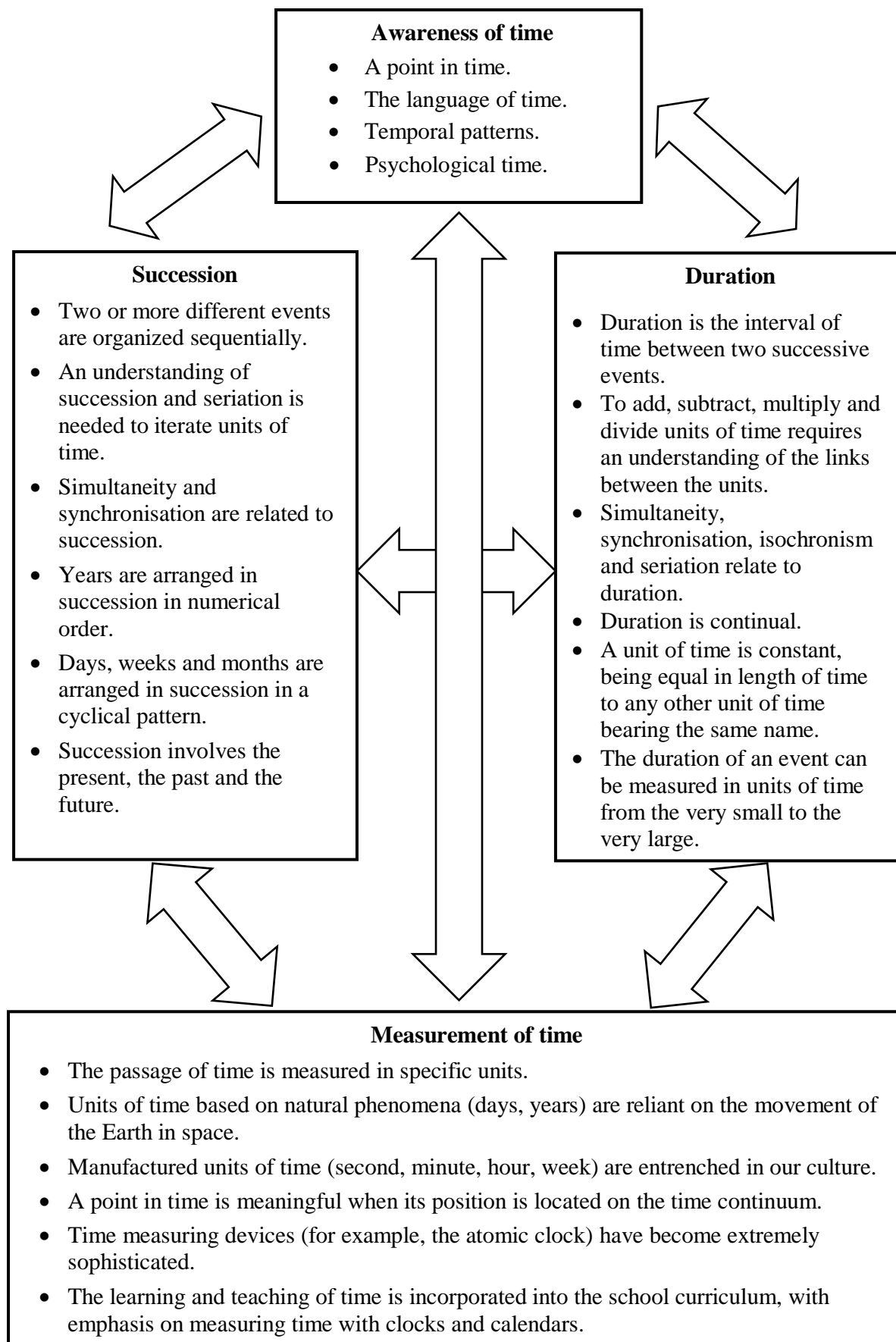


Figure 4.1. The initial Framework for the Learning and Teaching of Time.

The next sections detail the results from the one-to-one task based interviews undertaken before the teaching intervention commenced and results from the pre-test of NAPLAN items which the students completed on October 15, 2015. A brief explanation giving the reasons for the collection of each type of data is given with the results.

#### **4.4 One-to-One Task Based Interview Assessment**

The items in the one-to-one interview were formulated around the major Components of the Framework. The aim of the interview was to assess a deep understanding of the students' knowledge and understanding of the core ideas of time. Three major Components of the Framework, Succession, Duration and Measurement of time, were assessed explicitly. However, an Awareness of Time was deemed to be incorporated into each item and therefore was not assessed separately. The interview comprised 69 items. The detailed process of development of the one-to-one interview was described in Chapter 3 (see section 3.5.2). The results of the 27 students who completed the interview on both occasions are analysed in the following sections.

##### **4.4.1 Pre-intervention one-to-one interview results**

Each student's response to an item was assessed as demonstrating either a full understanding, a partial understanding, or no understanding of the relevant concept or skill. The scoring method was adapted from Clements and Ellerton (1995), whereby for each item 2 points indicated full understanding, 1 point indicated partial understanding, and 0 points indicated no apparent understanding. A number of extensive conversations between the researcher and the three supervisors of this study led to clarity on how each individual item would be scored.

The maximum number of possible points gained by answering all items with full understanding was 138. The maximum points possible for Succession, Duration, and Measurement, were 56, 62, and 98, respectively. Of course, these do not sum to 138 because, as explained in Chapter 3, a given item could be linked to more than one element in the Framework. From a possible score of 138, the students' scores ranged from 48 to 124. There was a mean score of 93.4, and a median score of 96. See Appendix H for individual scores for each student for each interview item.

To ascertain possible strengths and weaknesses, the score for each student was calculated for each major Component of the Framework. These scores, along with the total scores, can be seen in Table 4.1.

Table 4.1  
*Student Scores for Each Major Component in the Pre-Intervention Interview*

Student	Succession (Max. = 56)	Duration (Max. = 62)	Measurement (Max. = 98)	Total (Max. = 138)
01B4	41	34	63	95
02G3	40	33	66	92
03G3	28	13	31	54
04G4	46	47	79	114
05G3	35	33	66	91
06B3	43	43	74	108
07G4	50	51	88	122
08B3	44	43	81	109
09G3	41	33	51	81
10B4	48	54	88	124
11B3	37	36	73	99
12G4	37	31	59	87
13B3	39	30	51	79
14G4	43	37	66	96
15B4	42	45	79	106
16G4	42	43	81	112
17B3	35	33	65	89
18B4	33	43	74	99
19B4	33	35	56	77
20B3	33	29	49	71
21B4	39	38	75	99
22B3	34	35	63	87
23B4	16	20	29	48
24B3	42	43	78	109
25G4	45	42	80	111
26B3	42	32	71	101
27G3	36	18	38	61

The maximum score for the Succession items was 56. Students' scores for the Succession items ranged from 16 to 50, with a mean score of 38.6, and a median score of 40 (see Appendix I for the students' scores for the Succession items from the pre-intervention interview). Student 23, who scored 16, was regarded by the classroom teacher as a special case. He required additional assistance from the teacher for each lesson but the school did not receive funding for an aide to assist him. Without this student's score the mean score for Succession would increase to 39.5 and the median score to 40.5. The difference in mean and median was not considered sufficient to exclude student 23 from the study.

The maximum possible score for the Duration items was 62. Students' scores ranged from 13 to 54, with a mean score of 36.1 and a median score of 35 (see Appendix J for the students'

scores for the Duration items from the pre-intervention interview). Student 23 scored 20, the third lowest score. Student 3 scored 13 and student 27 scored 18.

The maximum score possible for the Measurement items was 98. Students' scores for the Measurement items ranged from 29 to 88, with a mean score of 65.7 and a median score of 66. (See Appendix K for the students' scores for the Measurement items from the pre-intervention interview.) Student 23 scored 29. Although his score was the lowest in the group, his score was only two points less than the next student, indicating that his performance was not substantially different from that of other students.

The spread of scores across all assessed areas of the Framework demonstrated a considerable spread of students' understandings of time concepts within this Year 3/4 classroom. Clearly students had some difficulty with the three major Components of the Framework that were assessed. These results informed the careful planning of the intervention lessons. The following analysis shows how this was accomplished.

#### 4.4.2 Items linked to the Framework's major Components and key ideas

It will be recalled that for each of the major Components of the Framework, a number of key ideas were listed that elaborated each Component. To gain a clear picture of what the students understood about each major Component, the interview items were designed to assess the understanding of each of the key ideas of the Framework. Tables were created in which each interview item was placed under the key idea the item was designed to assess. Multiple items covering a wide range were selected to gain a deeper understanding of the students' knowledge and abilities of each key idea within the major Components being assessed. As an example, Table 4.2 shows the items assessing one of the key ideas within the major Component Succession. The first column shows the number of the item from the interview with the item itself shown in the second column.

Table 4.2

*Items Linked to the First Key Idea Within the Major Component Succession*

<b>The relationship between units of time need to be understood to solve problems of succession.</b>	
<b>19</b>	What year were you in Prep?
<b>21</b>	How many days are in a week?
<b>23</b>	How many months are in one year?
<b>34</b>	Today's date is the..... (Give the date as the day number, the month and the year. For example, today's date is the 29 <sup>th</sup> of July, 2015.) What will the date be two years from now?
<b>35</b>	Show student the card with 24/9/2015 written on it. When people write the date like this, what do the different numbers mean?

To obtain some indication of students' understanding of each major Component, such as Duration, a score was calculated for each key idea within that major Component by adding the scores for the relevant items. Table 4.3 shows the items associated with one Duration key idea '*Duration is the interval of time between two successive events*'. The first step in this process is shown in the first row of Table 4.3. This row shows the calculation for item 2. Ten students scored 2, 11 students scored 1, and 6 students scored 0, thus giving a total classroom score of  $(10 \times 2) + (11 \times 1) + (6 \times 0) = 31$ . The classroom scores for each item dealing with this key idea were totalled as shown in the second last row of Table 4.3. Finally, these classroom scores were converted to percentages as shown in the last row of Table 4.3. Converting the total classroom scores to percentages gave a broad indication of the degree of difficulty of each key idea and ultimately, the more challenging aspects of each major Component of the Framework.

Table 4.3

*Interview 1 Items Assessing the Duration Key Idea "Duration is the Interval of Time Between Two Successive Events" Showing Frequency of 2s, 1s and 0s and Classroom Scores*

Item no.	Item	Scores of			Total
		2	1	0	
2	Today is Wednesday*. When did Wednesday* start? *State the actual day you are talking to the student.	10	11	6	31
3	When will Wednesday* finish?	3	13	11	19
6	Think about recess and lunchtime. Is recess longer or shorter than lunchtime? How do you know that your recess play is shorter/longer?	19	6	2	44
42	How long does it takes for the minute hand to go once around the clock?	18	0	9	36
44	How long does it takes for the hour hand to go once around the clock?	11	3	13	25
Frequency of 2s, 1s and 0s		61	33	41	155
Percentages (to the nearest whole number)		45	24	30	

These scores enabled comparisons to be made between items, with lower scored items being seen as more challenging than higher scored items, and therefore worthy of consideration in relation to the intervention lessons. The benefit of having multiple items to assess each key idea is evident when examining the individual item scores. While each item assesses the same key idea, the number of responses showing full understanding range from 3 (item 3) to 19 (item 6), demonstrating that no individual item alone fully reflected the one key idea. The total for each column, given as a percentage, as seen in the final row of Table 4.3, shows that fewer than half of the responses (45%) indicated a full understanding of the items relating to this key idea and

30% of responses gained zero points. All key idea tables for the three major Components assessed in the pre-intervention interview can be found in Appendix L.

Table 4.4 shows the complete assessment of all the Duration key ideas. To develop an overall comparative score for a key idea of the Framework, the scores for 2, 1 and 0 for each key idea were added and converted to percentages. Each percentage was calculated by dividing the number of responses for a particular score by the maximum possible score and multiplying the result by 100. For example, for Duration, 409 responses gained 2 points from a maximum possible score of 837 (31 items  $\times$  27 responses); a total of 49% of all the responses. Possible strengths and weaknesses could be determined by the percentage of 2 point responses for each key idea.

Table 4.4

*Interview 1 Frequencies for the Key Ideas under the Framework Component Duration.*

Duration key idea	Scores of		
	2	1	0
Duration is the interval of time between two successive events.	61	33	41
To add, subtract, multiply and divide units of time requires an understanding of the linkages between the units.	103	11	21
Simultaneity, synchronisation, isochronism and seriation relate to duration.	76	21	38
Duration is continual.	54	25	56
A unit of time is constant, being equal in length of time to any other unit of time bearing the same name.	73	19	43
The duration of an event can be measured in units of time from the very small to the very large.	42	48	45
Rotation and revolution of the Earth.	0	6	21
Total Duration responses scoring 2, 1 and 0	409	163	265
Total Duration responses scoring 2, 1 and 0 as a percentage (to nearest whole number)	49	19	32

Table 4.4 demonstrates that in the pre-intervention interview, 51% of all responses to Duration items did not satisfy the requirements for a full understanding, thereby indicating that the intervention lessons needed to encompass tasks and activities related to Duration to consolidate the learning of time. Tables showing the frequencies for the key ideas under each Framework major Component that was assessed can be found in Appendix M.



In Table 4.5, the percentage scores are shown which give an overall picture of the whole group. The percentage of responses that scored 2 points, 1 point or zero points in the pre-intervention interview indicate some degree of uniformity of understanding between the major Components.

Table 4.5  
*Percentage of Interview 1 Responses Scoring 2, 1 or 0*

Major Component from the Framework	Scores of		
	2	1	0
Succession	60	23	17
Duration	49	19	32
Measurement	59	16	25

While the individual interview scores illustrated strengths and weaknesses for each student, the group scores demonstrated the areas of concern for the class of students as a whole. The percentage of 2, 1 and 0 scores to all items in the pre-intervention interview show that 40% of the students' responses for the Succession items, 51% of the students' responses for the Duration items and 41% of the students' responses to the Measurement items did not satisfy the requirements for 2 points (a full understanding).

#### **4.4.3 Review of interview data**

The scores from the one-to-one interview (see Appendix H) showed that all students participating in the study found some items in the interview challenging. Scores ranged from low to high across all the major Components of the Framework. For example, the notion of time being in some way connected to the movement of the Earth around the Sun appeared to be a novel idea for almost all (78%) of the students. The reading of clocks and calendars is an important area of the *Australian Curriculum: Mathematics* (ACARA, 2016c), with specific mention made to telling the time and reading a calendar (as discussed in section 2.7.2), so it was interesting to see that 25 per cent of the Measurement responses were scored zero. The way in which the data from the one-to-one interview informed the planning of the eight-lesson intervention is outlined in the next section.

#### **4.4.4 Most challenging items**

To plan potentially effective lessons for the students, it was necessary to ascertain what key ideas of the major Components of the Framework were most challenging for students, and which would need particular attention. As each item was aligned with one or more major Components, ascertaining the key ideas that needed attention was achieved by identifying the

most challenging items of the interview. This was obtained by adding the scores for all students' responses (2, 1 or 0) for each interview item. The maximum score for an item was 54, which would be obtained if each of the 27 students scored 2. The researcher decided to make the focus of the lessons the mathematics underpinning those items for which the total score from the class was less than 75% of the maximum possible score. This equated to a raw score of 40 or less from a maximum possible score of 54. The items which scored 40 or less are shown in Table 4.6, alongside the score and the number of the lesson in which this concept was a focus (see Appendix N for the complete list of items and scores). Although 75% was a somewhat arbitrary figure, it indicated those key ideas for which improvement was desirable and hopefully achievable.

Although the interview items which scored 40 or less were spread across all key ideas from the three major Components assessed, the results for each key idea were unequal. The more challenging Succession items related to ordering events sequentially, iterating units of time, and understanding simultaneity and seriation. Challenging Duration items related to duration of time between successive events, the measuring of duration using the hands of a clock, and simultaneity and seriation. The concept that time is measured challenged many students. Other challenging Measurement items related to the relationship between the movement of Earth in space and the Measurement of time, converting between units of time, and the use of clocks and calendars to measure time.

The eight-lesson intervention was planned to incorporate activities that would focus on the concepts that had been identified as the most challenging for the students. The planning of the lesson intervention is explained in more detail in section 4.6.

#### **4.5 NAPLAN Assessment**

Australian students are assessed on their mathematical and numeracy competencies with annual NAPLAN tests being undertaken by students in Years 3, 5, 7 and 9 (ACARA, 2011). In the present study, six NAPLAN items from past test papers for Year 3 were given to the students in the Year 3/4 class (see section 3.5.3 for details) at the end of the first lesson of the intervention, which occurred on October 15, 2015. The students' responses to the NAPLAN items were collated as one source of information regarding the students' prior knowledge of curriculum items, and to further inform the sequence of lessons which were primarily based on the one-to-one interview responses. As the completion of the NAPLAN items preceded seven of the lessons, the first test of NAPLAN items is referred to as the pre-intervention NAPLAN test.

Table 4.6

*Interview 1 Items Which Scored Less Than 75% Ranked in Order of Points Scored and Related Lesson Number*

Item No	Item	Score	Lesson No
55	What do you know about the rotation and revolution of the Earth?	6	2
36	If you had a calculator, how would you work out your age in days?	10	6
9	Student marked the duration (beginning and end) of each event on the timeline	11	4,5,6
16	Tell me how we use clocks to measure time.	11	1,2,3,4,5,8
1	How do I know it is morning/afternoon?	16	2
17	How can we use a calendar to measure time?	18	2,6,7
3	When will Wednesday* finish?	19	2,4,5
4	Tell me when it is am and when it is pm?	20	2
5	When does am change to pm?	20	4
7	Mark on your timeline when you start lunch and when you finish lunch	20	4
37b	Draw a clock. Minute markers.	21	3,4,5
15	Tell me some other ways or things we use to measure time.	24	1-8
44	How long does it takes for the hour hand to go once around the clock?	25	4,5
54d	Calculate the train journey. 1 hour and 52 minutes.	25	3,4
11	Compares activities that take a short and a very short time to do.	26	
12	What units to measure time do you know?	27	3,4
47	Can the length of an hour change? Why? Why not?	27	2-5
32	What was the date exactly one month ago?	29	6
10	Compares activities that take a long and a very long time to do.	29	
51c	Write this digital time as seen on an analogue clock. $\frac{1}{4}$ to 6.	30	3,4,5
48e	Read the time. 7 minutes past 6.	30	3-5,8
48d	Read the time. 25 past 8.	31	3-5,8
14	Estimate 1 minute.	31	3
2	Today is Wednesday*. When did Wednesday* start?	31	2,4,5
24	If I ate the first egg on Wednesday, which day would I eat the last egg?	32	6,7
27	Tell me the full date including the day.	32	6
45	How long does it take for the hour hand to move from the 8 to the 9?	32	3
13	What is the shortest unit of time that you know?	33	
48c	Read the time. $\frac{1}{4}$ to 6.	33	3-5,8
33	If the date is 24 <sup>th</sup> October, what will the date be in 3 weeks?	34	6,7
43	How many minutes does it take for the minute hand to move from 4 to 5?	35	3,5
34	What will the date be 2 years from now?	36	6,7
42	How long does it take for the minute hand to go once around the clock?	36	3
46	What would take about an hour to do?	37	2,3,4,5
51b	Write this digital time as seen on an analogue clock. $\frac{1}{2}$ past 5.	37	4,5,8
26	Place three annual events in order.	38	6
31	What day of the week is the first of next month?	38	7
49	Which time comes first? $\frac{1}{4}$ to 8. $\frac{1}{4}$ past 8.	38	3-5,8
50	10 past 2. What time will it be in an hour?	38	4,5
53c	How long does the train journey take? 2 hours.	39	
19	What year were you in Prep?	40	6

A post-test using the same NAPLAN items was undertaken on November 30, 2015, four weeks after the final intervention lesson was taught; the results of which are provided in Chapter 5. All of the students in the Year 3/4 class (16 boys, 11 girls) attempted the NAPLAN items on at least one occasion. Of the 27 students, 25 attempted the items on both occasions. As no comparisons could be drawn from the results of the two students who attempted the items only once (Students 23 and 26), their data were withdrawn from the following analysis.

#### 4.5.1 Pre-intervention NAPLAN test results

The NAPLAN assessments for all schools are completed in May each year, which meant that all the students had undertaken this assessment once, either during the year of the study or the previous year. Hence it was expected and indeed was the case that all students were quite familiar with the format of the six items they were asked to complete. Students appeared to answer the NAPLAN items quite quickly.

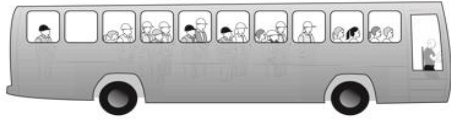
The data reported in Table 4.7 are for the 25 students who attempted the items on both occasions. The students scored 1 for the correct answer and 0 for an incorrect answer. The final row of the table has two entries. The first figure is the total number of students who correctly answered each item. The second figure gives the percentage of students who were successful for each item, rounded to the nearest whole number.

The performance on each of the six NAPLAN items is described below, followed by a summary of student responses.

##### Item 22, 2008

In relation to the Framework for the Learning and Teaching of Time, item 22 from 2008 (see Fig. 4.2) relates to both Duration and the Measurement of time. Eighteen of the 25 participating students (72%) selected the correct response of 11:15am. Errors were spread between the distractors: 10:30am (2), 10:45am (2), and 11:30am (3). In 2008, 50% of Year 3 students nationally (58% of Victorian students) selected the correct response. The *Australian Curriculum: Mathematics* lists finding the arrival time when given the departure time as an example of solving simple time problems, an outcome for Level 4 (ACARA, 2016c).

**22** A bus took some students to camp.  
It left the school at 10:00 am.



The bus trip took one and a quarter hours.  
What time did the bus get to the camp?

10:30 am      10:45 am      11:15 am      11:30 am

Figure 4.2. Item 22 from 2008.

Table 4.7  
Scores from NAPLAN Pre-Test 15.10.15 (n = 25)

Student	2008. Item 22.	2009. Item 8.	2009. Item 27.	2010. Item 15.	2010. Item 19.	2010. Item 28.	TOTAL
01B4	1	1	1	1	0	0	4
02G3	1	1	1	0	1	1	5
03G3	0	0	0	1	1	0	2
04G4	1	1	1	1	1	1	6
05G3	0	0	0	1	1	0	2
06B3	1	1	1	1	1	1	6
07G4	1	1	1	1	1	1	6
08B3	1	1	1	1	1	0	5
09G3	0	1	0	0	1	1	3
10B4	1	1	1	1	1	1	6
11B3	1	1	1	1	0	0	4
12G4	0	0	0	1	1	0	2
13B3	0	1	0	0	1	1	3
14G4	1	1	1	1	0	1	5
15B4	1	1	1	1	1	0	5
16G4	1	1	1	1	1	1	6
17B3	1	1	1	1	0	0	4
18B4	1	1	1	1	1	1	6
19B4	1	1	0	0	1	0	3
20B3	0	1	0	0	0	0	1
21B4	1	1	1	1	0	1	5
22B3	1	1	1	1	0	0	4
24B3	1	1	1	1	1	1	6
25G4	1	1	1	1	1	1	6
27G3	0	1	1	0	0	1	3
Total	18	22	18	19	17	14	108
%	72	88	72	76	68	56	72

### Item 8, 2009

Item 8 from 2009 (see Fig. 4.3) relates to Measurement of time on the Framework. To answer this item correctly, students need to be familiar with the movement of the hands on an analogue clock; to know the interrelationship between the minute and hour hands. This item was successfully answered by 22 students (88%), the highest correct response of the six items. This result is only a few percentage points above the 2009 score; nationally 80%, Victoria 85%. This item was also given to the Year 5 students in 2009, resulting in improved percentages (nationally 91%, Victoria 92%). The remaining three students selected 4 o'clock from the distractors. Reading half-hour times and knowing the placement of the hands for the half hour is a skill noted for Level 1 of the curriculum (ACARA, 2016c).

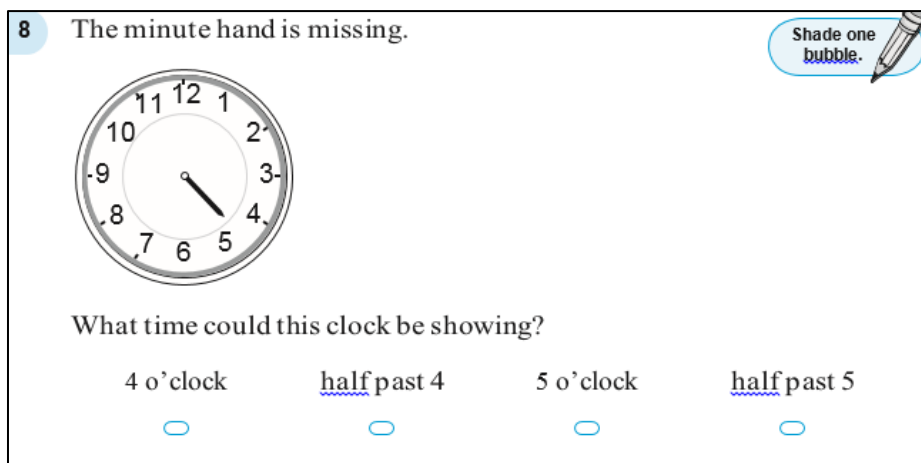


Figure 4.3. Item 8 from 2009.

### Item 27, 2009

The third item, item 27 from 2009, required students to understand the relationship between analogue and digital time (see Fig. 4.4). Students were asked to select from images of four watches the watch that showed a quarter to nine. This item also relates to the key idea of Measurement of time. Eighteen students (72%) selected the correct answer to this item. Five students gave the answer as 9:15 and two students selected 8:15. This percentage compares positively with the 2009 scores of 36% nationally and 46% for Victorian students. Although digital clocks are mentioned in Level 1 of the *Australian Curriculum: Mathematics* (ACARA, 2016c), telling the time to the quarter-hour is an outcome for Level 2.

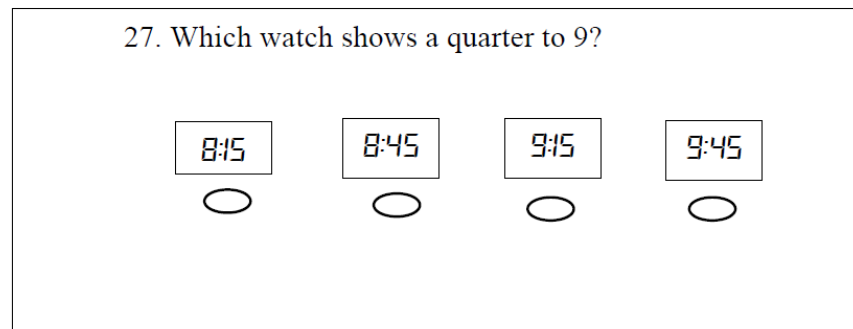


Figure 4.4. Item 27 from 2009.

#### Item 15, 2010

Item 15 from 2010 (see Fig. 4.5) also required the students to understand the relationship between analogue and digital time, that is, to know that a quarter past eight is 8:15. As with item 27 from 2009, this item also relates to the key idea of Measurement of time. Level 2 describes the telling of time to the quarter-hour on an analogue clock (ACARA, 2016c).

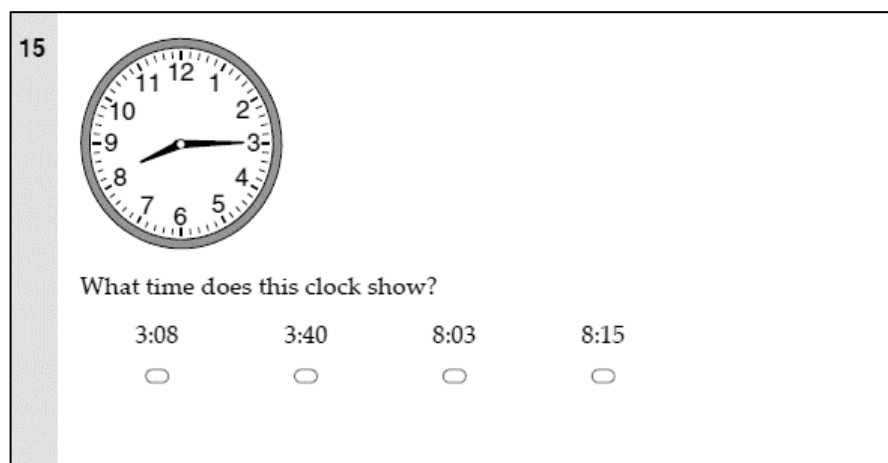


Figure 4.5. Item 15 from 2010.

Nineteen students (76%) selected the correct solution, four students selected 3:08, one student selected 3:40 and one student selected 8:03. In 2010, this item was also given to Year 5. The percentage scores for a correct response for Year 3 were 53% (nationally) and 58% (Victoria) and for Year 5, 83% (nationally) and 86% (Victoria).

#### Item 19, 2010


Item 19 from 2010 (see Fig. 4.6) relates to the major Components of Succession and Measurement of time. Students were given an incomplete calendar for the month of July. The numbers for the dates were written in boxes, but the words for the days were omitted. The writing informed them that 3 July is a Friday. From this information, students were required to

identify on which day 27 July occurs. Seventeen students (68%) accurately identified Monday, seven students selected Tuesday and one student chose Sunday. This result is similar to the 2010 percentages of 65% (nationally) and 69% (Victorian). The use of calendars to locate days and identify the date is an example of an outcome for Level 2 of the *Australian Curriculum: Mathematics* (ACARA, 2016c).

Ryan is making a calendar.  
3 July is a Friday.

What day is 27 July?

- Monday
- Tuesday
- Sunday
- Wednesday



July						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Figure 4.6. Item 19 from 2010.

#### Item 28, 2010

Item 28 from 2010 (see Fig. 4.7) required the students to have a knowledge of Succession and the Measurement of time. This was the most challenging item for the students with only 14 students (56%) selecting the correct answer. This result is a few percentage points above the 2010 results of 45% (nationally) and 52% (Victorian). Although students working at Level 4 solve simple time problems, it is not until Level 6 that students interpret and use timetables (ACARA, 2016c).

It is worth noting that the participating group of students consisted of 14 students from Year 3 and 13 students from Year 4. The national and Victorian scores given for each item are for Year 3 students, with the exception of two items for which scores for Years 3 and 5 were given. A higher percentage of correct scores would be anticipated from a Year 3 and 4 class than from a Year 3 class.



**28** Year 3 students go on a trip.  
This is the plan for the day.

Shade one bubble.

Start time	Activity
9:45	Leave school by bus
10:30	Arrive at Aquarium
11:30	Morning tea
11:45	Feed the seals
12:45	Lunch at the park
1:30	See movie 'Under the Sea'
2:45	Leave by bus
3:30	Arrive back at school

At 1:00 the students will be

with the seals.  
 seeing the movie.  
 having morning tea.  
 at the park.

Figure 4.7. Item 28 from 2010.

#### 4.5.2 Summary of NAPLAN data

From a possible total of six points, the mean for the 25 participating students was 4.3, the median 5.0, with a standard deviation of 1.5. This implies that the students had developed some understanding of the mathematics assessed by the items. These six items certainly do not represent the overall learnings that Year 3/4 students should have made about time. Nevertheless they are items from the national NAPLAN test and, with the exception of Item 28 from 2010, represent what is expected to be grasped by students in these year levels (ACARA, 2016c). It might have been expected that the students may well have performed better on these items. Of the three items anticipated to be mastered by the end of Level 2, between 68% and 76% of the students selected the correct answer, which suggests that, at the time this pre-test was administered, this group did not have mastery of the underpinning ideas. Eight of the 25 students were successful with all items, however four students only scored 1 or 2 marks. This suggests that overall there was a spread of understanding of time within this student group, something that became important when preparing the series of intervention lessons.

#### 4.6 Eight-Lesson Intervention

This section outlines the intervention lessons that were developed, based on the information obtained from analyses of the interview data and the NAPLAN items. Each lesson was planned to include the concepts that were identified as challenging after assessing the participating students' scores from the pre-intervention interview. Several items could be addressed in each lesson as the interview was structured to assess the major Components of the Framework by asking more than one question for any concept.

#### **4.6.1 Selection of learning foci for intervention lessons**

The data presented in Table 4.6 proved to be beneficial in the initial stages of planning the lessons. As the items that were identified as challenging were spread across the major Components of the Framework, a wide range of activities could be developed, with varying degrees of difficulty, hopefully enabling all students to be actively involved in each lesson. Each lesson was given a title which reflected the mathematical focus. Table 4.8 gives a summary of the eight lessons (numbered and named) and the mathematical focus for each lesson. Although Awareness of time was not specifically assessed in the interview, as it was considered to be incorporated into all of the items, some of the lessons emphasised Awareness more than others. Awareness of time has been included as a Framework item for the lessons in which it was more explicit.

In line with design research, each lesson was planned to develop the theory in practice by building on the previous lesson. At the conclusion of each lesson, the researcher reviewed her notes, reflected on the lesson in light of the Framework and examined the students' work before finalising the plan for the next lesson. While challenging items from the one-to-one interviews had been identified and lesson outlines had been developed in the initial planning, the foci and the final activities of each lesson were not completed until the previous lesson was reviewed.

Although each lesson focussed on different aspects of time, concepts were revisited and revised throughout the intervention. The eight lessons and the reflections on these are described in more detail in the next chapter. The mathematical foci are included in Table 4.8 to indicate how the lessons were designed in response to the student needs as identified by the interview assessment items and the preceding lessons.

More specific alignment of the content of the lessons to student needs is provided in Table 4.9 which shows the challenging concepts identified from the results of the pre-intervention interview, the corresponding interview items for each concept, and the lesson(s) in which each concept was addressed. The purpose of the lessons was for the students to explore the concepts behind the items in order to support a relational understanding of time, in which they learn what to do and why what is done occurs in a particular way (Skemp, 2006).

Each lesson commenced with the reading of a written text. The texts, which included both nonfiction and fiction, were selected to engage the students and direct their attention to the lesson focus. Table 4.10 lists the text for each lesson alongside the lesson focus. The lessons concluded with the students writing about their learning in the form of a self-reflection.

Table 4.8

*The Mathematical Focus Selected for Each Lesson of the Intervention*

N <sup>o</sup>	Lesson title	Mathematical focus	Framework's major Components
1	Talking about time.	Making connections between aspects of time through everyday language.	Awareness
2	Round and round we go.	The length of a day in hours. The length of a year in days and months. The calculation of a leap year.	Measurement
3	Tick, tock: Measuring seconds and minutes.	The coordinated movements of the 12 hour analogue clock. The durations of a second and a minute.	Duration Measurement
4	Make my day.	The duration of an hour. Reading and measuring an hour on analogue clock and digital clocks.	Duration Measurement
5	Fifteen minutes of fame.	Reading the hour and the minute hands of an analogue clock. Understanding the clock is measuring how much time has elapsed since midnight or midday.	Duration Measurement
6	Many happy returns.	Ordering of years and months. Counting years and months forwards and backwards.	Succession
7	Tomorrow is another day.	Language used to identify future and past days on a calendar. Calculating days, weeks and months forwards and backwards from a given date.	Succession Measurement
8	From time to time.	Telling the time on analogue and digital clocks.	Measurement

#### 4.7 Summary of Chapter 4

In this chapter the researcher has reported on the collection of two sets of data, items from a one-to-one task-based interview and NAPLAN items from past years, to evaluate the students' prior knowledge and understanding of the major Components of time based on the Framework. Details were given to explain how these data sets, collected prior to an eight-lesson intervention, informed the intervention. The data from the one-to-one, task based interview included the range of scores and an explanation of how these scores were obtained and used as a diagnostic tool. The six NAPLAN items from past years were described and the results given as one source of information regarding the students' prior knowledge.

Table 4.9

*Lessons Addressing Weaknesses Identified from the Pre-Intervention Interview*

Item numbers	Maximum score = 54 (27 students × 2 points). The following one-to-one interview items scored 40 or less.	1. Talking about time.	2. Round and round we go.	3. Tick tock. Measuring seconds and minutes.	4. Make my day.	5. Fifteen minutes of fame.	6. Many happy returns.	7. Tomorrow is another day.	8. From time to time.
2,3	Knowing when the day begins and ends.		X		X	X			
1,4,5	Knowing that am is from midnight until midday and pm is from midday until midnight		X		X				
9	Accurately marking the duration of periods of time throughout the day on a timeline.				X	X	X		
14	Estimation of one minute.			X					
16	Measurement of time with a clock. Understanding that time is measured.	X	X	X	X	X			X
12	Understanding that the units are a measure of time.	X	X	X	X	X	X	X	X
15									
17	Measurement of time with a calendar. Understanding that time is measured.		X				X	X	
19	Accurately counting back years passed to find a given year.						X		
24	Accurately counting on seven days in a week from a given day.						X	X	
26	Placing annual events in order.						X		
27	Giving the full date as the day, the number of the day, the month and the year.						X		
32	Calculating the date one month ago.						X		
31	The first day of the month.								
33	Calculating the date three weeks from a given date.						X	X	
34	Calculating the date two years hence.						X	X	
36	Calculating age in days.						X		
37b	Draw a clock. Positioning the minute markers accurately.			X	X	X			
42-45	Duration of time taken for hands to move around the clock.			X	X	X			X
46	Knowing an hour is constant.		X	X	X	X			
48 a-e	Reading the time on an analogue clock.			X	X	X			X
49									
50	Adding on one hour to a time given in hours and minutes.				X	X			
51	Writing digital time from analogue clock time. A quarter past and a quarter to.				X	X			X
55	Understanding the rotation of the Earth in relation to time.		X						

Table 4.10  
*Texts Selected for Each Lesson*

<b>Lesson</b>	<b>Text</b>	<b>Text Focus</b>
Talking about time.	Koscielniak, B. (2004). <i>About time: A first look at time and clocks</i> . New York: Sandpiper. Matthews, T. (2011). <i>Waiting for later</i> . Newtown, Australia: Walker Books, Australia.	Everyday language of time.
Round and round we go	Karas, G. B. (2005). <i>On Earth</i> . New York: Puffin Books.	The length of a day. The length of a year. Leap years.
Tick, tock: Measuring seconds and minutes.	Hutchins, P. (1970). <i>Clocks and more clocks</i> . London: The Bodley Head.	Duration.
Make my day.	Koscielniak, B. (2004). <i>About time: A first look at time and clocks</i> . New York: Sandpiper. Formichelli, L., & Martin, W. E. (2012). <i>Timekeeping</i> . White River Junction, VT: Nomad Press. Catherall, E. (1982). <i>Clocks and time</i> . Hove, Great Britain: Wayland Publishers. Robinson, R. (1987). <i>It's about time: A history of clocks and calendars</i> . Melbourne, Australia: The Macmillan Company of Australia.	Measuring the duration of an hour.
Fifteen minutes of fame.	Graham, B. (2013). <i>Silver buttons</i> . London: Walker Books Ltd.	Measuring the time on analogue clocks.
Many happy returns.	Baker, J. (1991). <i>Window</i> . Great Britain: Julia MacRae Books.	Succession.
Tomorrow is another day.	McCaughrean, G. (2002). <i>My grandmother's clock</i> . Great Britain: Harper Collins.	Counting days and months forwards and backwards on a calendar using common language such as 'the day before' and 'in two days' time'.
From time to time.	Matthews, P. & McLean, A. (2002). <i>A year on our farm</i> . Gosford, NSW: Omnibus books.	Measuring time on clocks. The passing of time.

The development of the eight-lesson intervention was explained in light of the data collected followed by a summary of each lesson. In Chapter 5, the eight lessons and reports on the data collected during and after the eight-lesson intervention are detailed.

## **CHAPTER 5. Post-Intervention Results**

### **5.1 Introduction**

This is the second of two chapters reporting the results from this study. In Chapter 4 the results from data collected prior to the commencement of the intervention were presented. The eight-lesson intervention, with details regarding the development and purpose of each lesson, was introduced. In this chapter the results from the data collected from the time of the commencement of the intervention are presented including a detailed description of the eight-lesson intervention and the data emerging from it, followed by the data from the post-intervention student interviews and a second set of results obtained by repeating the NAPLAN questions. (The rationale for the generation of these data was given in section 3.5.3.)

The data collected during the intervention included samples of the students' work, the students' self-assessments, and field notes from observations and audio-recordings of the lessons. As the lessons are described, reference will be made to these data sets. Post-intervention student interviews commenced three weeks after the last lesson. The NAPLAN items were given again six weeks after their initial administration. Results described in the current chapter were used as one measure of the effectiveness of the eight-lesson intervention in assisting children's development when learning about time.

Work samples described in each lesson are, where appropriate, from the sample group described in section 3.3.3.3, with selected work samples for the entire class provided in the designated Appendix section.

### **5.2 Eight-Lesson Intervention**

The following sub-sections include discussion of each of the eight lessons in turn. Each lesson is detailed and includes the targeted Framework Components and key ideas, the rationale for the lesson, the mathematical focus, links to the Australian curriculum and a reflection on the lesson in light of the Framework. The rationale for each lesson was based upon the data collected from the one-to-one interview and the NAPLAN items (see section 4.6.1). Also included are reflections and observations of the teacher-researcher, and in some instances a discussion of artefacts collected during the lesson.

Each lesson was 90 minutes long, as this was the time allocated by the classroom teacher for her mathematics lesson each day. This meant that the eight-lesson intervention was conducted over a total of 12 hours.

As described in Chapter 3, each lesson was audio-recorded to collect data on the students' conversations with each other and interactions with the teacher-researcher. More detail for the rationale for audio-taping lessons can be found in section 3.7.1. Although the students were encouraged to talk with each other about the mathematical tasks and their work on these, the recording equipment which was worn by the teacher-researcher was limited to collecting the interactions of students who were near the audio recorder.

### **5.2.1 Lesson 1: Talking about time**

The first lesson of the intervention was on Thursday, 15 October. All the students in the class had met the teacher-researcher informally in the classroom and individually when undertaking the one-to-one interview. This was the first lesson where the researcher was the primary instructor with the classroom teacher acting as an assistant.

#### ***Targeted Framework Components and key ideas***

Awareness:

- The language of time.

Measurement:

- Manufactured units of time (second, minute, hour, week) are entrenched in our culture.

#### ***Rationale***

The language relating to time can be confusing with words and phrases, such as past and to, having different meanings depending on context among other things. Several tasks from the one-to-one interview related to understanding the language of time, such as identifying 'the day after tomorrow' and 'the day before yesterday', and recalling units to measure time. In the pre-intervention interview, eight students listed four or more units to measure time, eleven students listed one to three units and eight students did not list any units to measure time. Although the NAPLAN questions required reading the instructions and information for each item, the items did not explicitly assess the language of time.

#### ***Mathematical focus***

The development of the concept of time is fostered by making connections between different aspects of time (Awareness of time, Succession, Duration and Measurement of time) through everyday language.



### *Links to the Australian curriculum*

- Compare and order the duration of events by using the everyday language of time. ACMMG007.

### *The lesson*

The lesson began with the teacher-researcher reading the first one and a half pages of the text, *About time: A first look at time and clocks* (Koscielniak, 2004), concluding with the question asked by the author, “So how do we define time?” After a brief discussion about defining time, the students were asked to complete the sentence ‘Time is ...’ before sharing their ideas with a partner. Table 5.1 lists the words and phrases that were selected by the sample group to define time.

Table 5.1  
*Words and Phrases Selected by the Sample Group to Define Time.*

<b>Student</b>	<b>Time is ...</b>
<b>03G3</b>	Hours. Minutes. Half past. Quarter to. Quarter past. Seconds. Tick tock 60 minutes is an hour. 30 minutes is half an hour. 60 seconds is one minute. Am and pm
<b>05G3</b>	Clocks. Future. Half past. Quarter past. Hours. Minutes. Seconds
<b>07G4</b>	A way to measure the rotation of the Earth around the Sun. Seasons Hour. Year. Day. Week. Second. Month. Minute
<b>13B3</b>	A way of telling the time. A measure of past, present and future. Time Time is a way of telling seconds, minutes and hours.
<b>18B4</b>	Useful. Precious. Everywhere. Endless. Present
<b>24B3</b>	A measurement of past, present and future. Time is a way of measuring in seconds, minutes and hours. A way of knowing how long it’s been.

While one student included the rotation of the Earth and others mentioned the past, present and future, over half of the words and phrases listed in Table 5.1 relate directly to the reading of time on a clock. It was apparent from the lists that students were familiar with some of the manufactured units of time.

After each student shared their ideas with a partner, a whole class list was compiled which was used by the researcher as a reference of known words and phrases. Some of the interesting expressions which came from the students were: time waits for no-one, time is on my side, time is everywhere, time is precious and don’t waste time. One student declared that “time was not

just the Earth, but the whole universe,” and that “time was not an invention, it was discovered.” This led to a small argument, so it was tabled as a question to be investigated over the next few lessons.

The class list of words was divided between groups of three to four students who worked together to sort the words and phrases into lists of their own choosing before adding new words of their own. There were no criteria for giving out the words as the class list was simply cut into seven pieces with approximately the same number of words on each, to be used simply as a starting point. Added words may have been common to another group as it was possible that groups would think of the same or similar words.

Table 5.2  
*Classification of Time Words by Students*

Group	Words	Word classifications
Group 1	centenary, century, year, decade o'clock, $\frac{1}{4}$ to, $\frac{1}{4}$ past, analogue digital	Measurement of time Analogue clock times
Group 2	present and future clocks, watches, hourglass past tense, wait everywhere. Generation weeks, century Don't waste time	Tense Things to measure time Length of time
Group 3	invented, discovery, endless $\frac{1}{2}$ , $\frac{1}{4}$ $\frac{3}{4}$ whole tense (past, present, future) milliseconds, seconds, minutes, hour) year, month, day, night, today, days universe, earth, star	Fractions of an hour Short times Long times Space
Group 4	Fast, slow, <i>quick, sluggish, 10/kh,</i> <i>speedy, walking pace</i> min/minute, measuring seconds, hours, <i>milliseconds, sundial, late, on time,</i> <i>day, month, year</i> helpful invention, amazing, <i>outstanding, stupendous, wonderful</i>	Movement of time Measurement of time Thoughts of time
Group 5	am, pm. late, early tell the time	Opposite group Tell the time
Group 6	rotation, seasons time waits for no-one, seconds tick by, tick tock an hour and a half, 24 hour time, second, hours, millisecond, nanosecond hands	Switching group Expressions of time Telling the time Parts of a clock
Group 7	Clocks time flies, time is on my side minutes, hour, time, times passed, past	Expressions Clock times Other words

A part of the sorting process was the naming or classification of each list of words. Students were required to justify their word groupings. Table 5.2 lists the classifications made by all the student groups. The original classifications were dependent on the words each group was given following the class listing of words. Group 4 displayed evidence of their thinking as they explained their three classifications of words: movement of time, which was related to speed; measurement of time, which listed words such as day, seconds and hours; and thoughts of time, which included words such as wonderful and amazing. Although the opportunity existed for the students to develop unlimited categories, common to all groups was the listing of clock and time telling related words such as analogue clock times, telling the time and fractions of an hour. Seconds, minutes and hours were also listed, but only o'clock, half past, a quarter past and a quarter to were listed as clock times. Several expressions such as don't waste time and time flies related to time although the students did not give any explanation of the meaning of these phrases.

#### ***Reflection on the lesson in light of the Framework***

The words and phrases that the students selected to define time indicated that the language that the students associated with time was strongly linked to the use of clocks and the formulated units used in reading the time. This association can be seen in the words and phrases selected by the sample group of students (see Table 5.1). Later lessons in the intervention were planned to determine the extent to which the students understood the units of time that had been listed, with the task to be repeated at the end of the intervention as a means of assessing possible growth in the students' vocabulary of words related to time.

To connect this task more closely to the Framework, the researcher categorised the students' words under the major Components of Succession, Duration and Measurement (see Figure 5.1). All of the words and phrases demonstrated an Awareness of time and there are many words that could be placed under more than one major Component. Two entries referred to time changing as the Earth spins while other entries listed specific facts such as the number of hours in a day and seconds in a minute. As the list of Measurement words is greater than the other major Components, it would appear that, for many students in this class, their concept of time may be closely aligned to what may be considered facts and figures. Although the term Duration was not introduced in this lesson, the students were able to contribute words and phrases that indicated that many of them had some understanding of periods of time that ranged from the very small to the very large.

<p><b>Succession:</b> A measure of past, present and future. Different between past and present. Future. It helps you know when to do things. Passed. Past. Past time. Present.</p>
<p><b>Duration:</b> A measurement of past, present and future. A way of knowing how long it's been. Day. Endless. Fast. It helps us know when to go to parties, shops, lunch, dinner, and breakfast, etc. Long. Night. Short. Super long. Super short. Time is a way of measuring in seconds, minutes and hours. Time is fast. Very long. Very short. What tells us when a day has passed, hour passed, year has passed. When Earth spins, time changes. Endless. Something that will not stop. Time is something that never stops. Century. Day/days. Decades.</p>
<p><b>Measurement of time:</b> 10 milliseconds is a second. 10 years in a century. 12 months in a year. 20 years in a decade. 24 hours is a day. 30 minutes in half an hour. 300 and something is a year. 4 ½ weeks in a month. 60 minutes in an hour. 60 seconds in one minute. 7 days in a week. A clock tells you the time. A way of telling the time. A way to measure the rotation of the Earth around the Sun. Am and pm. Analogue. Clocks. Digital. Half past. Hour/hours. If you look at a clock it will tell you the time. Milliseconds. Minutes/mins. Month/months. Nanoseconds. O'clock. Pm night and afternoon. Quarter past. Quarter to. Seasons. Seconds. The first number is 1 o'clock and the last number is 12 o'clock. Time is a way of telling seconds, minutes and hours. Time is on a clock. Time is something you can measure with. Times. Today. Watches. Week/weeks. Year/years. Tell the time right. Time is a helpful invention to help us tell the time. Stop watch. Century. Day/days. Decades.</p>
<p><b>Awareness of time:</b> A way of being either late or early. Amazing. Daylight saving. Don't waste time. Everywhere. Fun to learn. Generation. Helpful. If you don't have a look every now or again you might miss your future. Invention. It tells us what it is like. Mysterious. Not just in Earth but the whole universe. On time. Peaceful. Precious. Strange. Time happens by itself. Time is everywhere. Time is nice and mean. Time is on my side. Time sheets. Time waits for no-one. Time was discovered, not invented. To figure out time you can use different things like degrees such as 360°, 90°, 30°, 60° and patterns. Useful. Wait. You can't stop time.</p>

Figure 5.1. Words and phrases categorised under the Major Components of the Framework.

The listing and grouping task was of benefit for the researcher as one way of ascertaining prior knowledge of the language associated with time. It was noted during the whole group discussion at the conclusion of the word task that time could be confusing for many people, especially when what we say can mean different things to different people. To further encourage the students to think about this notion of communication and the language of time, the lesson concluded with the story *Waiting for later* (Matthews, 2011) which focussed on what may be meant by the word *later*.

Interestingly, the words listed by the students did not demonstrate any understanding of how time is linked to the rotation and revolution of the Earth. The second lesson was planned to demonstrate how the movement of the Earth gives us daylight and darkness, seasons and years. Lesson 2 was revised to ensure the inclusion of key words such as rotation, revolution, Leap Year, day (24 hours) and year.

### **5.2.2 Lesson 2: Round and round we go**

The second lesson of the intervention was on Monday, 19 October. It was not possible to conduct a lesson on the previous Friday owing to the beginning of the school swimming program. The students welcomed the researcher into the classroom as their teacher for the mathematics lesson.

#### ***Targeted Framework Components and key ideas***

Measurement:

- Units of time based on natural phenomena (days, years) are reliant on the movement of the Earth in space.
- The passage of time is measured in specific units.

#### ***Rationale***

The rotation of the Earth on its axis and its revolution around the Sun are important concepts to understand when measuring time. The length of a day, the seasons and the duration of a year are reliant on the Earth's movement in space. The Earth takes one day (24 hours) to spin, or rotate, on its axis giving us day and night. A year is the length of time the Earth takes to complete one revolution of the Sun (~365¼ days). A calendar year is 365 days but in order for our calendar to maintain its coordination with the Earth's revolution around the Sun, every fourth year is a Leap Year of 366 days. The tilt of the Earth on its axis gives us the seasons as the Earth faces towards or away from the Sun.

The NAPLAN items did not relate to the movement of the Earth in space as it is a topic in the Science curriculum. However, one item in the one-to-one interview asked the students to say what they knew about the rotation and revolution of the Earth, due to the relationship between time and the movement of the Earth around the Sun. In the pre-intervention interview six students gave a limited response and 21 students gave no response, indicating a need to explore further the movement of Earth, and its relationship to time.

#### ***Mathematical foci***

- The length of a day in hours.
- The length of a year in days and months.
- The calculation of a leap year.

### ***Links to the Australian curriculum***

- Year 2. Name and order months and seasons. (ACMMG040).
- Year 3. Tell the time to the minute and investigate the relationship between units of time. (ACMMG062).
- Year 4. Use am and pm notation and solve simple time problems. (ACMMG086).
- Year 3. Earth's rotation on its axis causes regular changes, including night and day (ACSSU048). The Australian curriculum has included the study of the Earth's rotation on its axis in the Learning Area of Science for Year 3, under the sub-strand Earth and Space Sciences (ACARA, 2015).

### ***The lesson***

The teacher-researcher introduced the lesson by reading the book *On Earth* (Karas, 2005) which described the movement of the Earth in space. Although the text was simple, the responses to questions related to the book indicated that the concept of the Earth's regular movement was still confusing for some students. To make the rotation and revolution of the Earth clearer to understand, the children modelled the movement of the Earth and the Sun, acting out the way these bodies move in our solar system. A large fit-ball covered in yellow plastic to represent the Sun was held up by a student wearing a red t-shirt with the word Sun written in yellow on the back and the front of the shirt. An inflatable Earth globe was carried by a student wearing a blue t-shirt with the word Earth written on the front and back of the shirt. A bright bike light, which was visible in the classroom despite the brightness of the day, represented the Sun's light. The students decided the placement of the Sun and located Australia on the inflatable Earth globe.

While the Sun remained in the centre of the room and illuminated the Earth, the Earth walked around in a large elliptical shape following directions by the teacher-researcher. During the re-enactment, the remaining students were prompted to talk about their observations of the Earth's movements, such as rotation and revolution, the tilt of the Earth and the seasons by discussing answers to questions and prompts from the teacher-researcher. The students were encouraged to consider what time could be measured by knowing the duration of the Earth's revolution and rotation (the duration of a day is measured with a clock and the duration of the year is measured with a calendar).

As the student holding the model of the Earth came to the end of a revolution, he/she was directed to complete the circuit with a quarter turn demonstrating that one revolution is  $365\frac{1}{4}$

days. (The students were not expected to rotate 365 times but could spin the globe in their hands.) As the calendar year includes only complete days, the students could see that after one year the calendar was a quarter of a day out of alignment with the revolution. The students counted and tallied each remaining quarter of a day from each revolution until four revolutions had passed and a whole day had been accumulated. The teacher-researcher explained how the extra day is added to the shortest month, giving February 29 days and the fourth calendar year 366 days. Student 10B4 calculated that the quarter of a day would be six hours. A selection of students' responses from the audio-recording has been transcribed below to give an insight into the students' participation and learning.

*Teacher: The Earth does three really important things. It rotates, (axis located), it goes around the Sun (revolves), but it does something else. [Demonstrated the tilt. Students had to determine which part of the Earth was closest to the Sun.] It tilts.*

[The students made a path for the Earth to revolve around the Sun and a student was directed to walk in a large ellipse/circle around the Sun.]

*Teacher: When you look at the Earth, is it daytime or night time in Australia?*

03G3: Daytime because the sun is shining on Australia.

*Teacher: Is it summer or winter?*

Student: Winter.

*Teacher: How do we know it is winter?*

Student: Because the northern hemisphere is facing the sun.

*Teacher: Keep moving, Earth. [Direction to the class.] When you think it is summer in Australia, tell the Earth to stop.*

Students: Stop.

*Teacher: Now Earth, turn around until it is night.*

Students: Stop.

*Teacher: When it is summer in Australia, the nights can be hot. Can you tell me why this happens?*

Student: The southern hemisphere is still closest to the Sun.

*Teacher: As the earth goes around, who can tell me how many times it will spin around before it gets back to where it started from?*

11B3: 365 times. That is one whole year.

[Students were asked to explain the movement of the Earth and the seasons to someone beside them.]

*Teacher: How long does the Earth take to spin on its axis once?*

18B4: 24 hours.

Whole class: One day.

10B4: It's one more day in a Leap Year.

*Teacher: Does it take one extra day each year? 365 days to go around in one year, the next year 365 days, the next year 365 days, whoops, slow down a bit, this year will be 366 days. Is that how it works?*

10B4: No.

24B3: We put together the ends of the days until we have one full day.

*Teacher: It actually has 365 and a quarter days. [The Earth moves to demonstrate.] So after one year we have 365 days but we save the quarter as we can't really measure it in this year. [The Earth makes another revolution.] The next year, we have 365 days and quarter of a day. How many quarters do we have now?*

Class: Two.

[Earth revolves around the Sun one more time.]

*Teacher: So, after another 365¼ days we have passed another year and saved another quarter. How many quarters have we saved now?*

Class: We have ¾ of a day now.

*Teacher: Then another 365¼ days. We have four quarters which is...*

Class: A whole day.

*Teacher: Now we have a whole day, let's add it on to the year. Where can we put the extra day? Let me see ... I know, we can put it at the end of February.*

The transcript above reveals how the students became better informed about Leap Years by being able to visualise the Earth's quarter turn.

For subsequent repetitions of the exercise while other students became the Sun and the Earth, a third role was available for students; the role of narrator. The narrator was required to give a commentary of the Earth's progress with assistance from the other students. Working together helped to reinforce what they had learned.

Following the modelling exercise, the students were instructed to draw a diagram to demonstrate their understanding of the rotation and revolution of the Earth and the time taken to complete these actions (an example is shown in Figure 5.2). As the students drew their pictures, they were able to recall many details of the Earth's orbit around the Sun, the seasons and the movement from daylight to darkness. Student 03G3 had the second lowest score for the



interview including 0 points for the rotation item. Her diagram illustrates the interest taken in the details of this lesson culminating in an improvement in understanding of this concept.

Much of the information that the students wrote and drew was retained over the next few weeks as students recalled this lesson when asked about the rotation of the Earth during the post-intervention interview although some students found it difficult to remember exact details of hours and days.

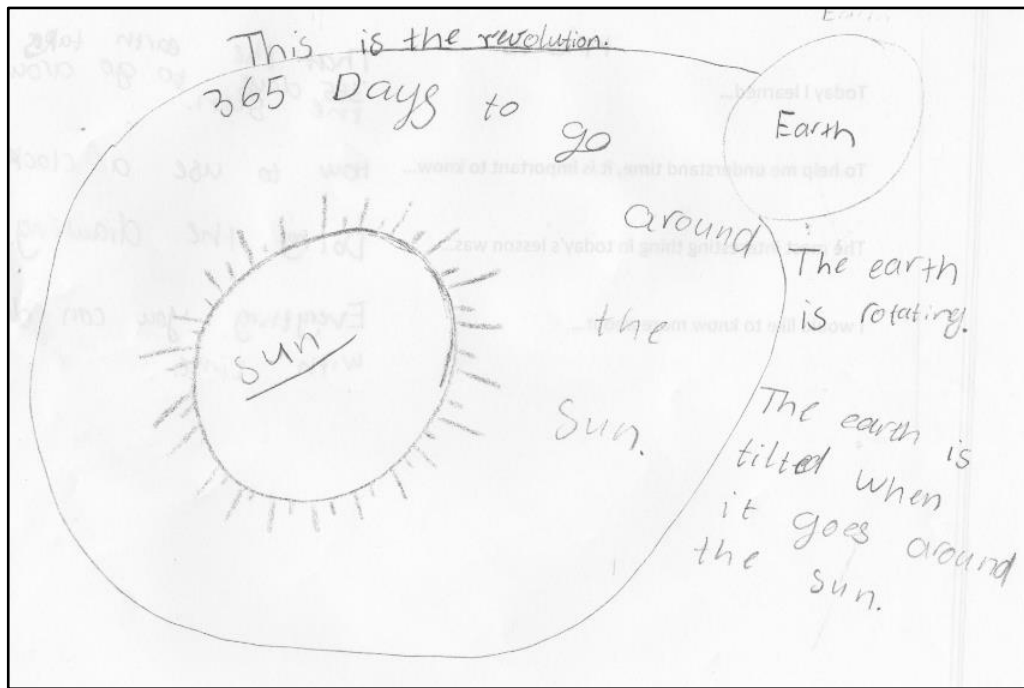


Figure 5.2. Rotation and revolution diagram drawn by 03G3.

To reflect on their learning, students were instructed to complete the following sentences:

- Today I learned .....
- To help me understand time, it is important to know .....
- The most interesting thing in today's lesson was .....
- I would like to know more about .....

All the students' responses were collected as one form of assessment of their learning. Responses from the sample group are displayed in Table 5.3. The student responses to the statements about their learning gives insight into what the children identified as new learning. The one-to-one interview identified the rotation and revolution of the Earth as an area of concern as only six students recalled any details with no student scoring more than one point. Although not a lot was written, it was evident from what the students did write, and from

Table 5.3

*Sample Group Responses to Lesson 2*


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03G3	<p>Today I learned <i>that the Earth takes 365 days to go around the Sun.</i></p> <p>To help me understand time, it is important to know <i>how to use a clock.</i></p> <p>The most interesting thing in today's lesson was <i>doing the drawing [of the Earth's movements].</i></p> <p>I would like to know more about <i>everything you can do with time.</i></p>
13B3	<p>Today I learned <i>that the Earth rotates.</i></p> <p>To help me understand time, it is important to know <i>measurement of past, present and future.</i></p> <p>The most interesting thing in today's lesson was <i>the Earth's rotation.</i></p> <p>I would like to know more about <i>the Earth's rotation.</i></p>
05G3	<p>Today I learned <i>that the Earth [goes] around the Sun for 1 year.</i></p> <p>To help me understand time, it is important to know <i>past, present and future.</i></p> <p>The most interesting thing in today's lesson was <i>drawing Earth.</i></p> <p>I would like to know more about <i>Leap Year.</i></p>
18B4	<p>Today I learned <i>[Student drew a diagram of the Earth's movement in space]</i></p> <p>To help me understand time, it is important to know</p> <p>The most interesting thing in today's lesson was</p> <p>I would like to know more about</p> <p><i>[Unfinished due to time spent drawing.]</i></p>
24B3	<p>Today I learned <i>about the Earth's rotation.</i></p> <p>To help me understand time, it is important to know <i>measurement of past, present and future.</i></p> <p>The most interesting thing in today's lesson was <i>the Earth's rotation around the Sun.</i></p> <p>I would like to know more about <i>the time of Earth's rotation.</i></p>
07G4	<p>Today I learned <i>about the axis on the north and south pole.</i></p> <p>To help me understand time, it is important to know <i>how to read digital and analogue clocks.</i></p> <p>The most interesting thing in today's lesson was <i>the demonstration of the Earth's rotation around the Sun.</i></p> <p>I would like to know more about <i>other planets time, like how many days does it take Saturn to rotate around the Sun.</i></p>

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anecdotal notes written by the teacher-researcher, that the students' responses to questions posed demonstrated an improved understanding of the Earth's movements in space.

***Reflection on the lesson in light of the Framework***

Having the students actively involved during the demonstration and modelling of the Earth's rotation and revolution not only captured their interest, but enabled the students to 'see' how the measurement of days and years was reliant on the Earth's movement in space. Two new words were introduced to the students, rotation and revolution. While both movements relate to the measurement and recording of time, these movements of the Earth are independent of each other. Rotating the Earth demonstrated to the students the passing of the days and nights

as each rotation is 24 hours. The revolution of the Earth around the Sun gives us our year and our seasons.

For the Earth to complete one revolution around the Sun and return to its original position it has to rotate  $365\frac{1}{4}$  times. The students realised that for practical purposes, a calendar year only records complete days. To demonstrate the reason we have a Leap Year, the Earth was rotated a quarter of a turn to return it to its starting point. The students could understand that it was not feasible to add the extra quarter of a day to the calendar, so the New Year commenced a quarter of a day early. After another calendar year, the Earth was two quarter turns away from its original starting point. By repeating this exercise for four revolutions, the students were able to see that another complete rotation (four quarters) was required to return to the starting point. To bring the calendar into sequence with the Earth's revolutions, an extra day was added to February making a Leap Year of 366 days instead of 365 days. It was important for the students to realise that each revolution, or year, has the same duration. Although an extra day is added every four years, this is not due to the Earth slowing down and taking an extra day every fourth year. A point in time could also be 'seen' as the Earth moved through days and nights and the seasons.

After experiencing the measurement of a day and of a year, the next lesson was planned to give the students activities that demonstrated how clocks were used to measure small divisions of the day. The next lesson was revised to include some discussion on the rotation of the Earth and how this continuous movement is measured with a clock.

### **5.2.3 Lesson 3: Tick, tock: Measuring seconds and minutes**

The third lesson was the next day, Tuesday, 20 October. Where possible, the lessons were planned to be on consecutive days, but due to interruptions to the school's regular classroom programs, this was not always possible. By this lesson, the students had become familiar with the teacher-researcher's style of teaching and role in the classroom, leaving the classroom teacher to have a reduced role.

#### ***Targeted Framework Components and key ideas***

Duration:

- Duration is the interval of time between two successive events.
- A unit of time is constant, being equal in length of time to any other unit of time bearing the same name.

Measurement:

- Manufactured units of time (second, minute, hour, week) are entrenched in our culture.

### ***Rationale***

The students' pre-intervention interviews revealed a weakness in understanding how a clock measures time. Many students saw the clock as only telling the time at any given moment, but not fully understanding that the movement of the hands on the clock measure the time that is passing as the day progresses. The clocks drawn by the students demonstrated a lack of understanding of the position and purpose of the minute markers, which could lead to difficulties in reading the time on a clock accurately.

When the students were required to draw a clock during the pre-intervention interview, five students drew an incorrect number of minute marks and ten students did not draw any minute marks. Of the 27 students, only 12 students demonstrated an understanding of the position of the minute marks. Five students drew four minute marks between the numbers. When asked to identify differences between their drawn clock and a real clock, these students noted the different number of minute lines but did not give any explanation for drawing 48 minute lines instead of 60. (Placing the minute marks in groups of five, the fifth minute mark is often not drawn on the clock face as it shares its position with a number.) Seven students drew clocks with sixty minutes evenly spaced around the face.

Three of the NAPLAN items related to reading the time on a clock face (see Section 4.5.1). As the quarter hour times presented difficulties for a quarter of the students, it was deemed important to include the quarter hour in the lessons.

### ***Mathematical foci***

- The coordinated movements of the hands of a 12 hour analogue clock.
- The duration of a second, a minute and an hour.
- A minute is a constant duration of time.

### ***Links to the Australian curriculum***

- Year 1. Tell the time to the half-hour. (ACMMG020).
- Year 1. Describe duration using months, weeks, days and hours. (ACMMG021).

- Year 2. Tell the time to the quarter-hour, using the language of ‘past’ and ‘to’. (ACMMG039).
- Year 3. Tell the time to the minute and investigate the relationship between units of time. (ACMMG062).
- Year 4. Convert between units of time. (ACMMG085).

### *The lesson*

The lesson commenced with a review of the activities from the previous lesson to establish links between the measurement of a day and measurement of smaller units of time within the day. The class was introduced to the term duration after listening to the story *Clocks and more clocks* (Hutchins, 1970). This book tells the story of Mr Hutchins who, as he moves through his house from room to room, finds that the time on his clocks is not the same and he is at a loss to explain why this occurs.

The term duration was a new term for the students and was defined as ‘the interval between two successive events, that is, the time taken for an event or action to happen’. This appeared to be an appropriate definition for the students of this age group as they identified periods of time that had a start and a finish. Most of their duration words related to specific units of time such as seconds, hours, nanoseconds, years, day, month and millisecond but some students included other words and phrases such as [in a] flash, instant, in a tick, and a jiffy, which demonstrated their understanding of the new term.

The first task required the students to work in pairs and to share a small battery operated clock. After checking that their clock was working and ensuring that their clock had all necessary features for this exercise (12 numbers, minute lines, three hands being the second, minute and hour hands) the students were informed that for this lesson, they would not be ‘using’ or reading the numbers as they would be concentrating on the minute lines. The students had to observe what happened on the clock face in one second and answer the question, “How is the clock informing (showing, telling) you that one second has passed?” (The second hand had moved from one line to the next, the clock had ticked and the second hand has crossed the space from one minute line to the next.)

It was explained to the students that the clock measured the duration of a second as the second hand moved from the beginning of the second to the end of the second. It was important at this stage for the students to understand that they were measuring the duration of a second, which was the length of time taken for the second hand to move from one line to the next. The next

step was for the students to count the seconds for a duration of 10 seconds and to count the number of spaces between the lines that had been crossed. This exercise was repeated for a duration of 20 seconds. Students were reminded that although these lines are called the minute marks, they also used to mark the passing of the seconds.

Students were then instructed to work in groups of three to four to investigate the movement of the minute hand for 60 seconds duration, and to use the minute markers to count and record the minutes passing. Questions such as “What happens to the minute hand as the second hand completes a complete circuit of the dial?” and “Have you noticed any patterns with the minute marks?” were asked as stimuli to their discussions. To illustrate their engagement in the task, some of the responses from the students as they observed the clock’s second hand, have been transcribed from the audio-taping of the lesson. The benefits of having working clocks to observe the movement of the hands as the time passed can be seen in responses such as, “It is moving,” “It moved one step” and “It ticks.”

21B4: Is it 12:03? Why is there an alarm?

*Teacher: Is your clock working?*

21B4: Yes. I can hear it ticking.

*Teacher: Does your clock have an hour hand, a minute hand and a second hand? Let me know if your clock stops working at any time.*

*Look at the second hand. Watch it moving. How does your clock tell you that one second has passed?*

08B3: The second hand has moved. It is moving.

02G3: It moved one step.

22B3: It goes to a new line. It ticks. Each tick is one second.

*Teacher: The lines and dots are minute lines and are used to measure minutes and also seconds.*

21B4 [Demonstrating his method for counting seconds]: One, one thousand, two, one thousand.

*Teacher: When we are measuring seconds, do we look at the line or the space?*

After a brief discussion, the teacher summarised the students’ contributions.

*Teacher: A second is the time it takes for the second hand to move from one line to the next. The time it takes to move through the space is the duration of one second. What could you do in 10 seconds?*

Student: Sing.

To complete the lesson, the students revisited the problem raised in the book *Clocks and more clocks* (Hutchins, 1970) to ascertain why Mr Higgins' clocks were displaying different times. From the responses during the whole group discussion, it became apparent to some of the students that Mr Higgins had not accounted for the duration of time that he took to move from room to room.

The students responded well to learning a new word. When the word duration was explained to them, they suggested their own examples to fit the definition. Having talked about duration, talking about the duration of a second was a logical step. A second takes time to pass, even if it is a short time, and the students quickly realised that the tick of the clock they could hear indicated a second had passed. Observing the movement of the hands on a working clock was very practical for the students as they could 'watch' the time pass and begin to understand how a clock measured the time.

The book *Clocks and more clocks* (Hutchins, 1970) created some interesting discussion. While some students were keen to explain what was happening, other students didn't respond voluntarily. The clock times shown in the book (minutes to and after the hour) were confusing for the students who were unable to read them.

### ***Reflection on the lesson in light of the Framework***

Students reflected on the lesson by writing what they had learned. The following responses were selected to demonstrate their recall of the new term, duration, although a definition was lacking in many cases.

01B4: The time it takes to get to a destination.

02G3: Learnt to count minutes.

03G3: I learnt how to read minutes properly. Duration.

08B3: Time waits for no-one. A new [word] for me is duration.

09G3: One important thing I've learnt is duration.

16G4: It is important to learn about duration.

27G3: One thing I learnt today is duration.

It is *more easier* to count the minutes now.

The students were able to measure the durations of seconds and minutes by observing and noting the second and minute hands as the space from one minute line to the next was crossed. Observing the movement of the hands on the clock assisted the students to see that a unit of time is constant, being equal in length of time to any other unit of time bearing the same name.

An observation recorded by the teacher noted that several students who had found the reading of clocks a challenge during the one-to-one interview, for example 03G3, appeared to be pleased with their achievements as evidenced by their desire to continue with the lesson.

Lesson 4, with a focus on the measuring of hours, was planned to follow on from Lesson 3, the measuring of seconds and minutes. To read and interpret a clock requires an understanding of the measurement of hours, minutes and seconds.

#### **5.2.4 Lesson 4: Make my day**

The Year 4 students attended a school camp for the three school days following the third lesson. The fourth lesson was conducted on Monday, October 26. Although half of the students had been away from the school and the teacher-researcher had not been at the school during that time, the intervention continued as though uninterrupted.

##### *Targeted Framework Components and key ideas*

Duration:

- A unit of time is constant, being equal in length of time to any other unit of time bearing the same name.

Measurement:

- Manufactured units of time (second, minute, hour, week) are entrenched in our culture.
- The learning and teaching of time is incorporated into the school curriculum, with emphasis on measuring time with clocks and calendars.

##### *Rationale*

One task from the one-to-one interview required students to add events to a timeline of a school day. While sequencing the events did not present any concerns in the pre-intervention interview, the duration of each event and the placement of times in the day were inconsistent with a matching timeline of hours in a day. As explained in the previous lesson discussion (see 5.2.3), three of the NAPLAN items related to reading the time on a clock face. The results from the NAPLAN items and the interview items were instrumental in the development of Lesson 4. The mathematical focus for this lesson was twofold, understanding the duration of an hour and the reading and measuring of an hour on analogue and digital clocks.

##### *Mathematical focus*

- Understanding the duration of an hour.



- Reading and measuring an hour on analogue clock and digital clocks.

### *Links to the Australian curriculum*

- Year 3. Tell time to the minute and investigate the relationship between units of time. (ACMMG062).

### *The lesson*

The lesson began with the teacher-researcher introducing a timeline from 1500BC to AD2015 and explaining how the years BC and AD were counted. Passages about important inventions and discoveries regarding time measurement were located in the following texts, then read to the students and discussed: *About time: A first look at time and clocks* (Koscielniak, 2004), *Timekeeping* (Formichelli & Martin, 2012), *It's about time: A history of clocks and calendars* (Robinson, 1987) and *Clocks and time* (Catherall, 1982). The years when each method for measuring time was in use were marked onto the timeline with a note of explanation. The texts began with the Egyptians and their use of sundials and obelisks and concluded with the first mechanical clocks. The history of clock development and the measuring of time interested the students, particularly the use of water to measure time with one student observing, "I didn't know you could tell the time with water". The students were very interested in the invention of a water clock. By looking at the tools invented to measure time, it became apparent that these measuring devices were becoming more sophisticated and subsequently, more precise. To consider possible reasons for this advancement, the students were asked questions such as "Why did people in the past decide they needed to break the day into smaller parts?" and "Why do we need to measure hours?" the following responses have been transcribed from the audio-recording of the lesson.

14G4: So we know when to do things.

06B4: It was a more exact time.

11B3: When someone comes when the sun goes down, if it is daylight saving or something, they won't have the right time.

The first two responses indicated an understanding of the need to measure hours but the third response related more to the need for an instrument to tell the actual time. Some of the responses from the one-to-one interview supported the notion that clocks were only used to read the present time but not to measure the time that had elapsed.

The measurement of the minute had been investigated in the previous lesson with the focus for this lesson being the hour. It had been stressed that the minute marks are used to measure the seconds and minutes and there are 60 lines for this purpose. The numbers are used to read the hours. (Some clocks use the position of the number as a minute line, so that only 48 lines are displayed.) The students completed three tasks relating to the investigation of an hour: measuring hours on a clock, reading the hours on a clock, and completing a timeline of a full 24 hour day. The batteries were removed from the clocks for this lesson as the duration of an hour was too long for the students to observe the movement and the position of the hands. The clocks were still very useful as the students could manually alter the position of hands by turning the wheel on the back but, as the hands were geared together, the relationship between the hands did not alter.

For the first task, the students were encouraged to position the hands of the clock on a time they could read. This time was drawn onto a paper clock as an aid to remembering it. The minute hand was advanced 60 minutes and the new time drawn onto a paper clock. In this way the students could observe the measurement of an hour. After commencing on the o'clock position, students were encouraged to commence the hour from many different positions or times. It was important to begin the measurement of an hour from different positions on the clock as nine students, when asked to add one hour to ten past two, had scored either 1 or 0 during the pre-intervention interview. Working together and verbalising their findings assisted in reinforcing the concept of an hour as a duration of time that can commence at any time. The following comments transcribed from the audio-tape of the lesson are examples of the findings of students when adding an hour to a time that did not begin with the minute hand on the 12.

It went to 6. It went from just after 5 to just after 6.

The hour hand is nearly to the 6 and now it is nearly to the 7.

It moved around an hour. Because it moved 60 minutes.

The hour hand was a little bit past 1 and now it is a little bit past 2.

The second activity required the students to use the skills they had been practising to answer questions such as those listed using the classroom analogue clock.

- Today began at 12 o'clock, midnight. Look at the classroom clock to determine how many complete hours have passed already today.
- How did you work out how many hours have passed so far?
- What parts of the clock are necessary to calculate the hours that have passed?

- What do you think we mean when we say 4 o'clock?

The second task was not as challenging as anticipated as it was 12 o'clock when this task was begun. As the time passed, some of the students added the extra minutes to the 12 hours demonstrating their ability to read hours and minutes, but not all the students who did this were successful. For example, one student wrote that 12 hours and 45 minutes had passed because the minute hand was on the 8, and she had counted by 5.

The third task was the completion of a 24 hour timeline. Comments from the students during the whole group discussion at the end of the lesson indicated that the students were interested to see how much time they spent asleep in the 24 hours and how much time was spent at school, the two events in a student's day with the greatest duration. If time had permitted, more events could have been added to the timeline with the hours and minutes spent on these events totalled and compared.

To reflect on their learning, students were required to complete a 3, 2, 1 activity: list three things remembered from the lesson, give two examples of what was learnt, and write one question relating to something that was confusing. Responses from the sample group of six students (Table 5.4) give an insight into the thoughts of the class as a whole. While many of the students found it challenging to think of a question to ask, the students' self-reflections in general were showing some improvement by lesson 4.

Many students were interested the timelines of their peers as times such as their bedtime, differed between the students. It was interesting that the students who wrote about the passing of an hour gave o'clock examples.

### ***Reflection on the lesson in light of the Framework***

As it had been six days since the previous lesson, at the end of Lesson 4 the students were asked to recall what they had learned from previous lessons. Responses included the following, which were transcribed from the audio-recording.

01B4: The Earth in space.

04G4: Doing the time.

14G4: We looked at the minute, second and hour hands.

04G4: Duration.

07G4: I was going to say the same.

*Teacher: What do you remember about minutes?*

06B4: Minutes are 60 seconds apart.

10B4: The duration of a minute is 1,000 milliseconds and a billion nanoseconds.

*Teacher: That is the duration of a second.*

10B4: Yeah, that's what I said.

21B4: It is 60 billion nanoseconds for a minute. Yeah, that's right.

Table 5.4

*Sample Group Responses to 3, 2, 1 Self-Reflection Activity*

Student	Student responses
03G3	<b>3.</b> The hour hand is the long hand. The hour hand moves around the clock to the next number every time. Three activities. <b>2.</b> Start at 6 o'clock and move a minute around the clock it will be 7 o'clock. I sleep for 11 hours.
05G3	<b>3.</b> I learnt that if it were 12:00 and 60 minutes = 1:00. How long an hour is. How long a minute is.
07G4	<b>3.</b> The timetable was cool because I got to see what other people's bedtimes are. The second hand is the same as the minute hand with using the same minute marks. <b>2.</b> We have 6 hours of school. I am awake 14 hours of the day.
13B3	<b>3.</b> The timeline. About the sundial. Questions. <b>2.</b> School goes for 6 and a quarter. I go to sleep for 7 hours and 30 minutes. <b>1.</b> What do you think we mean when we say 4 o'clock?
18B4	<b>3.</b> Timeline. Time (o'clock). One hour passed. <b>2.</b> Time. o'clock.
24B3	<b>3.</b> Answering question. Timelines. Following into. <b>2.</b> - - <b>1.</b> What do you think we mean when we say 4 o'clock?

It was interesting to note the recall of the word duration, the movement of the Earth in space and the hands of the clock. Some of the students showed an interest in the extremely small parts of a second and the very large numbers of these parts to form a second.

The 24 hour timeline allowed students to visualise the duration of time spent on different activities and to compare these durations with their peers. For the students who had thought that the day finished at 12 o'clock and the next day commenced at one o'clock, the timeline allowed them to see that there was an hour between these times. The recorded conversations indicated that the students had increased their knowledge of an hour as they discovered that 60 minutes could be counted from any starting point. The historical timeline was of interest to the students as demonstrated by their participation and questions and responses during this session.

The lessons on the measurement of hours and minutes were reviewed and the next lesson planned to consolidate the students' learning to count the duration of minutes. For the students who still experienced difficulty with reading the minutes on the clock, this lesson was revised

to include an activity to reinforce the features on a clock and how each feature was used to measure the time.

### **5.2.5 Lesson 5: Fifteen minutes of fame**

The fifth lesson was on the following day, Tuesday, 27 October. The students' response to the teacher-researcher continued to be positive as shown by their greetings on her arrival, their questions about the forthcoming lesson, their comments on previous lessons and their approach to the texts and tasks. This lesson was designed to challenge the students in novel ways.

#### ***Targeted Framework Components and key ideas***

Duration:

- Duration is the interval of time between two successive events.

Measurement:

- Manufactured units of time (second, minute, hour, week, month) are entrenched in our culture.
- The learning and teaching of time is incorporated into the school curriculum, with emphasis on measuring time with clocks and calendars.

#### ***Rationale***

Reading the time from clocks and calendars is an important life skill that students need to develop. Being able to read, measure and record the time assists us to plan for future events, be on time for current events and have an appreciation of our past. The one-to-one interview tasks which required students to read the time on an analogue clock were progressively more difficult (11 o'clock, half past 5, a quarter to 6, 25 past 8, and 7 minutes past 6). The difficulty was reflected in the results of the pre-intervention interview (four students did not correctly identify 11 o'clock, six did not say half past 5 or 5:30, 14 students did not respond with a quarter to 6 or 5:45, 12 students did not identify 25 past 8, and 12 students did not correctly state 7 minutes past 6). Recording digital times from an analogue clock challenged some students (Three students did not write 2:00 correctly; nine students did not write 5:30 correctly; and 12 students did not write 5:45 correctly). This lesson was divided into two tasks to cater for the different achievement levels and understandings demonstrated by the students during earlier lessons. The NAPLAN items only referred to half past, a quarter past and a quarter to the hour (see section 4.5.1), but the results from these items supported the inclusion of a lesson emphasising the quarter hour.

### ***Mathematical focus***

Telling the time on analogue and digital clocks.

### ***Links to the Australian curriculum***

Year 1. Tell the time to the half-hour. (ACMMG020)

Year 2. Tell the time to the quarter-hour, using the language of ‘past’ and ‘to’. (ACMMG039)

Year 3. Tell the time to the minute and investigate the relationship between units of time. (ACMMG062)

Year 4. Use am and pm notation and solve simple time problems. (ACMMG086)

### ***The lesson***

To introduce the concepts of simultaneity and synchronisation, the teacher-researcher commenced the lesson by reading the text, *Silver buttons* (Graham, 2013), which gives an account of the many things occurring in one city in the space of one minute. After a short discussion about the text, the students were placed into one of two groups and given a task to complete. The groups were formed according to the students’ learning needs, which had been assessed from the responses to tasks during the earlier assessment and the preceding lessons. The first group were assisted by the teacher-researcher while the second group worked independently.

The first group comprised the students who were experiencing some difficulty in reading hours and minutes. Their task was to construct a clock on the floor using walking sticks, the numbers 1 to 12 written on cards and laminated, and coloured pencils. The coloured pencils were used as the minute lines and matching walking sticks, adjusted to different lengths, became the hands. For this group the building of the clock face on the floor and the directions to read minutes without looking at the numbers were practical experiences. The novelty of the activity engaged this group of 14 students as everyone had a part to play, either being a number on the clock or moving one of the hands.

The second group of students had displayed competence in reading the time in hours and minutes. Their task required them to work in pairs to develop a timetable allowing each student in the room to experience 15 minutes of fame. This task gave the more experienced students an open-ended problem to solve which focussed their attention on the addition of 15 minutes to any given time. The timetables were to include the reason each student would achieve fame.

The novelty of the activity engaged this group. Students at this level believe in their ability to become famous in the future. They responded well to the opportunity to consider their future fame. Their response to this challenge was very positive, although many students developed their timetables beginning on the hour, half hour and quarter hour times. The times are recorded as written by the students, including the crossed out time of 12:60 that was amended to 1:00 (see Table 5.5).

Table 5.5  
*A 15 minutes of Fame Timetable*

Start	Name	Famous for	Finish
12:00	01B4	Astronaut	12:15
12:15	19B4	Shops	12:30
12:30	21B4	Teaching	12:45
12:45	04G4	Being pretty	<del>12:60</del> 1:00
<del>12:60</del> 1:00	26B3	Inventing	1:15
1:15	Student not in study	Singing	1:30
1:30	18B4	Robber	1:45
1:45	12G4	Swimming	2:00
2:00	07G4	Maths	2:15
2:15	15B4	Scary	2:30
2:30	Student not in study	Singing	2:45
2:45	11B3	Tunes	3:00

At the end of the lesson, each pair of students was eager to share their timetables. Most pairs had included every student in the room and, in a few instances, included the adults as well. Some of the timetables had students achieving fame with another student and others gave individual students their own reason for fame. Some examples were being a hero, best hair tie thrower, coolest person, fly killer, quietest person, most creative, best at working together, for being funny, for being smart, and for being my friend.

### ***Reflection on the lesson in light of the Framework***

The group of students who built the clock on the floor demonstrated a willingness to be involved and to read the constructed time by counting the minutes and reading the hours. It was interesting that this group wanted to have more examples of clock times to read from a smaller clock when the session was concluding. It was pleasing to see that the movement of the clock hands was becoming more meaningful to these students as they became more familiar with relationships between seconds, minutes and hours. The group constructing the timetables demonstrated their ability to add 15 minutes to a quarter hour time. Only one group produced a

timetable that deviated from this pattern (see Figure 5.3). These students explained the gaps in their timetable as making a pattern of minutes (5,2,3,5,5,5).

1:00 to 1:15 J. 5 minute break.
1:20 to 1:35 N. 2 minute break.
1:37 to 1:52 J. 3 minute break.
1:55 to 2:10. C. 5 minute break.
2:15 to 2:30. T. 5 minute break.
2:35 to 2:50. E. 5 minute break.
2:55 to 3:10. S. 5 minute break.
3:15 to 3:30. A. 2 minute break.
3:32 to 3:47 H. 3 mins.
3:50 to 4:05. L. 5 mins.
4:10 to 4:25. J. 5 mins.
4:30 to 4:45. N. 5 mins.
4:50 to 5:05. E. 5 mins.
5:10 to 5:25. I. 2 mins.
5:27 to 5:42. E. 3 mins
5:45 to 6:00. L. 5 mins.
6:05 to 6:20. T. 5 mins
6:25 to 6:40. 5 mins

*Figure 5.3.* A 15 minute timetable not commencing on the quarter hour.

The calculations used in this timetable demonstrated a more advanced understanding of the addition of minutes than the students who began each session on the quarter hour. Each group of students who worked on this problem demonstrated an understanding of duration as an unbroken period of time. For this task the duration was 15 minutes.

The creation of a day and a year were introduced in Lesson 2. A review of Lesson 5 indicated that the students were developing an understanding of the day and its breakdown into smaller units such as minutes and hours. The next lesson was developed to promote the further understanding of the measurement of years.



### **5.2.6 Lesson 6: Many happy returns**

On Wednesday, the students were involved in their swimming program. The sixth lesson was Thursday, 29 October. This was the first lesson to focus on calendars.

#### ***Targeted Framework Components and key ideas***

Succession:

- Two or more different events are organized sequentially.
- Years are arranged in succession in numerical order.
- Succession involves the present, the past and the future

#### ***Rationale***

One-to-one interviews with the children prior to the intervention identified some weaknesses in aspects of succession and duration of time relating to calendars. Weaknesses included calculating the date one month ago (Item 32 scored 29 points from a possible 54 points), calculating the date three weeks from a given date (Item 33 scored 34 points from a possible 54 points) and calculating the date two years hence (Item 34 scored 36 points from a possible 54 points). These items were identified as weaknesses as each scored below the researcher's selected figure of 75% accuracy (see Section 4.6.1). These concepts were not included in the NAPLAN items assessed but were still considered important elements of the language of time to be incorporated into the lesson intervention.

#### ***Mathematical foci***

- Ordering of years, months in succession.
- Counting years, months forwards and backwards.

#### ***Links to the Australian curriculum***

- Describe durations using months, weeks, days and hours. ACMMG021.
- Name and order months and seasons. ACMMG040.
- Tell the time to the minute and investigate the relationships between units of time. ACMMG085.
- Convert between units of time. ACMMG085.

### *The lesson*

An important major Component from the Framework, Succession, was introduced to the students as a new word to be added to the list commenced in Lesson 1. To introduce this concept, the teacher-researcher showed the children the book *Window* (Baker, 1991). This book, which follows the life of a man from babyhood to adulthood by looking at and through his bedroom window, has no written text. The readers of the book are made aware of the succession of time by observing the changes occurring within the room and through the window.

The students' task was to work with a partner to create a calendar that extended across 18 years. The calendar had to be constructed in the correct order, beginning with 2000 and ending with 2018, resulting in a timeline of years past and years in the future. Once completed, the students marked significant events on the calendar such as the month and year of their birth, the commencement of school each year, Christmas each year, siblings' birthdays, and the school holidays for 2015 and 2016. Once completed, the students calculated how many days, weeks or months since their last birthday to the present day or month. Ages could be compared and ordered according to years and months or years and days.

The students talked a lot as they constructed their calendars. The following questions and comments have been taken from the audio recording of the lesson.

Student A: (speaking to the Teacher): Why did you make 2016 and 2017?

*Teacher: Because the world is not going to stop this year. This is the future. You might like to mark on your calendar when you will be in Year 5 or 6.*

Student A: That is my future. I will be in Grade 5.

Student B: What year were you born in?

Teacher: 1952. I was born in January.

*Student B: Wow.*

*Student C: My dog Scruffy was born in June 2013.*

*Teacher: How old would he be? Can you count the months after 2 years?*

Student C: 2 years and 4 months.

*Teacher: How many months before Scruffy is 3?*

Student C: 8 months.

Student D: We put birthdays. A leap year.

*Teacher: What Leap Year is after 2000?*

Student D: 2004, then 2008, then 2012, then 2016. My brother will have a birthday next year.

Student E: 2017 we will be graduating from primary school.

Although birthday celebrations vary between families due to ethnic, cultural and religious beliefs and customs, each child had a date of birth which could be placed on the calendar. When they calculated their ages in years and months, students were surprised at the small gaps between the ages of their peers. The oldest student in the class was 11 years and one month, but the second oldest student was only six months younger. After calculating their ages in years and months, students lined up in order of age, a task several students found challenging, requiring assistance to find their place in the line.

The completed list of years was both a calendar and a timeline and as a group the students could see why this was the case. Going from 2000 to 2017 included the past, the present and the future.

### ***Reflection on the lesson in light of the Framework***

The students' responses to the tasks demonstrated an understanding of the new term, succession. Further experiences which encouraged this word to be used frequently would be advantageous to consolidation of language and problem solving related to succession. As the students put their calendars into chronological order the pattern of years became evident, so that calculating the year that would be two years into the future or two years past became much easier than solving a similar problem mentally as was required during the one-to-one interview. All the years were placed in correct order on the calendars demonstrating the group understanding of the succession of years. The assistance of more capable peers would have aided the learning of the students who did not demonstrate a full understanding of the sequence of years during the pre-intervention interview. Placing years into the future created opportunities for discussing time that differed from reading clocks to find the present time or calculating durations of time between past events.

New words had been introduced to the students' vocabulary over the preceding six lessons. The next lesson was developed to promote the use of words that although in common usage within

the population, had not been demonstrated by the Year 3 and 4 students as being understood. After reviewing the previous lessons, additional words and phrases were added to the game.

### **5.2.7 Lesson 7: Tomorrow is another day**

Lesson seven was on the following day Friday, 30 October. This was the second lesson to focus on calendars and the first lesson that incorporated a game as a learning strategy.

#### ***Targeted Framework Components and key ideas***

Succession:

- Succession involves the present, the past and the future.

Measurement:

- The learning and teaching of time is incorporated into the school curriculum, with emphasis on measuring time with clocks and calendars.

#### ***Rationale***

Calendars, like clocks, have two major functions. Students need to identify the current time. As clocks are used to measure units of time up to and including one day (24 hour clock), calendars are used to measure time in days, weeks, months and years. Calendars allow us to measure and record how many days, weeks or months have elapsed since an event, how many days weeks or months will occur or have occurred between events, or will elapse before an event. There are words and phrases used to determine when events have occurred or will occur. The language of calendars refers to the language used every day to reference days not only in the past, but also the future. Words and phrases referring to the past include yesterday, last week, three weeks ago and last night. Today and now refer to the present, while next week, in another three days and tomorrow are all in the future. The key understandings selected for this lesson included understanding words and phrases in common usage when discussing time, and adding words and phrases relating to time to their vocabulary in order to explain or describe when events have occurred or will occur.

Two items in the interview administered prior to the intervention asked the students to identify the day before yesterday and the day after tomorrow. From a possible score of 54, these items scored 45 and 50 respectively. Although these scores were not low (83% and 93%), the researcher had anticipated that all children would know these terms resulting in scores being closer to 100%. The NAPLAN items given to the students did not include questions relating to understanding the language of time.

### *Mathematical foci*

- The language (words and phrases) used to identify days on a calendar.
- Calculating days, weeks and months forwards and backwards from a given date.

### *Links to the Australian curriculum*

- Year 1. Describe duration using months, weeks, days and hours. (ACMMG021)
- Year 2. Name and order months and seasons. (ACMMG040)
- Year 2. Use a calendar to identify the date and determine the number of days in each month. (ACMMG042)

### *The lesson*

The text used for this lesson was *My grandmother's clock* (McCaughrean, 2002). This story tells how a grandmother uses different events to determine the time of the day, the days of the week and the seasons of the year. While we, like the grandmother in the story, use many clues to ascertain times, we also use different words and phrases to explain when events have occurred or will occur.

To promote the language previously described, the teacher-researcher developed a game and named it, 'Tomorrow is another day.' The game consisted of a game board made with a 12 month calendar, cards with words and phrases relating to the past and the future, and counters to determine a player's position on the board. The aim of the game was for a player to take a card, then move from their present position to the day specified on the card. For example, if a player's counter was on August 26 and the next card selected had 'a week ago' written on it, the player had to move his or her counter to August 19. When all the cards were exhausted, the player closest to a pre-arranged date was declared the winner.

The students really enjoyed the novelty of this game and played it several times. An additional challenge was to place a clock beside their game and to time the duration of each game. At the conclusion of the lesson, students were encouraged to give suggestions for improvements to the game which included alternative words and phrases, names for the game and possible new rules. The suggestions, listed below, indicated an interest in the game and some improvement to the students' vocabulary of time-related phrases.

Start on today and try and catch and eat the other person.

Some more days/another month. A 13 or 14 month calendar.

After 31<sup>st</sup> December, off the board means out.

Some more words and phrases that are a bit harder. A month ago or 31 days ago.

Go back 3 months so we don't stay on the same spot.

3 players. One to read the cards. Cross out the month when it is passed.

Cross off a date so it becomes off limits.

Go back to today so you are not completely out.

Some of the cards could go the opposite way. Forwards and backwards.

(There were some).

Go to a date furthest from your target.

When asked if the time limit was a suitable duration, the responses varied, but the general consensus was that it was the right amount of time. Recorded times for the games were three minutes, five minutes, eight minutes, and 12 minutes. The students decided that this was a suitable period of time to play a game.

To continue to reinforce the language of time, this game would need to be played regularly. New words could be added and the game board could be altered to accommodate longer or shorter periods of time, such as several years or only a month.

The students were very positive about playing the game from the outset. After a demonstration game, one student immediately said that he had thought of another name for the game. The rest of the class thought that his suggested name of *Time Warp* or *Time Warp*, was an excellent choice. It was pleasing to see their enthusiasm when giving ideas to improve the game and their honesty in evaluating the game as many of the improvements such as the addition of more days and months to the board and more challenging phrases to the cards would add to the vocabulary used to play the game. As this was the first time the game had been played, the students took the responsibility of giving feedback quite seriously.

### ***Reflection on the lesson in light of the Framework***

The students assisted each other when playing the game by ensuring the pieces were moved to the correct date. If a student was unsure of a phrase, playing the game with a more knowledgeable peer would help potentially him or her to become familiar with the language required. The game was a practical way for the students to experience the language relating to

the past, the present and the future as well as observing each day as a point on the time continuum.

The sample group's letters reflect the class interest in the rotation and revolution of the Earth and the key concepts of duration and succession as shown in Table 5.8.

The analysis of the students' letters (see Appendix P) was of assistance in evaluating the classroom experiences of the eight-lesson intervention, as several words, phrases and ideas appeared in many of the letters. It was interesting to note that revolution, rotation, and duration appeared often. Twenty students wrote something about the Earth's movements and 16 students used the word duration. One student gave a definition of duration. Less often, but also of interest was the mention of hours, minutes and/or seconds, calendars and succession. Six students wrote something about calendars, six students mentioned units of time and five students wrote that they had learned about succession. Twelve students commented on the game although only one student wrote that the game was a calendar game.

The next lesson was planned to bring the ideas learned from the previous seven lessons together. As the lessons were reviewed, ideas that needed further clarification were listed and suitable activities devised to reinforce them.

### **5.2.8 Lesson 8: From time to time**

The last lesson was on Monday, 2 November. This was the final lesson of the intervention with a variety of activities to assess the students' learning and the effectiveness of the program.

#### ***Targeted Framework Components and key ideas***

Measurement:

- Manufactured units of time (second, minute, hour, week) are entrenched in our culture.
- Time measuring devices (for example, the atomic clock) have become extremely sophisticated.

#### ***Rationale***

Reading the time from clocks and calendars is an important life skill that students need to develop. Being able to read, measure and record the time assists us to plan for future events, be on time for current events and have an appreciation of our past. Throughout the intervention, students were introduced to the concept of time being measured in seconds, minutes and hours (which can be determined by only reading the hour hand), as well as years and months.

### *Mathematical focus*

- Telling the time on analogue and digital clocks.

### *Links to the Australian curriculum*

- Year 1. Tell the time to the half-hour. (ACMMG020)
- Year 2. Tell the time to the quarter-hour, using the language of ‘past’ and ‘to’. (ACMMG039)
- Year 3. Tell the time to the minute and investigate the relationship between units of time. (ACMMG062)
- Year 4. Use am and pm notation and solve simple time problems. (ACMMG086)

### *The lesson*

We recognise the passing of time as events come and go, the seasons change, and we grow older. To promote discussion on the passing and measuring of time, the teacher-researcher read *A year on our farm* (Matthews & McLean, 2002), which follows the month by month changes on an Australian farm. A variety of responses were given to the question asked by the teacher-researcher, “How do we know time is passing?” Student responses included: the seasons change, we have day and night, months, years and days go past, seconds tick by, minutes go by, the sun moves across the sky, decades and centuries pass, the weather changes from warm to cold, special dates are repeated yearly, the sun’s position changes, a clock changes, stars come out, and the date changes.

Four activities were designed to focus on the passing of time and to reinforce the ideas presented in the last seven lessons. The first two activities required the students to solve problems, with the third activity being a quiz, whereby teams of students had to work together to find solutions to the questions. The fourth activity required the students to complete a task begun in lesson 1.

For the first activity, students were presented with the following problem. Eight one-minute sand timers were placed on the table. The teacher-researcher explained that the sand timers had to be checked for accuracy as there was the possibility that the manufacturer had made them cheaply without considering their accuracy. The students’ task was to determine the duration of time for the sand to run through each sand timer and to record their results. While this was an enjoyable activity to complete, the students were making use of their skills in reading seconds and minutes on a clock as evidenced by Table 5.7 which displays the results from the sample group of students. Although the students worked in pairs to check on each reading, the



sand timers were found to produce both inaccurate and inconsistent results. Trials completed by the researcher before the lesson produced similar results.

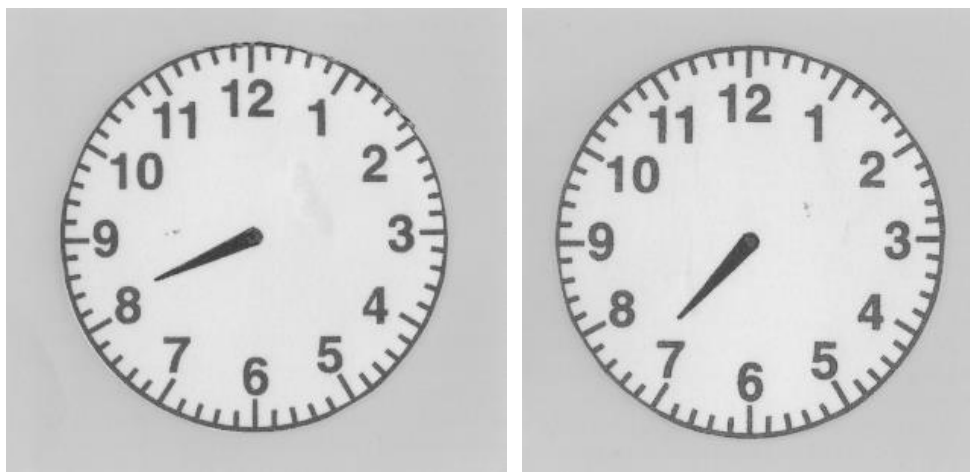
Table 5.6

*Recorded Times for Sand to Run Through Each Sand Timer*

	Numbered sand-timers							
	1	2	3	4	5	6	7	8
<b>03G3</b>	84 secs	70 secs	78 secs	86 secs	76 secs			
<b>05G3</b>	72 secs	84 secs			45 secs	84 secs		87 secs
<b>07G4</b>	1m 15s	1m 25s	1m 20s	1m 35s	1m 20s	1m 34s	1m 20s	1m 25s
<b>13B3</b>	1m 31s	1m 26s	1m 38s	1m 30s	1m 25s		1m 26s	
<b>18B4</b>		1m 24s	1m 25s			1m 40s	1m 22s	1m 30s
<b>24B3</b>	1m 35s	1m 25s	1m 25s	1m 35s		1m 13s		1m 23s

Many of the students were amazed at the inaccuracy of the sand timers as they had assumed that each sand timer would measure one minute. The times for the sand to flow from one end to the other varied from 45 seconds, to one minute and 38 seconds. This was an engaging activity as the end result was often a surprise but also beneficial as the students used the clocks to measure time.

The second problem required the students to understand the purpose of the hands on a clock. The students were told that one of the hands had fallen off my clock. “When I woke up this morning, I saw that one hand had fallen off my clock. I went back to sleep and when I woke up again, the clock hand had changed. I have drawn pictures to show how the clock looked each time I woke up.” The one-handed clocks are shown in Figure 5.4.



*Figure 5.4. The one-handed clocks used in lesson 8.*

The students were asked to decide and justify the order of the pictures, and then calculate the time between the first awakening and the second. This task was to be solved independently. Several students drew the extra hand on the clock to complete the drawing. Students were encouraged to use a clock to match the remaining hand, as the remaining hand was not pointing directly to a number as they first thought. When the hand was matched to a clock with both hands present, the times were not found to be 7:30 and 8 o'clock, but were 24 past 7 (25 past 7 was also accepted) and 12 past 8 (10 past 8 and 11 past 8 were also accepted). There were multiple solutions to this problem. If the hour hand had been missing, the extra sleep may have only amounted to four minutes, but other possible solutions could be any number of hours plus four minutes.

Several students looked for the simple solution. With the first picture, the students assumed that the hand was pointing half way between the 7 and the 8, indicating half past seven. The second clock was assumed to be 8 o'clock as the hand appeared to be pointing to the 8. These students were encouraged to get a small clock, look carefully at the illustration to determine the position of the hand and then place one clock hand in the same position as the hand that was illustrated. The teacher-researcher guided the students who were having difficulty by suggesting they look at the minute lines to determine the exact position of the drawn clock hand.

A brief overview of the lessons and a review the activities concluded the intervention. The review took the form of a quiz, whereby the students were placed into teams of four based on their classroom mathematics groups, to answer questions. Students had to work as a team to recall aspects of time that had been introduced throughout the intervention such as, 'What is the third month of the year?', 'Would it take me a second or a minute to blink?' and 'Why is it dark on the other side of the world?' Although the quiz consisted predominantly of closed questions, the format of the quiz and the structure of the teams ensured all students were engaged. Only one student was noticed sitting back and shrugging her shoulders, leaving the others in her team to answer. This student had scored 61 for the pre-intervention interview and had required additional assistance with tasks throughout the eight-lesson intervention.

This final lesson was also of importance when evaluating the eight-lesson intervention as the activities were designed to add to the assessment of the students' learning over the intervention period.

### ***Reflection on the lesson in light of the Framework***

Measuring the duration of the sand timers with the clocks focussed on comparing informal measurement of time with the more precise formulated units of time. The positive response to

this task and the way the students worked together to time and record the duration of each sand timer indicated that these students were able to measure and record times in seconds, minutes and a combination of minutes and seconds.

At the commencement of the unit on time, the students had written sentences or dot points to complete the statement, *Time is....* To complete the unit, students repeated this exercise taking into consideration what they learned over the past eight lessons. To compare the list of words and phrases from lesson one with the list from lesson eight, the responses from the sample group are displayed in Table 5.7. Points of interest included the number of words and phrases in each list, the addition of key words such as *succession* and *duration*, and items relating to the rotation and revolution of the Earth.

### **5.2.9 Summary of lessons**

It was interesting to note the changes in the students' overall concept of time and related skills. In the first lesson, many students had listed words directly related to clocks and telling the time but, after the eight lessons, they added more specific details such as the revolution of the Earth around the Sun, being able to draw a clock, and noting that one-minute timers were inaccurate. Students wrote many more words including new words such as *succession* and *duration* on the second occasion. An overall number of words and phrases for the class was obtained by adding all the words in each individual list. In the first exercise the class listed 234 words or phrases and when the task was repeated the list grew to 281 words or phrases associated with time, an increase of just over 20 percent. The inclusion of words that had been introduced to the students during the eight weeks indicated that students had not only expanded their vocabularies, but had developed their concepts of the major Components of time.

The students used the terms rotation and revolution throughout the intervention. The lesson which focussed on the movement of the Earth in space was instrumental in promoting an understanding of the connections between days and years in a practical way. The relationship between the northern and southern hemispheres which experience seasons and night and day at different times of the year became much clearer to the students through the modelled demonstration. The analysis of the students' letters as shown in Table 5.8 further demonstrated the addition of time related words to the students' vocabulary.

The use of clocks to measure the progression of time allowed the students to see how the gaps on the clock face as well as the lines were important to the reading of the time that had passed. Separating the reading of minutes from the reading of the hours on a clock benefited many of the students who had found the reading of clocks during the pre-intervention interview

confusing. Referring to the numbers for the reading of hours and the lines for the reading of the minutes was a strategy that assisted these students to measure the passing of time.

Table 5.7  
*Pairs of Sample Group Students' Responses to "Time is..."*

Student	Response
03G3. 15.10.15	Hours. Minutes. Half past. Quarter to. Quarter past. Seconds. Tick tock 60 minutes is an hour. 30 minutes is half an hour. 60 seconds is one minute. Am and pm.
03G3. 2.11.15	Useful. Helpful to be on time. Special because you can take as long as you want when you are doing something. The Earth takes 365 days to get around the Sun. Duration. It is very important with life. It's everywhere. Amazing.
05G3. 15.10.15	Clocks. Future. Half past. Quarter past. Hours. Minutes. seconds.
05G3. 2.11.15	Today I learnt how to draw a proper clock. These 8 days I've had an awesome time with Mrs T. Time is very quick.
07G4. 15.10.15	A way to measure the rotation of the Earth around the Sun. Seasons. Hour. year. day. week. second. month. minute.
07G4. 2.11.15	A way to measure the rotation of the Earth around the Sun. Minute. Rotation. Second. Stop watch. Nanosecond. Century. Days. Bicentenary. Months. Hours. Seasons. Weeks. Years. Revolution. Decade.
13B3. 15.10.15	A way of telling the time. A measure of past, present and future. Time Time is a way of telling seconds, minutes and hours.
13B3. 2.11.15	Time is seconds, minutes and hours. Time waits for no-one. Interesting Rotation of the Earth.
18B4. 15.10.15	Useful. Precious. Everywhere. Endless. Present
18B4. 2.11.15	Today I learnt lots more about time and egg timers are not accurate to one minute. Time is very useful. You can take time to figure out a hard question.
24B3. 15.10.15	A measurement of past, present and future. Time is a way of measuring in seconds, minutes and hours. A way of knowing how long it's been.
24B3. 2.11.15	Rotation of Earth. Seconds. Milliseconds. Nanoseconds. Minutes. Hours. Days Weeks. Months. Seasons. Years. Generation. Decades. Centuries. Present. Past Future. Time is how we measure length of an event. Succession. Duration.

As a reflection of their learning over the past seven lessons, the students were required to write a letter to a family member, a teacher or a friend explaining all that they had learned. To ensure the students had sufficient time to think about their learning and to write their ideas, this task was begun in at the end of this lesson and completed at the end of the last lesson. They were to include new words, new ideas and any other item of interest regarding time. Copies of the letters were retained as another form of assessment of their learning and also the success of the

intervention. Letters from the sample group have been copied below. All of the students' letters are listed in Appendix O. The analysis of the letters is listed below in in Table 5.8.

03G3

*Dear Mr T (Principal's name here),*

*Thank you for organising Miss T. to help us with time. We learnt that the Earth takes 365 days to go around the Sun once, the duration, hours and minutes. We learnt how to read time on a clock by reading minutes and then read the number the hour hand is on. Thank you for your time.*


*Kind regards,*

*L.*

05G3

*Dear Dad,*

*I missed u. I hope you enjoy my letter. In math my class learnt time with a lovely lady called Mrs T. We had a great time.*

 *,from S. xoxo. Lots of love. Xoxoxoxo.*

*P.S. I learnt that the earth goes around the sun for 365 days.*

07G4

*Dear Mum,*

*I'm writing to tell you about Mrs T's classes. I've liked learning about the following: duration, succession, revolution, rotation, [and] different ways to measure time, games and so on.*

*From E.*

13B3

*Dear Santa,*

*I have learned about duration of hours, minutes and seconds. And we also learned about revolution and rotation. After that we learned that there's 365 days in a year.*

*Cheers,*

*L.*

18B4

*Dear Mum,*

*In maths I have been learning about time. The new words I know is duration, revolution and succession. I loved all the activities and it was easy.*

24B3

Dear A,

*I have learnt about duration which is the length of time. Mrs T showed us how to play a game that involved a calendar.*

All the time related words and phrases written in the letters were listed under the appropriate major Component of the Framework (see Table 5.8 for an analysis of the sample group's letters). In the same way that the one-to-one items could be placed under more than one major Component, so could the words and phrases from the students' letters. Although the students were encouraged to write what they had learned over the eight lessons, the brevity of the students' letters suggested that the students had selected the aspects of the lessons that had interested them the most. Nevertheless, the analysis of each letter in relation to the Framework was further evidence of perceived learning.

Table 5.8

*An Analysis of the Sample Group's Letters*

Student	New ideas or words from three major Components			Additional feedback
	Succession	Duration	Measurement	
03G3		It takes 365 days to go around the Sun once. Duration.	Hours Minutes Reading time on a clock.	Thank you for organising the lessons.
05G3		The Earth goes around the Sun for 365 days. Duration		We had a great time.
07G4	Succession Rotation Revolution	Duration Rotation Revolution		I have liked learning about duration, succession, revolution, rotation and different ways to measure time. Games.
13B3	Revolution Rotation	Duration. Revolution Rotation 365 days in a year.	Minutes Seconds Revolution Rotation	
18B4	Succession Revolution	Duration Revolution		I loved the activities and it was easy.
24B3		Duration which is the length of time.		We played a game that involved a calendar.

Most notable were the words connected to the movement of the Earth in Space with 18 students writing about rotation and/or revolution. Eight students mentioned calendars while only six students included hours, minutes or seconds in their letters and three wrote about different ways time had been measured in the past. Sixteen students used the word *duration* but only five of these students included the word *succession*. The analysis of the students' letters in this way indicated the students' acceptance of a broader idea of time.

Activities such as building a clock on the floor, developing a timetable and measuring the duration of the sandglasses with a small clock gave the students opportunities to work together to solve problems about time. The students enjoyed working in groups as evidenced by their behaviour and their conversations within the groups. Further evidence of their enjoyment of the lessons came from the words and phrases written in their letters that could not be classified under any major Component but were considered important feedback from the students although not all students included writing to fit this category. As the letters were analysed, the words and phrases were listed under the heading *Additional feedback*. Table 5.9 lists the students who included this feedback in their letters and what they wrote.

Of particular interest were issues of concern which emerged from the lessons. Although the lessons were based on the results of the one-to-one interviews, it was still surprising to see in the first lesson the predominance of words and phrases based on clocks and telling the time and words such as amazing, outstanding, stupendous and wonderful, which seemed to have little relationship to the concept of time. One particular concern for the teacher-researcher was the culture of the classroom which appeared to encourage quiet independent work and finding the answers to questions, with little discussion with others. The intervention tasks were designed for learning to occur as the students worked through tasks, but some students were apt to rush just to finish. The discussion of their findings at the end of the lesson helped to overcome this attitude as students were encouraged to think about their own learning. Whilst the opportunity to work together to complete activities and to discuss their findings encouraged students to verbalise their thoughts, several students did not complete their self-reflections. A review of the lessons led the researcher to conclude that the writing skills of the students, the time available, and the students' limited experience in self-reflection may all have had some effect on the completion of the self-reflections.

Table 5.9

*Additional Feedback Included in Student Letters*

Student	Additional feedback
01B4	Time game was the most interesting thing. I suggested the name.
02G3	My favourite was calendars.
03G3	Thank you for organising the lessons.
04G4	Maths was AMAZING.
05G3	We had a great time.
06B3	Lots of inventions like sundial, water clock, and lots of other stuff.
07G4	I have liked learning about duration, succession, revolution, rotation and different ways to measure time. Games.
08B3	Other words.
09G3	Played a game called Time Warps.
10B4	The game was interesting. It was hard and I love a challenge. New types of clocks.
11B3	Interesting game. I liked doing the world going around the Sun on its axis.
12G4	Some things were hard but I gave it a go. We learned a game and a lot more.
15B4	I liked the game. We have been learning about time. I liked the teacher.
16G4	Finding out who I was born near. Some grade 3s should be grade 4s. T and L are older than me. I liked the book 'Grandmother's clock'.
17B3	Learning about clocks and Earth.
18B4	I loved the activities and it was easy.
19B4	A new game.
20B3	I have learnt so much. Sand clocks. Water clocks.
21B4	A game. Reading books was interesting. Finding out what 'time is' is a little bit hard.
22B3	We played a game that had months in it.
23B4	Learning about clocks, time and the Earth.
24B3	We played a game that involved a calendar.
25G4	One of my favourite things was the game. The world always faces the Sun.
27G3	M was teaching Maths and time. Some stuff was hard. I fiddled with my name tag. I enjoyed it.

**5.3 Post-Intervention NAPLAN Administration**

As described in Chapter 4, the students completed six items from past NAPLAN papers. (Details of the first NAPLAN test are in section 4.4.1.) After the intervention, the students were retested on the same six NAPLAN items and re-interviewed using the same one-to-one task-



based interview described in Chapter 3. Using the same assessment procedures following the intervention enabled comparisons to be made between the two sets of data, and provided one assessment of the impact of the intervention.

### **5.3.1 Post-intervention NAPLAN results**

The six NAPLAN items were given to the students four weeks after the conclusion of the eight lessons. The test conditions were the same as the first testing, with each student seated with a vacant chair beside him/her and supervised by one of the three teachers in the room. Twenty-six students completed the post-intervention NAPLAN items, with one student absent. Student 26B3 was absent for the first NAPLAN test, and student 23B4 was absent for the post-intervention NAPLAN test. The data below are for the 25 students who attempted the items in both October (15/10/15) and November (30/11/15). The format of the items was given in Chapter 4 (section 4.4.1) and as the items were the same as the first NAPLAN test, only the wording of these items is given here.

#### ***Item 22, 2008***

A bus took some students to camp. It left the school at 10:00am. The bus trip took one and a quarter hours. What time did the bus get to the camp? 10:30, 10:45, 11:15, 11:30. (See Figure 4.2).

Twenty-two students selected the correct response, two students selected 10:30, and one student selected 10:45. Six students changed their score for this question; five students who had previously selected an incorrect response chose a correct response and one student chose an incorrect response the second time after choosing the correct response in the first test. The percentage of correct responses increased from 72% to 88%.

#### ***Item 8, 2009***

An analogue clock is drawn with the hour hand pointing midway between 4 and 5 (See Figure 4.3). The minute hand is missing. What time could this clock be showing? 4 o'clock, half past 4, 5 o'clock, half past 5.

Two students who had previously selected an incorrect response selected a correct response the second time. One student who had selected the correct response in the previous test selected half past five despite drawing the minute hand pointing to the 6 onto the clock image. As a class, the number of correct responses increased by one from May (88% correct) to November (92% correct).

### ***Item 27, 2009***

Four watches are drawn, each showing a digital time (See Figure 4.4). *Which watch shows a quarter to 9? 8:15, 8:45, 9:15, 9:45.*

The number of correct responses to this item remained the same as for the first test (72%). Although three students who had previously selected an incorrect response had selected the correct response, three other students had changed their responses from correct to incorrect. Four students selected incorrect responses in both tests. The students who selected an incorrect response all chose a time showing a 9; five of the students selected 9:15 and two students selected 9:45.

### ***Item 15, 2010***

An analogue clock is drawn with twelve numbers and 60 minute markers. The hands are showing the time as 8:15 (See Figure 4.5). *What time does this clock show? 3:08, 3:40, 8:03, 8:15.*

Three students who had previously selected an incorrect response selected the correct response in the repeat test. Two students who had selected the correct response in the first test selected incorrect responses (3:08 and 3:40) in the repeat test. Although the percentage of correct responses rose from 76 per cent to 80 per cent, the increase amounted to only one student.

### ***Item 19, 2010***

The image is of a boy and a calendar for the month of July. The spaces are filled with the numbers one to 31, but there are no names on the calendar for the days (See Figure 4.6). *Ryan is making a calendar. 3 July is a Friday. What day is 27 July? Monday, Tuesday, Sunday, Wednesday.*

Four students who had previously selected an incorrect response to this item chose the correct response, although the responses from four other students changed from correct to incorrect, so that the percentage of correct responses remained the same (68%). One of these students selected six correct responses on the first test and five correct responses on the second test, making this her only error. Four students selected the incorrect response in both tests. The correct response for this item was Monday but the eight students with incorrect responses selected Tuesday.

### *Item 28, 2010*

Year 3 students go on a trip. This is the plan for the day. A timetable shows eight activities and the start time for each (See Figure 4.7). At 1:00 the students will be with the seals, seeing the movie, having morning tea, or at the park.

This item appeared to be the most challenging for the students in both tests. Only 14 students (56%) correctly identified the correct answer for the first test, but this number increased to 17 (68%) for the second test. Five students changed their response from incorrect to correct, two students changed from correct to incorrect and six students selected an incorrect answer in both tests. The Australian curriculum places the interpretation and use of timetables at Level 6 (ACARA, 2016c).

### **5.3.2 Summary of NAPLAN data**

Although the NAPLAN items and the test conditions were the same, between one and four students selected an incorrect response for a given item in the post-intervention test after selecting the correct response in the first test. This may be due to the students not reading the items carefully, guessing the correct response or making a conceptual error processing the item. This is discussed further in Chapter 6.

The results from the pre- and post-intervention NAPLAN tests are displayed in Table 5.10. The number of correct responses increased from the pre-intervention test to the post-intervention test in four items. The overall performance on items 27 (2009) and 19 (2010) remained the same.

Table 5.10  
*Pre- and Post-Intervention NAPLAN Scores (n = 25)*

Item	2008. Item 22.		2009. Item 8.		2009. Item 27.		2010. Item 15.		2010. Item 19.		2010. Item 28.	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Total	18	<b>22</b>	22	<b>23</b>	18	<b>18</b>	19	<b>20</b>	17	<b>17</b>	14	<b>17</b>
%	72	<b>88</b>	88	<b>92</b>	72	<b>72</b>	76	<b>80</b>	68	<b>68</b>	56	<b>68</b>

The histogram displaying the percentages of correct responses (see Figure 5.5) shows that although the results for each question either remained the same or improved, for three of the six questions the class as a whole scored 72 percent or less on both occasions. The highest percentage was for item 8, 2009 (92%) and the lowest percentage was for item 28, 2010 (68%). These results indicate that while the students had a reasonable understanding of the items in the

first NAPLAN test, there was some improvement in the students' NAPLAN results after the intervention. Statistical significance will be addressed later in this chapter.

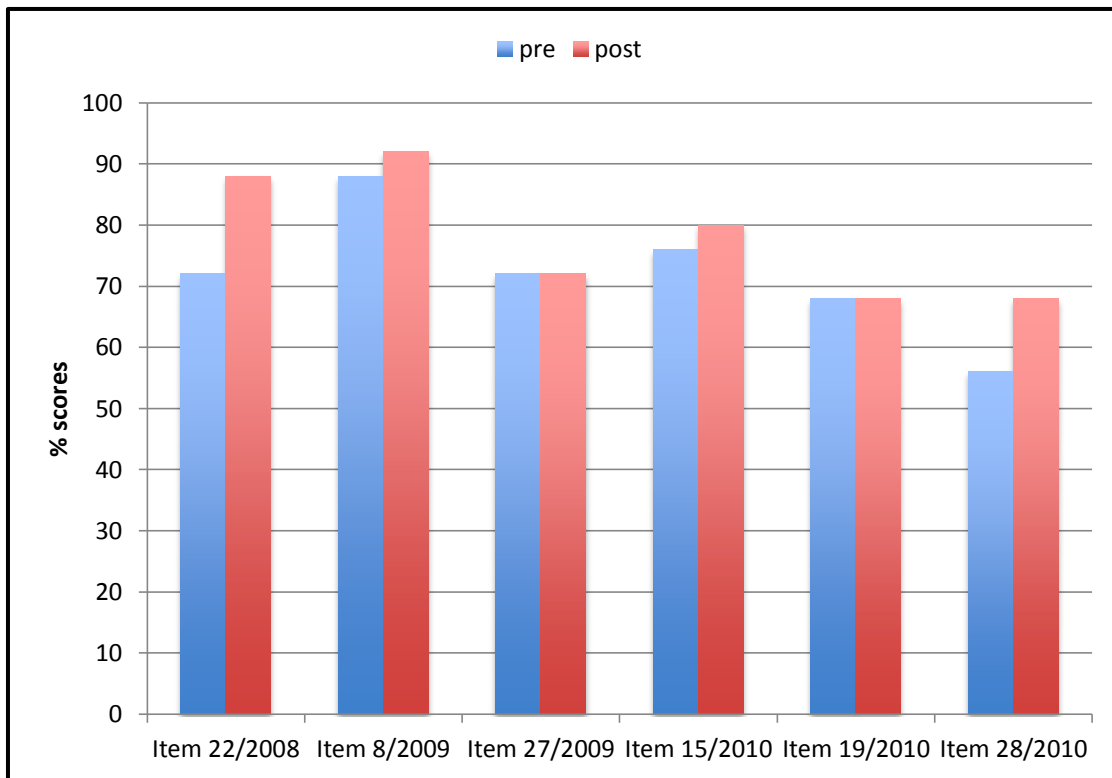


Figure 5.5. Percentage of correct responses to pre- and post-intervention NAPLAN items.

#### 5.4 Post-Intervention One-To-One Interview Data

Prior to the eight-lesson intervention, each participating student was interviewed by the researcher. The interview comprised 69 items and each student's responses were audio-taped. Three weeks after the conclusion of the intervention, the participating students were re-interviewed using the same one-to-one interview. The data from the pre-intervention interview were analysed to ascertain possible weaknesses or lack of development in the students' knowledge and understanding of time, and to aid in the planning of the eight lessons described in section 5.1. The data from the post-intervention interview were analysed as one means of assessing the knowledge and understanding gained through the intervention program, and ultimately, the effectiveness of the intervention program itself. (See Appendix P for post-intervention interview results.)

One way of representing improvement in the students' knowledge and understanding is to display the total score for the class on a box plot (see Figure 5.6) for each interview. As stated in Chapter 4 (4.5.1), the students' scores for the pre-intervention interview (T1) ranged from 48 to 124 with a mean score of 93.4. By comparison, the post-intervention interview scores

(T2) for the students ranged from 63 to 133 with a mean score of 108.0. The outlier in the second boxplot (see Figure 5.6) is Student 23, the student with special needs.

From interview T1 to interview T2, the minimum score increased by 15 points and the maximum score increased by nine points.

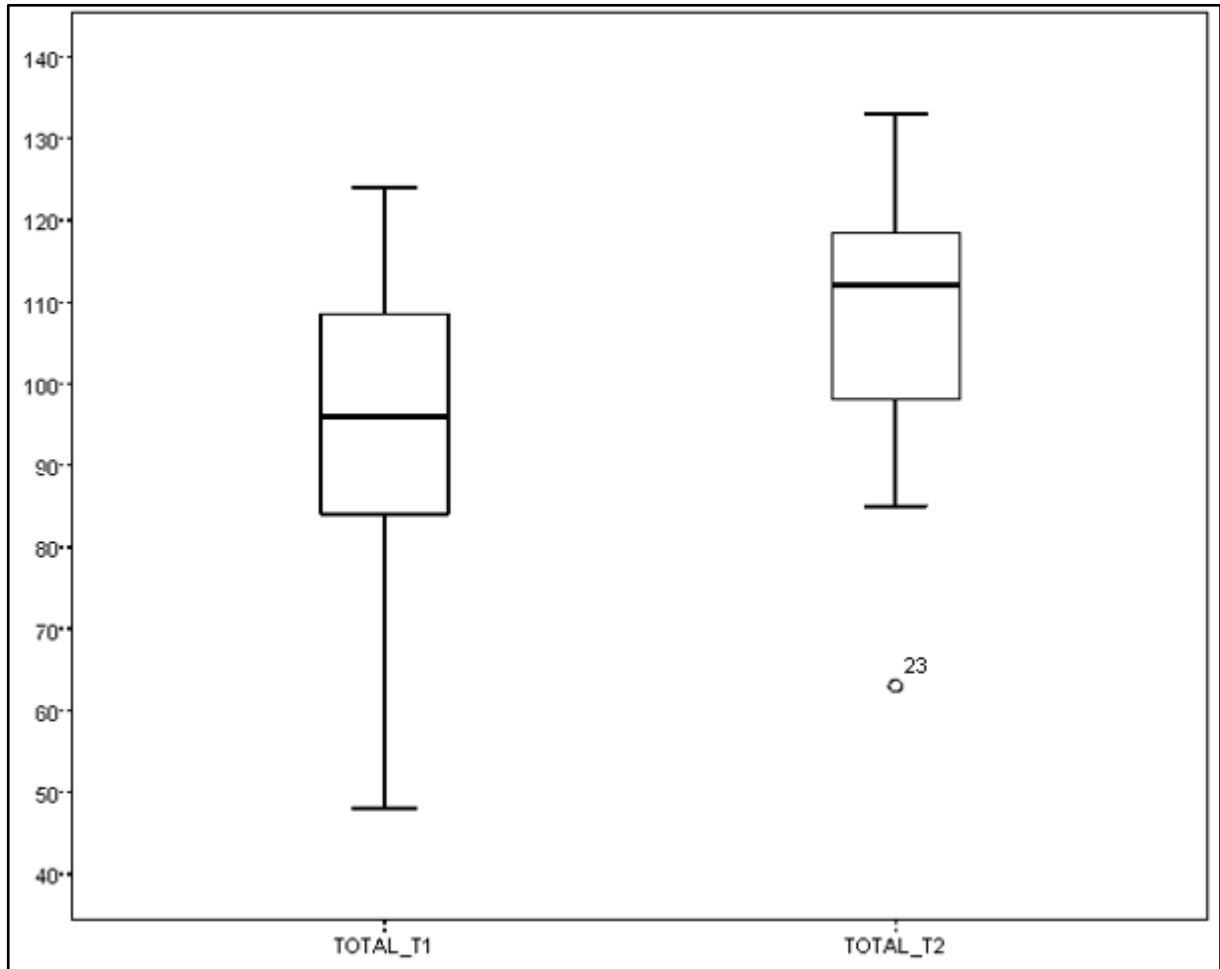


Figure 5.6. Boxplot of total scores from the pre-intervention (Total\_T1) and post-intervention (Total\_T2) interviews.

Although all students gained a higher total score for the post-intervention interview than for the pre-intervention interview, not all of the students' responses to interview items increased their score from 0 to 1, 0 to 2, or 1 to 2 as shown in Table 5.11. Of course, it was not expected that all students would improve in all items. The overall increase and decrease in scores can be seen in the crosstabulations in Table 5.12. Of the 1,863 responses, 432 scores (23%) increased in this way, 1,263 scores (68%) remained the same, and 168 scores (9%) decreased from 2 to 1, 2 to 0, or 1 to 0. Crosstabulations for individual items in the interview are in Appendix Q. Possible reasons for the decrease in scores for responses are discussed in Chapter 6.

Table 5.11

*Increases and Decreases in Students' Scores from Pre- to Post-Intervention Interviews*

	0-0	0-1	0-2	1-0	1-1	1-2	2-0	2-1	2-2	Total items
01B4	7	3	6	1	6	4	0	4	38	69
02G3	5	7	4	3	6	5	2	0	37	69
03G3	14	6	17	1	4	5	0	1	21	69
04G4	0	1	3	3	8	5	2	0	47	69
05G3	9	5	6	0	5	2	1	5	36	69
06B3	2	2	4	1	6	7	0	6	41	69
07G4	0	0	3	0	3	7	0	2	54	69
08B3	2	2	5	2	5	4	0	2	47	69
09G3	8	7	6	3	3	9	4	2	27	69
10B4	0	0	1	0	3	9	0	5	51	69
11B3	4	3	7	2	5	4	2	2	40	69
12G4	6	3	10	0	6	7	2	1	34	69
13B3	13	7	7	1	3	1	3	6	28	69
14G4	3	2	6	6	9	5	5	2	31	69
15B4	1	2	4	1	7	10	2	1	41	69
16G4	4	2	3	0	5	3	0	6	46	69
17B3	1	6	11	0	8	5	2	3	33	69
18B4	2	2	7	2	7	8	2	2	37	69
19B4	7	3	15	1	7	3	3	4	26	69
20B3	10	3	11	2	7	9	2	5	20	69
21B4	3	0	10	1	6	6	5	4	34	69
22B3	6	7	6	2	7	4	3	3	31	69
23B4	24	7	7	5	6	3	2	0	15	69
24B3	2	0	7	2	3	6	2	1	46	69
25G4	1	4	2	1	4	8	1	1	47	69
26B3	3	3	6	1	4	8	3	5	36	69
27G3	15	9	10	1	3	5	4	1	21	69
Total	152	96	184	42	146	152	52	74	965	1863

As is clear from Table 5.12 there are a number of items for which many students' responses improved from 0 to 2. Three items for which this was the case were:

Succession: Without turning the page, look at this month and tell me, what day of the week will be the first of next month?

Duration: What is something that takes a very short time to do? (The interviewer will need to make a judgement as to the reasonableness of the response before asking the second part of the item.) What is something that can happen in an even shorter time?

Succession, Duration and Measurement: People say that time has something to do with the rotation and revolution of the Earth. Do you know anything about that? What can you tell me?

Table 5.12  
*Crosstabulation of Item Scores from the Pre-and Post- Intervention Interviews*

		Post-intervention interview			Total
		0	1	2	
Pre-intervention Interview	0	152	96	184	<b>432</b>
	1	42	146	152	<b>340</b>
	2	52	74	965	<b>1091</b>
	Total	<b>246</b>	<b>316</b>	<b>1301</b>	<b>1863</b>

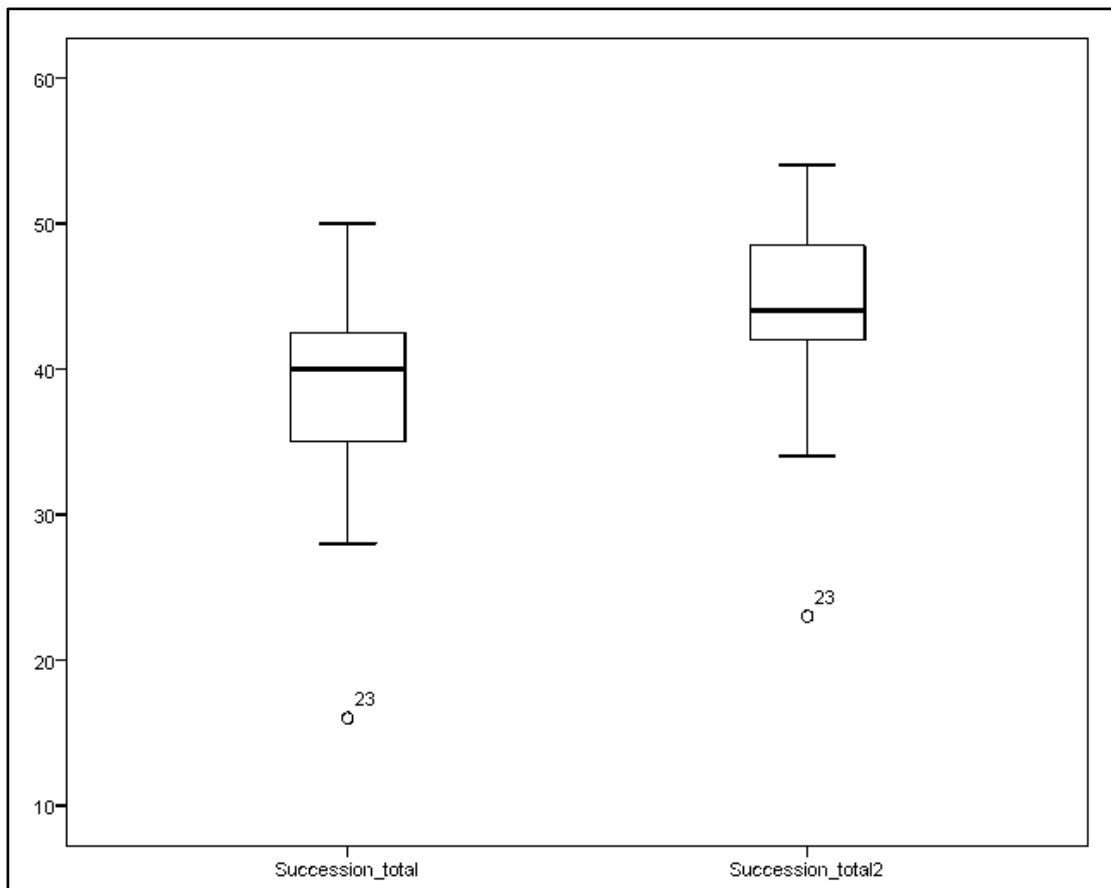
The next section shows the comparison between pre- and post-intervention scores for the interview for the Components of the Framework using boxplots. The relative descriptive statistics for Succession, Duration and Measurement are shown in Table 5.13. The statistics describe the whole group of 27 students including the outliers shown on the boxplot.

Table 5.13  
*Descriptive Statistics for Succession, Duration and Measurement*

	Succession		Duration		Measurement	
	Sept 2015	Nov 2015	Sept 2015	Nov 2015	Sept 2015	Nov 2015
Mean	38.7	43.7	36.1	44.8	65.7	76.7
Median	40	44	35	47	66	78
SD	6.8	6.3	9.4	8.0	16.0	13.0
Minimum	16	23	13	26	29	38
Maximum	50	54	54	59	88	96

#### 5.4.1 Comparison of the pre- and post-intervention Succession results

The pre- and post-intervention interview scores for the Succession items are displayed in Figure 5.7. Student 23 is shown as an outlier in both interviews. The minimum score for Succession increased seven points (16 to 23) from the pre-intervention interview to the post-intervention interview. The maximum score increased four points (50 to 54) from the pre-intervention interview to the post-intervention interview. The mean score increased from 38.7 to 43.7, an increase of five points. The median score increased from 40 to 44. The circumstances of student 23 have been discussed earlier.



*Figure 5.7.* Boxplot of total Succession scores from the pre-intervention (Succession\_total) and post-intervention (Succession\_total2) interviews.

#### 5.4.2 Comparison of the pre- and post-intervention Duration results

The Duration scores also improved from the pre-intervention interview to the post-intervention interview (see Figure 5.8). The pre-intervention (Duration\_total) interview scores ranged from 13 to 54 with a mean score of 36.1 and median of 35. The post-intervention (Duration\_total) interview scores ranged from 26 to 59 with a mean score of 44.8 and a median of 47. The maximum possible for the Duration items was 62.



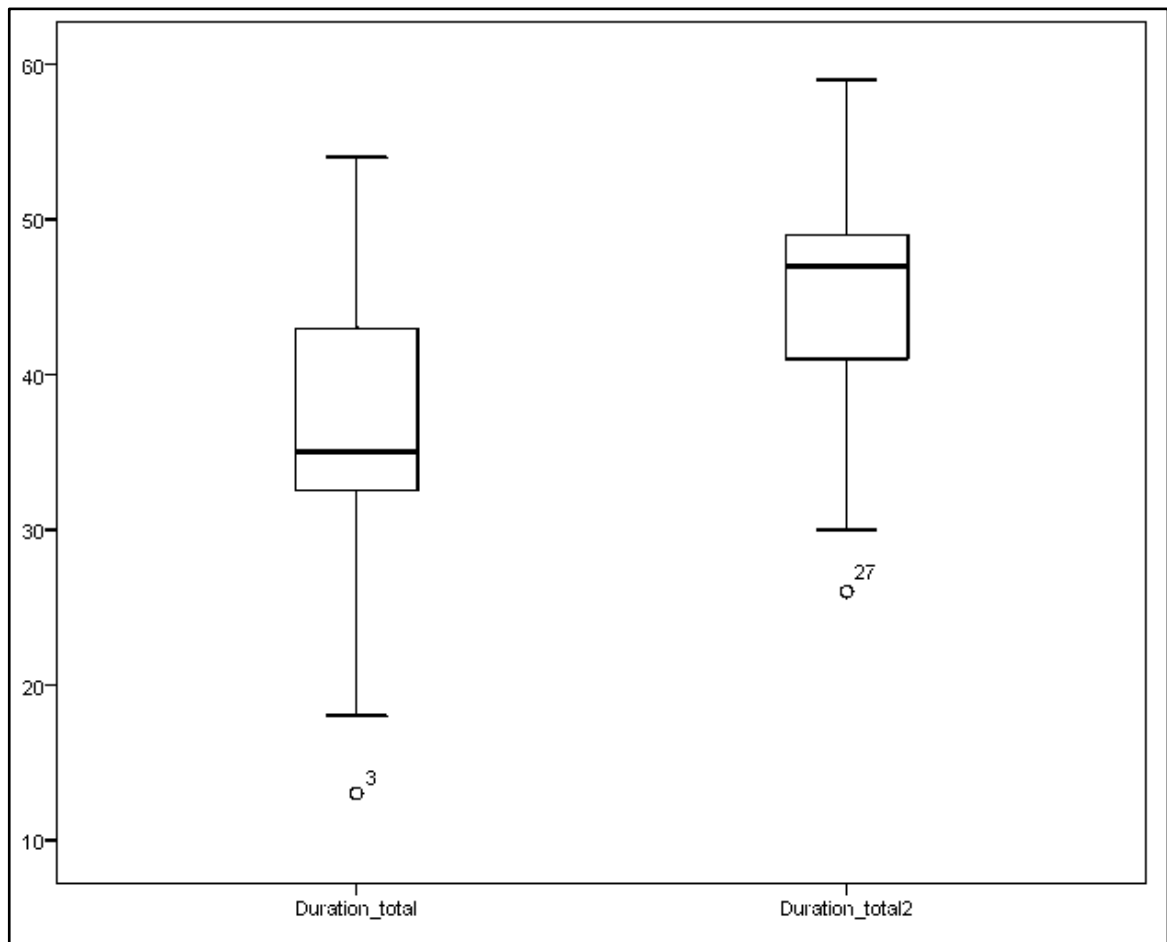


Figure 5.8. Boxplot of Duration scores from the pre-intervention (Duration\_total) and post-intervention (Duration\_total2) interviews.

### 5.4.3 Comparison of the pre- and post-intervention Measurement results

The scores for the Measurement items also improved from the pre-intervention (Measurement\_total1) interview to the post-intervention (Measurement\_total2) interview (see Figure 5.9). The minimum score increased from 29 to 38, the maximum score increased from 88 to 96 and the mean score increased from 65.7 to 76.7, an increase of 11 points. The median score increased from 66 to 78. The maximum possible score for the Measurement items was 98. Although Student 23 had shown an improvement in his scores from 29 to 38, the improvement from the other students placed him as an outlier. For the other students the second lowest score was 54; this was 25 points greater than the lowest score for the pre-intervention interview.

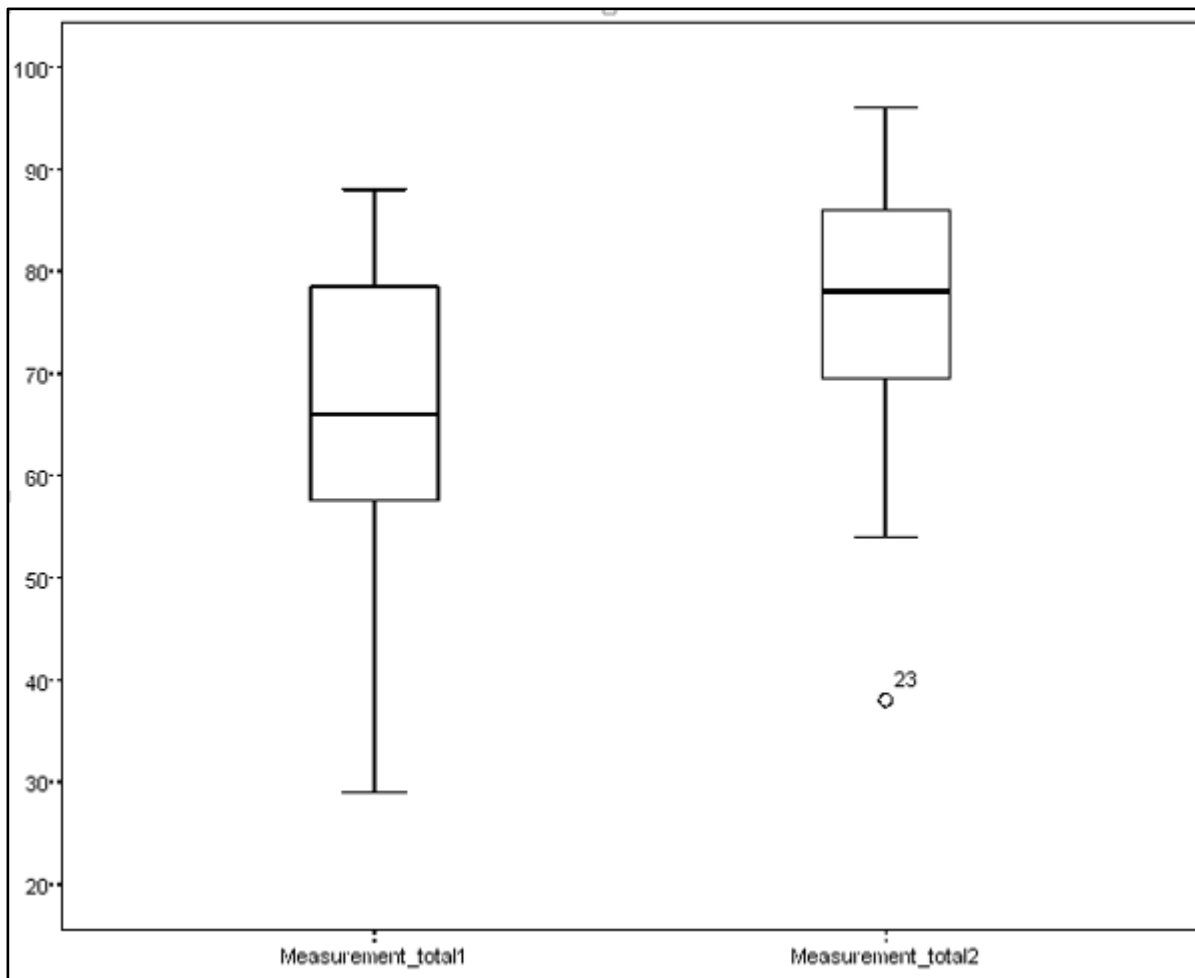


Figure 5.9. Boxplot of Measurement scores from the pre-intervention (Measurement\_total1) and post-intervention (Measurement\_total2) interviews

#### 5.4.4 A comparison of scores for individual students

Another indicator of how students responded to the post interview items is to look at percentage gains and losses. As indicated previously, for each item of the interview, two points were given if the student's response demonstrated a full understanding of the item, one point was given if the response showed a partial understanding, or zero points if the response showed no apparent understanding.

The percentage of responses that gained two points increased in all major Components; the percentage of responses that gained one point decreased for Succession and Measurement; and the percentage of responses that gained zero points decreased in all major Components of the Framework (see Table 5.14). An increase in the number of students gaining two points informs us that more students demonstrated a full understanding of the items. As the number of students gaining two points increased, the numbers gaining one or zero points decreased accordingly.

Table 5.14

*Percentage of Pre- and Post-Intervention Interview Responses Scoring 2, 1 or 0*

Major Component from the Framework	2		1		0	
	Pre	Post	Pre	Post	Pre	Post
Succession	60	67	23	21	17	11
Duration	49	62	19	21	32	17
Measurement	59	71	16	15	25	14

The improvement in scores from 0 to 1, 0 to 2 and 1 to 2 were shown to be items from many of the key ideas: Succession (three), Duration (five) and Measurement (6). When taken together these key ideas suggest an improvement in their understanding that time is passing at a constant rate and measured sequentially in units of equal duration. Prior to the eight-lesson intervention, responses to the interviews indicated that students had little understanding that time is measured, for example, days are measured in hours and minutes from midnight to midday and from midday to midnight.

#### **5.4.5 Considerations of correlations**

Correlations were calculated in order to examine the degree of association between the variables. Correlations were calculated for all possible pairs of variables from NAPLAN 1, NAPLAN 2, TOTAL 1, TOTAL 2, DURATION 1, DURATION 2, SUCCESSION 1, SUCCESSION 2, MEASUREMENT 1, AND MEASUREMENT 2. All correlations were highly significant at the 0.01 level, using Spearman's Rho. On reflection, the high correlations were to be expected, given that a particular item could be included in both the Duration and Succession set, for example. This overlap means that the correlations, while high, are of little practical significance.

#### **5.4.6 Summary of interview data**

The boxplots of the students' scores indicated an improvement in the three assessed major Components of the Framework from the pre-intervention to the post-intervention interview. A review of the percentage of responses which gained 2, 1 or 0 points also indicated an improvement in all the three major Components with a greater number of responses demonstrating a full understanding and fewer responses demonstrating a partial or no understanding. An improvement in the interview items relating to succession, duration and measurement indicated an overall improvement from the pre-intervention interview to the post-intervention interview.

## 5.5 Investigating the Statistical Significance of the NAPLAN Data

Twenty-seven students in the Year 3/4 class (16 boys, 11 girls) attempted the six Year 3 NAPLAN items on at least one occasion. Ages ranged from 8.83 years to 11.08 years. Of these 27, 25 attempted the items in both September and November, and the data reported below are for these 25 students. Relevant descriptive statistics are in Table 5.15.

Table 5.15

*Mean, Median and Standard Deviation for NAPLAN Item Totals*

	T1 ( <i>n</i> = 25)	T2 ( <i>n</i> = 25)
Mean	4.4	4.7
Median	5.0	5.0
Standard Deviation	1.6	1.5

As the data did not meet normality requirements on either occasion (Shapiro Wilk statistics .862 and .827,  $p = 0.003$  and  $p = 0.001$ , respectively), a Wilcoxon Signed Ranks Test was used to determine whether there were significant differences in performance from September to November. The Wilcoxon Signed Ranks Test showed that there was no significant difference from T1 to T2 (Wilcoxon  $Z = -1.062$ ;  $p = 0.288$ ). There were also no significant differences by age or gender on either occasion (for age:  $p = 0.125$  [T1],  $p = 0.145$  [T2]; for gender:  $p = 0.788$  [T1],  $p = 0.0472$  [T2]). These results were not surprising, owing to a ceiling effect. Of the 25 children, 14 scored either 5 or 6 out of 6 on the first occasion, giving little scope for improvement. Eleven students improved their total, five scored lower, and nine stayed the same. In hindsight, using items from Year 5 NAPLAN as well as Year 3 would have been desirable.

## 5.6 Investigating the Statistical Significance of Changes in Students' Interview

### Performance

Twenty-seven students were assessed using the interview in September and November. The maximum score possible on each occasion was 138. The data is summarised in Table 5.16.

#### 5.6.1 Age and gender

As the total score data did not meet normality requirements (Shapiro Wilk statistic 0.865;  $p = 0.002$ ), a Wilcoxon Signed Ranks Test was used to determine whether there were significant differences in Age or Gender. There were no significant difference by age or gender (for age:  $W = 176$ ;  $p = 0.343$ ; for gender:  $W = 222.5$ ;  $p = 0.952$ ). This was also the case for the individual Components, Succession, Duration, and Measurement.

Table 5.16  
*Mean, Median and Standard Deviation for the Interviews*

	T1 ( <i>n</i> = 27)	T2 ( <i>n</i> = 27)
Mean	93.4	108.0
Median	96.0	112.0
Standard Deviation	19.4	15.2
Minimum	48	63
Maximum	124	133

### 5.6.2 Comparison of results from the pre- and post-intervention interviews.

The Wilcoxon Signed Ranks test showed that the differences in total score from September to November were highly significant ( $Z = -.4.5$ ;  $p < 0.001$ ; two tailed). This was not surprising, given that all 27 students improved in total score from the first to the post-intervention interview. Table 5.17 shows the relevant descriptive statistics for Succession, Duration and Measurement.

Table 5.17  
*Descriptive Statistics for Each Component in September and November Respectively*

	Succession		Duration		Measurement	
	Sept 2015	Nov 2015	Sept 2015	Nov 2015	Sept 2015	Nov 2015
Mean	38.7	43.7	36.1	44.8	65.7	76.7
Median	40.0	44.0	35.0	47.0	66.0	78.0
SD	6.8	6.3	9.4	8.0	16.0	13.0
Minimum	16	23	13	26	29	38
Maximum	50	54	54	59	88	96

This highly significant result was also the case for the different major Components of the Framework, as shown in the Table 5.18. Twenty-six out of the 27 students improved in total score for Duration, 25 out of 27 for Succession, and 26 out of 27 for Measurement. Once again, there were no significant differences by age or gender.

### 5.6.3 Changes in the sample group

This section gives a brief description of the six students selected as a representative sample of the class group (see section 3.3.3.3 for details of the sample group) and the observed changes

Table 5.18  
*Significance of Major Components*

Major Component		
Duration	Z = -4.5	p <0.001 (two tailed)
Succession	Z = -4.4	p <0.001 (two tailed)
Measurement	Z = -4.5	p <0.001 (two tailed)

in their understanding of time. Data on the students were gained from discussions with, and observations of, the six students.

**Student 03G3**, a Year 3 girl, was aged nine years and nine months at the time of the pre-intervention interview. A quiet girl, she did not present as a strong student in mathematics. During the pre-intervention interview, she would often respond to an item by saying, “I don’t know”. Her score of 54/138 (Succession 26/54, Duration 13/62, Measurement 31/98) was the second lowest, with the lowest score belonging to a student who had been assessed by the classroom teacher as requiring special assistance. She was an enthusiastic participant in all classes, displaying pleasure in her new learning, in particular the reading of times on a clock, a skill which had previously been a challenge to her. Prior to the intervention, she read o’clock and half past times on an analogue clock, but only wrote o’clock times in a digital form. The letter she wrote to the Principal near the conclusion of the intervention reflected her enthusiasm and enjoyment (see Section 5.2.9). Her post-intervention interview score increased 43 points to 97/138 (Succession 38/54, Duration 30/62, Measurement 67/98), placing her equal to, or above, six other students.

**Student 05G3** was a Year 3 girl aged nine years and one month. Although she demonstrated a sociable and cooperative manner in the classroom, she was not highly motivated to begin mathematics tasks. She would not commence any task, whether she was working individually or in a group, until the teacher had checked that she knew what to do and had given her some encouragement. Her pre-intervention interview score of 91/138 (Succession 33/54, Duration 33/62, Measurement 66/98) ranked her at number 17 in the class. Although correctly reading the time from an analogue clock, she named litres and metres as units of time and did not understand how time could be measured. Her post-intervention interview score of 103/138 (Succession 39/54, Duration 44/62, Measurement 73/98) showed improvement in all major Components.

**Student 07G4** was a Year 4 girl aged nine years and 11 months. She appeared to be a keen learner as she enjoyed participating in all classroom activities and demonstrated an eagerness to answer questions often raising her hand before the other students. Although a reserved student, her classroom work appeared to be of a high standard as she quickly understood what was expected of her for each of the activities. The completion of all her self-reflections gave an insight into what she had learned although she had begun the intervention lessons knowing more about time, as assessed by the interview, than all but one other student. Her pre-intervention interview score of 122/138 (Succession 48/54, Duration 51/62, Measurement 88/98) was the second highest score. Her post-intervention interview score of 133/138 (Succession 52/54, Duration 59/62, Measurement 96/98) was the highest score, only five points from the maximum possible.

**Student 13B3** was a Year 3 boy aged nine years and five months. He appeared to be a popular boy in the classroom as many of the boys chose to sit with him, but he could be easily distracted from set tasks by the presence of his peers. His pre-intervention interview score of 79/138 (Succession 37/54, Duration 30/62, Measurement 51/98) placed him in the lowest 20% of the class. He named centimetres and millimetres as units of time, listed all the months of the year in order but was unable to name the season which included July or place annual events in order. He misread all the times displayed on an analogue clock. Although his score increased to 88/138 (33/54, Duration 34/62, Measurement 61/98) his improvement in Duration and Measurement (Succession score was lower) was not sufficient to improve his classroom ranking which dropped to the third lowest.

**Student 18B4** was a Year 4 boy aged 10 years and one month. His pre-intervention interview score of 99/138 (Succession 31/54, Duration 43/62, Measurement 74/98) may have been a reflection of his attitude in the classroom. He displayed some interest in learning but did not appear to be very highly motivated as he was often distracted by, for example, talking to his peers. Nevertheless, this behaviour did not prove to be a problem as he attempted each task with some confidence. This improved approach to his mathematics was reflected in his post-intervention interview score of 115 (Succession 40/54, Duration 46/62, Measurement 83/98).

**Student 24B3** was new to the school commencing at the beginning of the term. His ethnicity placed him in a minority group within the school with only 4% of the students from a language background other than English, but he soon became popular with the students as he taught them to solve the Rubik's cube puzzle quickly. He was a keen student who was quick to learn and despite being the youngest in the class at eight years and 10 months of age, his pre-intervention interview score of 109/138 (Succession 40/54, Duration 43/62, Measurement 78/98) placed him

seventh in the class ranking. He provided carefully thought out responses which presented an insight into his thinking. For example, when asked to order three annual events his response was,

Is this autumn? We don't celebrate Easter, so I'm not sure when Easter is. Summer. Winter and Easter might be in autumn, or spring. If it was autumn, it will be there [pointed] and in spring, it will be there.

His post-intervention interview score improved by 13 points to 122/138 (Succession 47/54, Duration 51/62, Measurement 86/98), the fourth highest score.

#### **5.6.4 The sample group's response to the intervention**

The pre-intervention interview scores for the sample group of students ranged from 54 to 122 demonstrating that this group was a representative sample. The six students all showed improvement in their scores from the pre-intervention interview to the second with improvements ranging from nine to 43 with a mean increase of 17. The tasks undertaken during the intervention lessons appear to have been instrumental in developing the students' understanding of the major Components of time. The students' verbal and written responses to tasks and their approach to using the available tools and materials displayed evidence of their learning (see Tables 5.6 and 5.7). The students demonstrated a positive attitude to the lessons by listening to and discussing the texts read to them, showing an interest in using the battery operated clocks and sand timers, and developing their own timelines and calendars. By actively undertaking the variety of activities and talking about their experiences without prompting demonstrated to the researcher that they had developed an interest in viewing the measurement of time in ways that were new to them.

#### **5.6.5 A summary of the sample group's learning**

Table 5.19 shows the performance of the sample group and the whole class on each of the major Components for each of the two interviews. The similarity in these scores demonstrate that the sample group of students were broadly representative of the whole class.

### **5.7 Summary of Chapter 5**

This chapter is the second of the two chapters reporting on the results of the study. The eight lessons of the intervention have been described with details of the Framework foci, the rationale for the lesson, the mathematical focus, links to the Australian curriculum and the collection of data included in the description.



Table 5.19  
*Mean Scores of Sample Group Compared with Whole Class*

Component	Pre-intervention interview mean score		Post-intervention interview mean score		Difference pre-and post-intervention interview mean scores	
	Sample group	Whole class	Sample group	Whole class	Sample group	Whole class
Succession	35.8	38.7	41.5	43.7	5.2	5.0
Duration	35.5	36.1	44.0	44.8	8.5	8.7
Measurement	64.7	65.7	77.7	76.7	13.0	11.0
Complete interview	92.3	93.4	109.7	108.0	15.6	14.6

Results from the post-intervention student interviews and the second set of NAPLAN results have been given with graphs and boxplots to compare the two sets of results.

In Chapter 6, the results of the study will be discussed in order to answer the research sub-questions stated in Chapter 1.

## CHAPTER 6. Discussion of Results

The purpose of this study was to build on available knowledge on the development of time concepts in primary school students through the introduction of a Framework for the Learning and Teaching of Time, the development and implementation of assessment tools, and an eight-lesson intervention focussing on experiences and pedagogies for learning and teaching the concepts of time in a Year 3 and 4 classroom. The main research question of this study, the identification of major Components of time and how these major Components might be described, assessed and supported in the primary school classroom, is discussed in detail in this chapter. To respond to this question, the researcher developed a Framework for the Learning and Teaching of Time (the Framework), devised a one-to-one task based interview incorporating the major Components of the Framework, then planned and taught eight lessons informed by insights from the interviews and related NAPLAN items. The eight-lesson intervention included rich assessment tasks that added to the data on the students' understanding of time. To provide a measure of the impact of the eight lessons on students' understanding, each student was re-assessed three weeks after the intervention using the same NAPLAN items and one-to-one interview.

In this chapter, the results of the research are discussed in relation to how they give insights for the sub-questions of the study. For each sub-question, the discussion draws upon the literature discussed in Chapter 2 and results outlined in Chapters 4 and 5.

The sub-questions are re-stated here and are used to structure this chapter:

1. What are the major components of a clear understanding of time?
2. How can student learning and understanding of time be assessed?
3. What are middle year primary school students' understandings about time?
4. What classroom experiences and pedagogies might support student learning about time?

The next section is a response to the first sub-question, "What are the major Components of a clear understanding of time?"

### 6.1 The Major Components of Understanding Time

There is a paucity of research on the learning and teaching of time in the primary school years (Burny et al., 2009; Earnest, 2017; Friedman & Laycock, 1989; Kamii & Russell, 2012). Time is an included topic in the Australian curriculum, but the frameworks summarising the key

elements of an understanding of time that do exist in curriculum documents and other research were found to be inadequate in that they are not comprehensive and/or focus largely on measuring time with clocks and calendars. These limitations led to the development of a more comprehensive Framework that would cover the major underpinning Components of time, one based originally on the available research literature on time, but then modified as it was further informed by the data collection and analysis within this study. Four major Components that needed to be included in this Framework emerged from the literature. In summary, students need to have an Awareness of time, an understanding of Succession of time and Duration of time, and be able to Measure time to be fully equipped to understand, interpret and make use of time measuring tools.

The Framework for the Learning and Teaching of Time (known in this thesis as “the Framework”) was developed to incorporate these four major Components (Thomas, Clarke, et al., 2016). Groups of key ideas that were found in the research literature to be essential to the teaching and learning of time were listed under each of the major Components as key ideas (see Chapter 2). The major Components and key ideas of the Framework informed the development of a one-to-one, task based interview used to assess Year 3 and 4 students’ understanding of time before and after an eight-lesson intervention (see Chapter 3).

Data collected during the interviews and the lessons gave further insight into the students’ understanding of time (see Chapters 4 and 5). This examination confirmed the basic structure of the Framework to be appropriate, but it did lead to a re-examination and revision of the key ideas under the major Components of Awareness, Succession, Duration and Measurement of time. As the key ideas listed under the major Components of time extend beyond the curriculum expectations, the wording of each key idea needed to be carefully constructed to ensure that future users of the Framework are given clear guidance. When reviewing the results of the pre-intervention interview and the students’ responses to the lesson activities, the need for several changes to the key ideas that expounded upon these major Components became apparent.

In the following sections the new and revised Framework is introduced with a full explanation of the reasons for, and changes to the key ideas. Each Component is dealt with in turn.

### **6.1.1 Awareness of time**

For ease of comparison, the Awareness of time key ideas from the initial Framework are shown in Figure 6.1, with the amended key ideas of the final Framework shown in Figure 6.2.

- Awareness of time**
- A point in time.
  - The language of time.
  - Temporal patterns.
  - Psychological time

*Figure 6.1.* Awareness of time key ideas from the initial Framework.

- Awareness of time**
- Any event on the time continuum can be used as a reference (e.g., an occurrence, a period of time).
  - The language of time includes specific terms (e.g., yesterday, tomorrow) and informal words and phrases (e.g., in a jiffy, soon).
  - Temporal patterns occur with regularity (e.g., daily and weekly routines, months of the year).
  - Psychological time is an individual's perception of time.

*Figure 6.2.* Awareness of time key ideas from the final Framework.

In the initial Framework, the brevity of each key idea under an Awareness of time was useful in starting to elaborate what were the deeper meanings captured by the key points as shown by the existing research literature. But as the study progressed it became apparent that insufficient information was given to fully clarify the requirements for an understanding of this major Component. Expanding the key idea phrases into sentences in the final Framework, with some examples, defined each key idea more clearly. It was also deemed necessary to change the wording of the first key idea. The initial Framework stated that a point in time could be used as a reference point on the time continuum or passage of time. A reference point could be an event, an occurrence or a period of time such as the year 1788. When viewed mathematically, a point indicates a precise location or a dot, and in the context of time, would be an instant. Changing the wording from *a point in time* to *an event on the time continuum* ensured that the meaning was consistent with the reference examples. Continuum refers to the range of known time from the past to the future, but in this context does not refer to the space-time continuum, where space and time are seen as a four-dimensional continuum. Items in the one-to-one task based interview such as stating the date two years into the future or one month in the past were

dependent on an awareness of the time continuum as were lesson activities that used timelines and calendars.

### 6.1.2 Succession

Figure 6.3 shows the Succession key ideas from the initial Framework with the revised key ideas from the final Framework shown in Figure 6.4.

- Succession**
- Two or more different events are organized sequentially.
  - An understanding of succession is needed to iterate units of time.
  - Simultaneity and seriation are related to succession.
  - Years are arranged in succession in numerical order.
  - Days, weeks and months are arranged in succession in a cyclical pattern.
  - Succession involves the present, the past and the future.

*Figure 6.3.* Succession key ideas from the initial Framework.

- Succession**
- Two or more different events are organized sequentially.
  - An understanding of succession and seriation is needed to iterate units of time.
  - Events can occur simultaneously (at the same time) or occur in the same period of time (synchronal).
  - The relationships between units of time need to be understood to solve problems of succession.
  - The names of days and months follow a recurring pattern while years are named in numerical order.
  - Succession involves the present, the past and the future.

*Figure 6.4.* Succession key ideas from the final Framework.

When reviewing the key ideas for Succession, it was decided to combine the third and fourth key ideas from the initial Framework as these units of time are based on natural phenomena, the rotation and revolution of the Earth around the Sun and observations of the Moon. The results from the pre-intervention interview indicated a lack of understanding of the relationship between days and years. The intervention lesson, which focussed on the movement of the Earth in space, demonstrated this relationship by illustrating how days are established sequentially and how the continual succession of days become one year. Modelling the relationship between

these natural units of time was found to not only be of benefit to the overall understanding of the concept of succession, but also demonstrated the need for the succession of days, months and years to be linked together as their dependence on each other had become more apparent during the lesson.

“Week” was removed from the list of examples as, unlike days and months, which have names and years that are named in numerical order, a week is not named or numbered in the same rigorous manner. While not specifically stated, the week is a part of the last key idea as it can be identified within the present, the past and the future. A week, while consisting of seven days, can begin on any day and conclude at the end of the seventh day. Some students were confused when asked to identify the seventh day of a week that began on Wednesday. In the pre-intervention interview, eight students identified Tuesday, but this number increased to 12 in the post-intervention interview. Lesson seven involved the students playing a game based on the calendar to help clarify the language related to the identification of a week in past, present and future time.

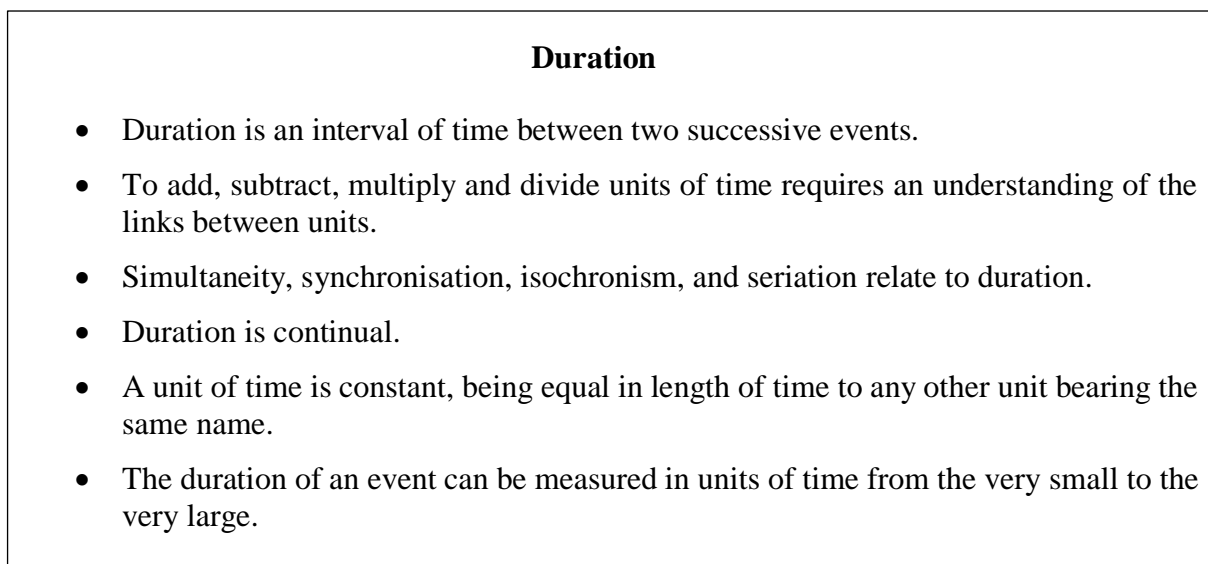
As the students developed a timeline of years from 2000 to 2018, they were encouraged to place important dates, including their birth dates, on the timeline so that the students’ births could be placed in sequential order. Several students discovered that they were born on the same day as another student in the class. Other events were also found to coincide in time, such as Easter and the commencement of the school holidays. When reviewing this lesson and referring back to the research literature, two additional points were identified which subsequently led to the first form of the Framework being revised to include these important aspects of Succession. While Succession is defined as two or more events organised sequentially, events which occur simultaneously or are synchronal, while not strictly sequential, present special cases to be considered when developing an understanding of Succession and were subsequently added as a key ideas of Succession.

The unit/attribute relationship and additivity (Lehrer, 2003; Wilson & Osborne, 1992) have been identified as important aspects when learning about measurement. To solve problems related to Succession, it is necessary to understand the relationships between the units of time, such as hours and days. For example, Tuesday will follow Monday but will only commence when Monday has completed 24 hours. Several items in the interview asked the children to solve problems related to succession, such as identifying the first day of next month from this month’s calendar page, recognising that the last day of a week is the seventh day, and adding or subtracting years and months from a given date. As some students had difficulty solving

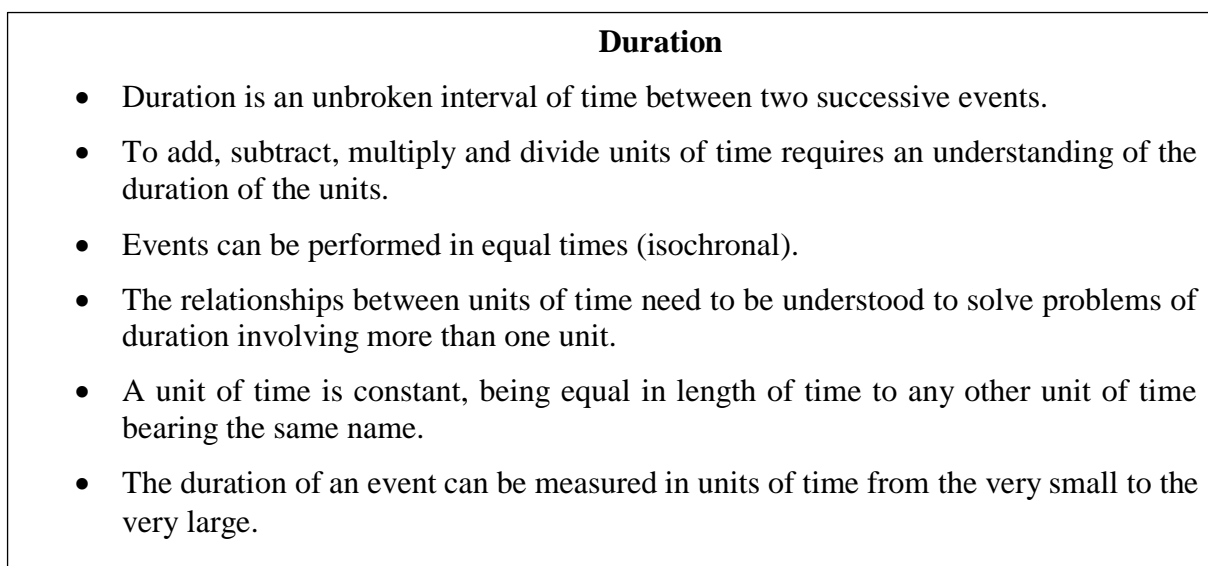
these everyday problems, it was deemed necessary to include a key idea related to the understanding of relationships between units and the solving of problems.

### 6.1.3 Duration

Several changes were made to the key ideas under Duration. Figure 6.5 shows the initial key ideas with the final key ideas shown as Figure 6.6.



*Figure 6.5.* Duration key ideas from the initial Framework



*Figure 6.6.* Duration key ideas from the final Framework.

The students were introduced to new terms throughout the intervention lessons. One of the new words was *duration*, which was defined as the interval between two events, having a start and a finish. To further explain the meaning, different actions such as walking across the room were demonstrated, and the duration of time taken for the action discussed. The students'

understanding was enhanced when they could see that the action, and the duration of the action, had a start, a finish and was continuous and uninterrupted. As the definition of duration was improved with the additional wording, *unbroken* was added to first key idea to indicate to users of the Framework that students need to be made aware that the interval of time is uninterrupted. With the addition of the word *unbroken*, the fourth key idea in the initial Framework (Duration is continual) was considered to have been included in the first key idea and was no longer required to be listed separately.

The second key idea under Duration in the final Framework explains the importance of understanding the duration of units in order to solve problems relating to the addition, subtraction, multiplication and division of time. The Australian curriculum states that at Levels 3 and 4, students should be investigating the relationship and converting between units of time (ACARA, 2016c). Solving time problems such as calculating the number of hours or minutes in a given duration can be applied to many everyday situations, such as deciding when to leave home to arrive at school on time. Although the students were familiar with the number of seconds in a minute and minutes in an hour, the interview items which required the students to solve duration problems, such as converting their ages to days, and calculating the length of a train journey, did not score as well as expected. The researcher considered it necessary to include a key idea which involved the four processes to promote problem-solving in general. The focus on the unit/attribute relationship during the intervention proved to be beneficial to the students who had previously experienced difficulty distinguishing between minutes and hours on an analogue clock as they demonstrated an improvement in their responses to these items in the post-intervention interview.

It became apparent when planning the intervention lessons for the students that the terms simultaneity, synchronisation, isochronism, and seriation, whilst being identified in the literature as important elements of duration, were not clearly defined, and with little explanation given in the Framework, could be confusing for other users of the Framework. From the interaction with the students as they undertook activities during the lessons related to duration, the most important of these terms to emerge was isochronal, knowing that some events can take the same amount of time, an important aspect to understand when measuring time. The key idea which had previously included all the terms was amended to only include isochronism and its relationship to Duration. Whilst not on the Framework, the other terms can still be introduced to students incidentally.

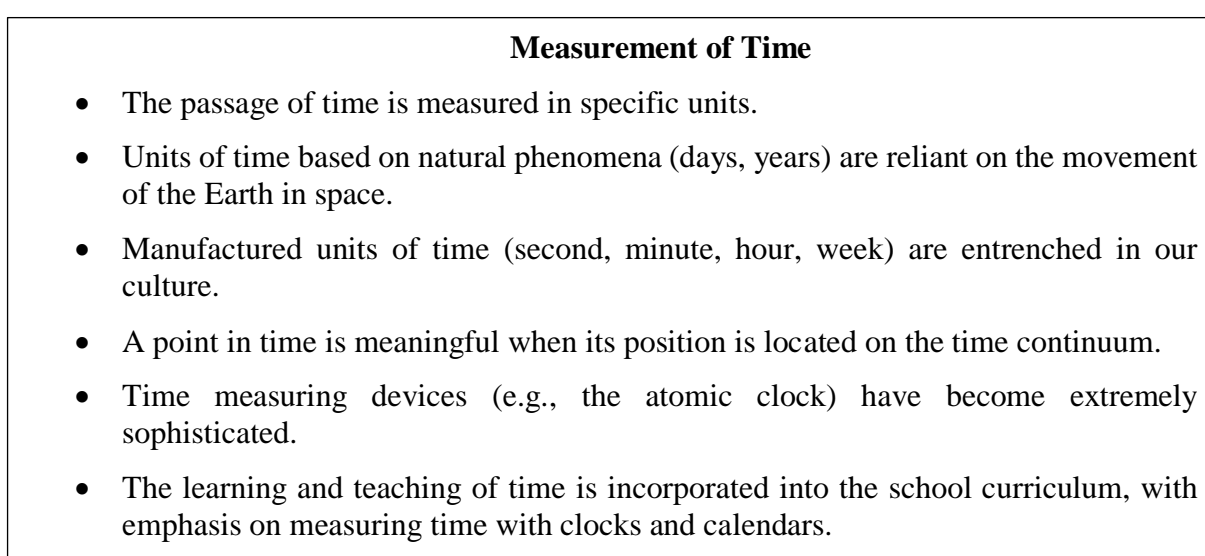
In order to read time measuring tools, such as clocks and calendars, students need to know that units of measure are constant or identical (Lehrer, 2003). Results from the pre-intervention



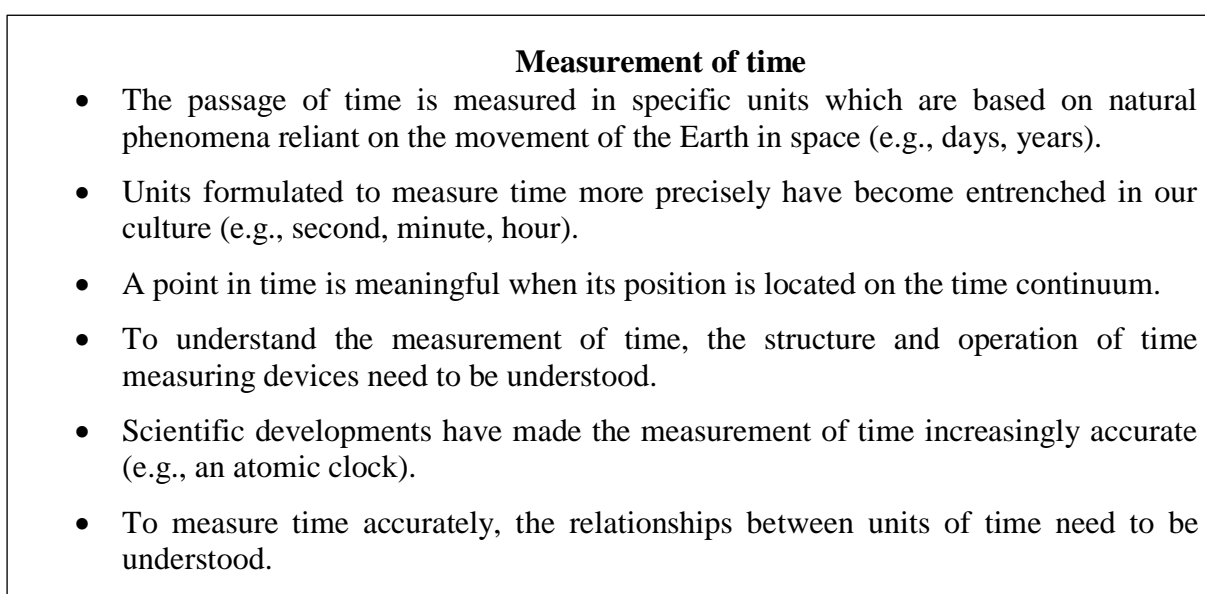
interview show that 22% of the students interviewed from Years 3 and 4 were unsure or thought that the length of an hour could change. Using working clocks during the intervention lessons which focussed on reading minutes and hours on a clock emphasised the importance of a minute or an hour always being the same duration. To ensure all units of time were included in this key idea, the fourth key idea on the initial Framework was reworded to imply any unit of time was included.

#### **6.1.4 Measurement of time**

Figure 6.7 shows the Measurement of time key ideas on the initial Framework with the amended key ideas shown in Figure 6.8.



*Figure 6.7.* Measurement of time key ideas from the initial Framework.



*Figure 6.8.* Measurement of time key ideas from the final Framework.

Time features in the *Australian Curriculum: Mathematics* (ACARA, 2016c) under Measurement, where the focus is on the reading of clocks and calendars. As the Framework extends beyond this focus to encapsulate a broader concept of time, the need for several changes to this major Component became apparent as the results of the pre-intervention interview and the students' responses to the lesson activities were reviewed.

The first change required was to improve the clarity of each key idea so that meanings were clear to all users of the Framework. To achieve the desired clarity, the first two key ideas on the initial Framework were blended, while the third key idea was re-worded. A term to describe the units of time such as the second, minute and hour whilst being in constant use, but not fitting the criteria of natural phenomena, was difficult to uncover. In the initial Framework, these units were described as “manufactured,” but this term, like many others such as “devised by humankind,” was not considered by the author to be the most appropriate. “Formulated” was selected to describe the units in question, as each unit is mathematically calculated. The measurement of a second is very precise (Taylor & Thompson, 2008), resulting in minutes and hours being measured with greater accuracy than when hours were first developed by the ancient Egyptians (Hannah, 2005).

The other key idea to be re-worded for clarification concerned time measuring devices which were previously described as becoming more sophisticated. When reflecting on the literature, it appeared that advances in scientific developments had been responsible for the increased accuracy of time measuring devices and as such, needed to be included in the key ideas for learning to measure time.

The second change to this major Component was the addition of three key ideas related to the measurement of time and the removal of a statement about the curriculum which, on reflection, was not a key idea for learning about time. Conversely, locating a point in time, understanding the structure and operations of time measuring devices, and understanding the relationships between units had been found from the children's responses to the interviews and lesson activities, to be key ideas to the learning of time and were subsequently added to the Framework.

### **6.1.5 The double headed arrows**

An important feature of the Framework is the placement of double-headed arrows. The arrows are placed between each of the major Components to indicate the interconnection between them; to show each major Component is of equal importance and relies on the other Components for a deep understanding of time.

### **6.1.6 Summary for sub-question 1**

The Framework for the Learning and Teaching of Time as shown as Figure 6.9 is the final version of the Framework. It encompasses the amendments made to the key ideas during the study as explained in the preceding sections.

This Framework has been developed to answer the sub-question regarding the major Components for a clear understanding of time. The major Components have been identified as an Awareness of time, Succession, Duration and Measurement of time underpinned by key ideas identified from the literature and one-to-one interactions with students in Years 3 and 4.

The next section is a response to the second sub-question, “How can student learning and understanding of time be assessed?”

## **6.2 Assessing Student Learning and Understanding of Time**

As outlined in Chapter 2, student understanding can be assessed in a number of ways depending on the purpose of the assessment. Understandings can be assessed by summarising what a student has learned (summative) or by giving feedback on the student’s performance (formative) (Department of Education and Training, 2015; Ginsberg, 2009). The purpose of the assessment conducted throughout this study was to gain a comprehensive insight into children’s understanding of time and as a result, different forms of summative and formative assessment were adopted.

In this section the researcher reports on the assessment of students’ understanding of time prior to, and during, the eight-lesson intervention. The principal form of assessment to ascertain what students knew at these year levels, was the one-to-one task-based interview with the six NAPLAN items from previous years adding some additional data. The benefits gained from interviewing students included insights into each student’s thinking, the strategies used and an awareness of the common problems and misconceptions (Clarke et al., 2011). The data from these tools were supplemented from insights gained during the teaching phase particularly when students attempted open-ended tasks and wrote self-reflections, and at other times when the audio recording of in-class conversations with students proved insightful. Results from these assessments were detailed in Chapter 4.

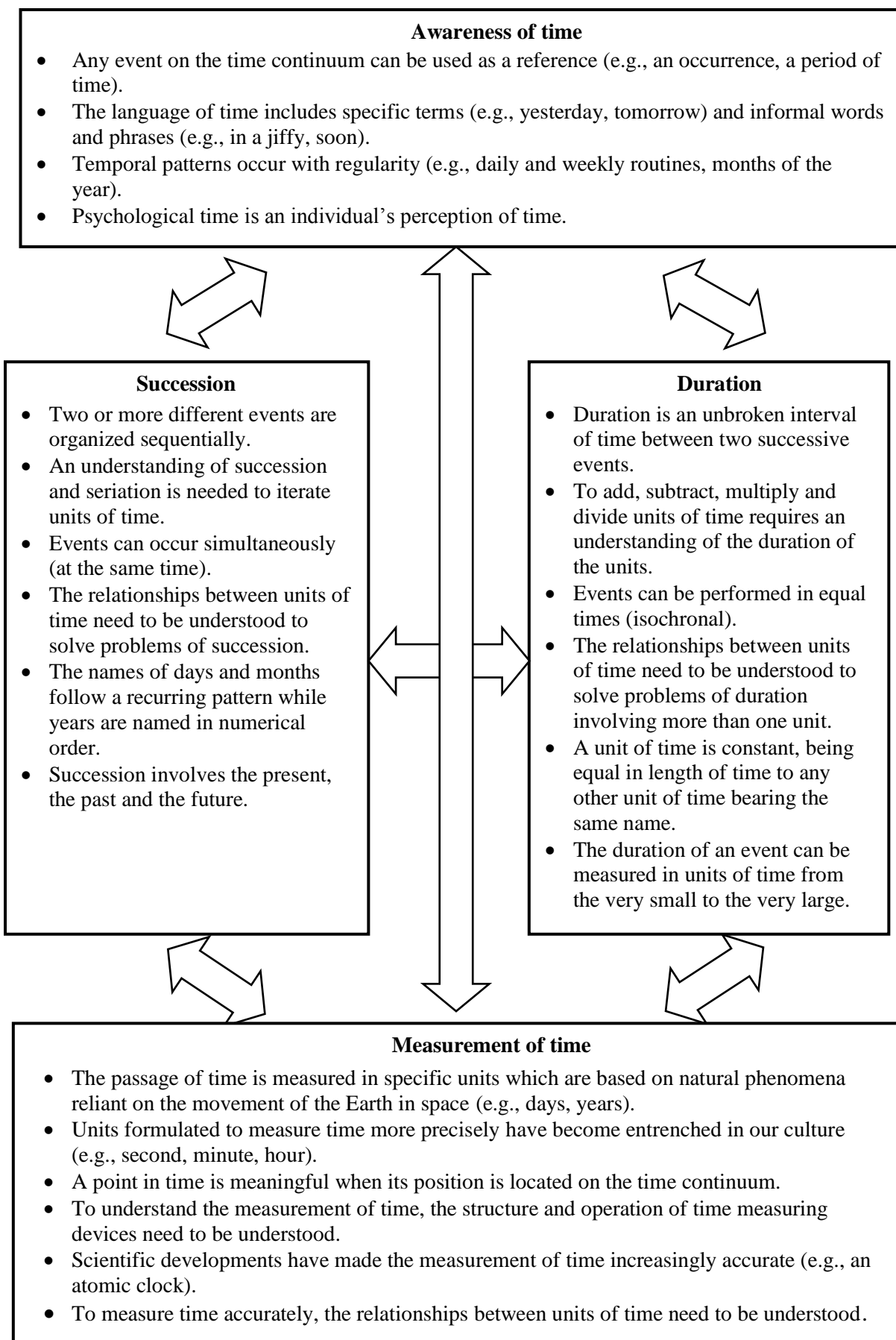


Figure 6.9. A Framework for the Learning and Teaching of Time (final version).

A multi-methods approach was used to assess the students, as the concept of time is complex and the assessment needed to include items that related to all the major Components of the Framework. Several items were used to assess each of the key ideas so that a clearer measure of their understanding could be gained. The interview included several different types of questions and tasks such as drawing and writing on a timeline, locating present and future dates on a calendar, answering questions, solving problems related to timetables, reading times on clocks and estimating the duration of a minute. As NAPLAN is the national numeracy assessment for Years 3, 5, 7 and 9, past NAPLAN items were selected as another form of assessment. The students were familiar with this form of assessment as the Year 3 students had completed the NAPLAN assessment earlier in the year with the Year 4 students completing the tasks the previous year. Together with the data gained from the students' responses to the NAPLAN items, comprehensive insights into their understanding of time were gained. The various tools to assess the students' understanding of time were outlined in Chapter 3.

### **6.2.1 One-to-one task-based interview**

A review of each item of the pre-intervention interview and the corresponding responses indicated that while all the items were valuable in assessing the students' understanding about time, both individually and collectively, some items gave the interviewer access to more information than others. Of particular value were the items which sought to assess the students' awareness that time is measured. Items that required students to list units of time, to explain am and pm, the beginning and end of the day, and the revolution and rotation of the Earth assessed their understanding of the need for, and purpose of, time measuring tools such as clocks and calendars. The interview was also of benefit in assessing how the students perceived time. This was achieved by asking the students to estimate a minute, complete a timeline and talk about long and short durations of time. Asking the students to name the next month, find a day three weeks into the future and name the day before or the day after the current day, and to solve problems were valuable tasks to assess the language that students at these year levels understood.

The interview proved to be an excellent assessment tool. Having 69 items ensured that the three major Components of time could be assessed with a variety of questions and tasks. Nevertheless, a review the results indicated some improvements could be implemented. One item asked for the student to name the year he or she was in Prep (their first year at school). The marking system gave two points for the correct year but only one point if the response was the year before or after the correct year. On reflection, some incorrect responses may be due to errors in calculation rather than an inability to count back years. For example, a student may

respond with the following calculation: I am in Year 4. I have been at school for five years. It is 2015, so if I take five from 2015, the answer is 2010. While the mathematics appears to be sound, 2010 is the year the student was in pre-school as all the years of school have been deducted. Asking for further clarification may be of value for this item. Likewise, when a clock is drawn with 48 minute lines, further questioning could also be of benefit in gaining a better understanding of the student's knowledge of clocks.

The one-to-one interview also proved to interest students who all appeared to become engaged from the outset as they met the researcher, maintaining their interest during and after the interview. On the way to the interview room, the researcher chatted informally with each student about herself as a researcher and the student's role in the overall study. At the outset of the interview, each student was informed that their attendance was voluntary and they could leave at any time. The students were assured that their responses to items, although audio-taped, would be confidential and saved under a pseudonym. Students were encouraged to attempt each item although while some items would be easy, others could be tricky and it would be alright to say, "I don't know". Having developed a rapport with the student, interest in responding to items in the interview was facilitated by including interview items that focussed on the individual's thoughts and ideas such as "What might take an hour to do?" and "Tell me how you measured a minute". To develop a thorough assessment of student's understanding of time, each item was selected to assess the key ideas of the Components Succession, Duration and Measurement of time.

The interview seemed to be suitably challenging for the students owing to the range from simple to challenging questions with the scores for the pre-intervention interview ranging from 48 to 124 from a possible total of 138. With only one third of the students gaining a score of more than 75%, and the highest score being 90%, it was apparent that no student was able to answer all items. This meant the interview could be used twice, giving an opportunity to show the growth in understanding for each student. The scores for the post-intervention interview ranged from 63 to 133 (96%) with almost two thirds of the students gaining a score in excess of 75% (See Appendix P for post-intervention scores).

### **6.2.2 NAPLAN items**

The style of assessment used in the NAPLAN testing requires students to select one of four solutions to answer a question. The time questions generally require the students to read and compare analogue and digital clock times, and to read and interpret timetables and calendars. Classroom activities and assessment often require the students to answer the same type of

questions about time as a means of determining if the students have attained the achievement standards established in the *Australian Curriculum: Mathematics* (ACARA, 2016c). The students responded to the items under test conditions (students worked silently with no additional assistance or further explanation given) and the items were scored as correct (one point) or incorrect (zero points). Eight students scored 100% for the six questions before the intervention with 10 students scoring 100% after the intervention.

### **6.2.3 Rich assessment tasks**

The use of rich assessment tasks during the intervention lessons was an example of assessment *as* learning. The tasks were rich in the sense that they connected to the students' interests and experiences, and engaged them students in what was being taught. A range of responses was expected from the students as they made connections with previous learning and explained what they knew (Downton, Knight, Clarke, & Lewis, 2006). For example, in Lesson 5, the students discussed the idea of 15 minutes of fame, following which pairs of students had to construct a timetable in which every student in the classroom was rostered for 15 minutes to achieve fame. The development of the timetables demonstrated the students' understanding of 15 minutes as part of an hour, while also demonstrating that the students needed more experiences in using of any point on the clock apart from 12 as a zero point from which to count on 15 minutes.

### **6.2.4 Self-reflections**

Students were encouraged to discuss their learning as they worked in small groups, to write self-reflections on their learning after each lesson and to share their findings with others as a whole group. Writing self-reflections gave the students an opportunity to consider what they had learned from the activities they had completed whilst giving the teacher-researcher an insight into their thoughts after they had completed the tasks set for the lesson. One approach to writing a self-reflection was for the students to write a letter to an adult giving examples of their learning. The following examples illustrate the interest in correct terminology by the students.

Today we learnt duration, succession, revolution, rotation, [a] game, and different ways to measure time. I found reading books was interesting. Finding out what "time is" is a little bit hard.

We have been learning about time. This is what I can remember.

We learnt about minutes, seconds, duration, hours, succession, calendars, revolution, and different ways to measure time, a new game and rotation.

I learnt about time with M. Some things were hard but I still gave it a go. We learnt about duration, hours, minutes and seconds, calendars, a game we learnt and a lot more.

### **6.2.5 Informal assessment**

Informal assessment was ongoing throughout the lessons as conversations between the students and between the students and teacher-researcher were audio-recorded and transcribed after the lesson. Although data from the interviews gave a greater insight into the students' understanding, additional information from informal observations enhanced the researcher's insight of their understanding. Notes regarding the students' verbal responses were added to the anecdotal notes from the lesson when the recording was reviewed giving the teacher-researcher further insight into the students' ideas. For example, when asked to explain the meaning of *past*, responses included "it has gone before", "it has happened", "it was before now", "on a clock", "time goes past", "opposite of future because in the future is anything that will happen [but] it hasn't happened yet". When asked, "What does 'to' mean?" the students' responses included "present", "it is right now", "to the future", "going somewhere", and "I have to go there". The responses indicated that in relation to time, the students had a better understanding of the word *past* than the word *to*, an important point for the teacher-researcher to know.

### **6.2.6 Summary for sub-question 2**

Each type of assessment implemented within this study was of benefit in developing a clearer understanding of the students' knowledge and skills. The interview proved to be a comprehensive assessment as the selection of tasks to assess each key idea ensured all the major Components of the Framework were covered, and provided a crucial measure of understanding over time. The NAPLAN items, while assessing some aspects of time, did not prove to be of much benefit when assessing the students' deeper understanding of time. The decision to include only Year 3 NAPLAN items contributed to this difficulty. This is discussed further in Chapter 7. Rich assessment tasks and informal assessment while the students were completing tasks proved to be of benefit when planning for individual learning in the study classroom.

The one-to-one interview proved to be an excellent assessment tool for students in Years 3 and 4 as items in the interview were directly linked to the major Components of the Framework. As a form of summative assessment, the interview was framed in such a way as to assess by the student's response, if their response demonstrated a full understanding, a partial understanding or no understanding. By working directly with each student, more information would be



requested to ensure the child had completed his/her response. By contrast, when responding to the NAPLAN assessment items, additional information could not be requested or given.

Compared to NAPLAN type assessment, the one-to-one interview developed in this study proved, as was anticipated, to be a far more comprehensive assessment of the students' knowledge and understanding of time. Through this interview process, the researcher could ascertain from a student's response whether the errors made were a misunderstanding of the item, a demonstrated misconception, or a lack of knowledge. The interview incorporated several assessment styles including summative assessment in which the students were asked to respond to items to demonstrate their knowledge and skills as an assessment *of* their learning, and formative assessment, an assessment *for* their learning, where the interview responses were used by the researcher to plan future learning experiences for the students.

The next section is a response to the third sub-question, "What are middle year primary school students' understandings of time?"

### **6.3 Middle Year Primary School Students' Understandings of Time**

This section will reflect on the students' understanding of time as assessed prior to the eight-lesson intervention.

When the individual results of the first one-to-one interview were converted to percentages of the maximum score of 138, student scores ranged from 35% to 90%, with a mean score of 68% and a median score of 70%. Despite the wide range of scores, there were some items in the interview for which most of the students gained two (maximum) points. Many of these items could be classed as facts that could be committed to memory such as the number and names of the days of the week, the name of the current year and the next month, the number of seconds in a minute and minutes in an hour, and the accurate drawing of a digital clock with an appropriate time displayed. Although certainly important for understanding time, and they do certainly contribute to that, nevertheless such facts do not give much insight into students' deeper understanding of time.

In the following sections, the findings from the one-to-one interviews which demonstrate what children in this study understood about time before the lesson intervention, are linked to both the Framework and the developmental steps in learning to measure time as discussed in Section 2.5. Unless specified otherwise, the data reported are those from the pre-intervention interview, as this can be seen as reasonably representative of what typical Year 3 and 4 students know and can do.

### 6.3.1 Awareness of time

Awareness of time was deemed to have been included in all items in the interview. Particular interests in this study were the responses to items relating to the key ideas of psychological time and temporal patterns. Items relating to psychological time gave insights into each student's perception of time, while a student's responses to items relating to temporal patterns indicated the level of understanding achieved when rote learning for example, days of the week. Aspects of the key ideas of an Awareness of time were familiar to the students, although understanding of temporal language and temporal patterns differed between students. Experiences, both at school and at home, may have influenced the students' development. When considering events that would take a long time to do (psychological time) responses were as varied as sleeping, driving to Melbourne, hard questions in maths, and catching a fish. A low-achieving student gave this response: "Sometimes when you don't like your tea, it takes a long time to eat it." This response clearly emphasised psychological time as an individual's perception of time as, without additional information, the duration of time taken to eat her tea could not be judged by another person as a long time. When asked what could take an hour to do, 12 students scored two points and 13 students scored one point indicating that many students at these year levels have not developed a strong understanding of what can be achieved in the duration of an hour. Students were confident to give the days of the week and the months of the year, but did not understand the relationship between the movements of the Earth and temporal patterns such as day and night, the duration of a year and seasonal changes.

It was interesting to note that this group appeared to have had limited previous experience and lesson time regarding the rotation and revolution of the Earth in space. The intervention lesson which focussed on the Earth's movements in space gave the students an opportunity to put their knowledge of the number of hours in a day, the number of days in a year, the rotation of seasons and the succession of day and night into the context of the passage of time. Prior to this lesson, the responses from the students indicated that their prior learning was based on specific facts they had learned, such as the number of hours in a day or the number of days in a year, many of which were difficult to recall. Students' facial expressions when asked how they would calculate their age in days, ranged from surprise to amazement indicating that this item on the interview was a problem that they had never encountered. Only 10 students showed a partial understanding of this before the intervention, and 12 after. No student gave a response that demonstrated a full understanding.

### **6.3.2 Understanding Succession**

The interview required students to mark events on a timeline in sequential order. In the pre-intervention interview, all of the students were able to mark where on their timeline they thought lunchtime would occur and then to add two events before and two events after lunch, although only 12 students marked lunchtime within the time slot selected to gain any points.

Twenty-five students identified the current year while similar numbers could name the days of the week and the months of the year indicating that these facts were widely known. Ascertaining the first day of the next month by looking at the previous month, locating a date three weeks from a given date, and stating the date exactly one month ago appeared to be more challenging questions as only approximately half of the students gained two points, while others did not gain any points.

Although the big ideas of the Earth's movement and seeing time as a continuum were not evident in many students' responses, there were some perceived strengths within the classroom as a whole. When analysed, the students' strengths consisted mainly of items such as the number and names of days in a week, the number of seconds in a minute, the number of minutes in an hour and a half hour and the number and names of the months; items that had been committed to memory but did not indicate a deep understanding (as stated in 6.3). The weaknesses included some confusion regarding the beginning and end of a day and identifying am and pm. The students who said the day ended at 12 o'clock with the new day commencing at one o'clock demonstrated a lack of understanding of the relationship of units of time. The students who said am was the morning and pm was in the afternoon may have had their experience limited to the school day. Most of the students in this study could identify the day and the date and place annual events in order. The students were familiar with digital clocks, could identify the hour numbers and the minute numbers and read the time on the display.

It would appear that although students had memorised facts regarding units of time such as seconds, minutes, hours and days, their knowledge and ability to solve simple problems was limited. A lack of understanding of time as continuous and measurable, and related to the Earth and its movement in space, appeared to reduce the students' concept of succession to personal experiences of before and after particular events, such as lunch, and automatic recall of days of the week and months of the year.

### **6.3.3 Understanding Duration**

The introduction of the word duration made the related lessons more meaningful as the students became more aware of the movement of the hands and the working of the clock to measure

time. Prior to the lessons, the students' understanding of duration was limited. The key ideas under Duration in the Framework did not score as well as expected when the students were interviewed prior to the intervention. For example, the key idea with the greatest percentage of 2 points (76%) related to understanding the duration of units to solve problems of addition, subtraction, multiplication and division. This score, whilst bolstered by the students' knowledge of the relationships between some units of time, was of concern to the researcher as many students were unable to think of a way to work out their ages in days or calculate the length of a train journey that departed at 5:07 and arrived at 6:59. Nineteen students could explain why their recess was of a shorter duration than lunchtime, but when asked how long the clock hands would take to move around the clock face once, the reduced number of correct responses indicated a lack of experience in measuring durations of time. Few students understood that clocks and calendars measured time in durations of seconds, minutes and hours (clocks) and days, weeks, months and years (calendars) and while one third of the students could explain satisfactorily why an hour could not change, the same number of students either did not know if an hour was always the same or could not explain why this would be the case.

#### **6.3.4 Understanding Measurement**

One item on the interview required students to name units used to measure time. Students were given the example of length being measured in small units such as centimetres and very large units such as kilometres, before being asked to name any units used to measure time. Of the 27 students, 19 students identified between one and four units but eight students did not identify any units used to measure time. The challenge for the students was the concept that time was measured and that clocks and calendars were the tools used to measure time. Many of the students, including the students who could accurately read the time, regarded the clock as an instrument which one had to learn to read. When read, the clock gave the present time, which was not seen in the context of a whole day. An important aspect of the lessons was to introduce the students to the notion of time being measured and that clocks and calendars were used for this purpose. Although this idea was new to the students at the beginning of the intervention, activities such as using a clock in the lessons to measure seconds and minutes improved their understanding of measuring time. When asked how a clock was used to measure time in the pre-intervention interview, 10 students (37%) gave a response that indicate a full or a partial understanding, but this number rose to 22 students (81%) for the post-intervention interview. Similarly, when asked how a calendar was used to measure time, 13 students (48%) gave a full or partial response the first time with this number increasing to 25 (93%) for the post-intervention interview.

### **6.3.5 Summary for sub-question 3**

From the initial data collected from these students, it seems that they were aware of time when it is closely connected to their own perception of the passing of time. Durations appeared to be short or long to them, depending on their particular situation. In summary, the students' understanding of Duration was often limited to knowing important numbers, such as the minutes in an hour and the hours in a day. The students in this study were not aware of the movements of the Earth and how these movements were matched to our days and years. Their understanding of Succession was based primarily on what they had learned about the order of the days of the week and the months of the year. During the pre-intervention interview it seemed that these students' abilities in measuring time was often limited to knowing important numbers, such as the minutes in an hour and the hours in a day.

In summary, student's understanding about time were based on factual items that could be committed to memory. Their Awareness of time was influenced by their perception of time; how long a period of time appeared to take was based on individual experiences. The students' knowledge of succession and duration was restricted as many of the students seemed unaware of time being continuous and measurable and related to the Earth's rotation and revolution around the Sun. The students who were able to read the time on a clock did not demonstrate an awareness of the clock time as a measure of the time that had elapsed since midnight or midday. Although the students had some knowledge of time, a deep understanding of the major Components of time, Awareness of time, Succession, Duration and Measurement of time, was not apparent.

The next section is a response to the fourth sub-question, "What classroom experiences and pedagogies might best support student learning about time?".

### **6.4 Classroom Experiences and Pedagogies to Support Development**

As was strongly evident in Chapter 5, there was statistically significant improvement in all Components of the Framework following the eight-lesson intervention. It is reasonable to attribute these significant changes to the classroom program which was developed following the pre-intervention assessment. In this section, different aspects of the pedagogy are explored, which can reasonably be linked to this change in the students' understanding.

Although the researcher and classroom teacher sometimes used similar teaching strategies, the researcher introduced alternative classroom pedagogies during the intervention to those commonly used by the regular classroom teacher. During the intervention, the classroom teacher said that she was keen to add these to her repertoire of pedagogies in the future. These

pedagogies and experiences were based on the teaching style of the researcher as a teacher, and informed by the results from the one-to-one interviews, the literature focussing on best practice, and the intended focus of each lesson. The next sub-sections describe the experiences and related pedagogies for the effective teaching of mathematics (see section 2.10) which appeared to assist the students to develop their understanding of the concept of time, and hence also comment on how the students' understanding of time changed.

#### **6.4.1 The use of children's literature**

Each lesson began with the reading of a text related to the content focus of the lesson (see Table 4.10). Reading and discussing children's books which relate to the mathematical focus of the lesson has been found to enhance students' learning of mathematics (Elia, van den Heuvel-Panhuizen, & Georgiou, 2010; van den Heuvel-Panhuizen, van den Boogaard, & Doig, 2009). While some of the texts read to the students were factual or non-fiction, many of the books read and discussed during the lessons were children's story books. Each text was selected to appeal to the age level of the students, related to the focus of the lesson and its use was instrumental in introducing the goals of the lesson (Sullivan, 2011). The books selected did not include any books on how to tell the time, although there are many texts of this type available. Stories were selected not only to introduce an Awareness of time and to create discussion on new ideas such as succession, duration and how time has been measured over the centuries, but were also used to foster engagement (Clarke et al., 2002) and assist the students to make connections with other aspects of their learning (Clarke et al., 2002; Sullivan, 2011). A synopsis of each book read and discussed in the intervention lessons is given in Appendix R.

#### **6.4.2 Physical involvement**

For students in Years 3 and 4, mathematics may be perceived as involving calculations, counting and number work (McDonough, 2002). As measurement topics such as length, volume and mass also involve mathematical activity, children need opportunities to become familiar with measuring tools, and to explore important concepts such as the relationship between units and attributes to be measured (Lehrer, 2003). In lessons about time, movement and activity are also important. Being physically involved in Succession, Duration and Measurement of time activities fosters engagement (Clarke et al., 2002), assists the students to make connections (Sullivan, 2011) and promotes fluency and transfer by building connections between mathematical ideas (Askew et al., 1997).

As a break from routine and to capture their interest, the students were encouraged to move around the room and to become physically involved. In Lesson 2: *Round and round we go*, the

students acted out the roles of the Sun and the Earth, moving around the room to imitate this celestial action, while other children gave a narrative explaining what was occurring. In other lessons, students were encouraged to manipulate clocks and sand timers, with a game played during the penultimate lesson. Informal discussions after the lessons that involved physical movement indicated that these lessons had been both enjoyable and meaningful to the students' learning.

#### **6.4.3 Manipulative resources**

The selection of equipment to be used in the lessons was important to the activities undertaken. Planned lessons incorporated a range of materials which appeared to foster engagement (Clarke et al., 2002), identified by Sullivan (2011) as a skill of an effective teacher. The decision to use 'real' clocks that had batteries and ticked as the second hand moved, contributed to the success of the lessons. Although some of the students may have watched the hands on a clock move, or the numbers on a digital clock change, they did not indicate by words or actions that this was a familiar activity. During the lesson, the students appeared to be absorbed in watching the clock hands move, which demonstrated to the students the concept of succession, the ongoing passage of time and how durations of time could be measured. A non-working clock or a clock that is stopped at a given time infers that clocks are used solely for the purpose of reading the time with scant regard for what the time on the clock really means or how the particular time relates to the 24 hour day. By using the clocks to measure the duration of the sand timers, the students displayed an understanding of the clock as a measuring tool. Other important pieces of equipment included sand timers which could be manipulated and the movement of the sand observed, the large fit ball and the inflatable beach ball which became the Sun and the Earth, tee-shirts the children could wear over their clothes to identify their role as the Sun or the Earth, walking sticks and pencils used to make a large floor clock, and the game constructed to promote language development.

#### **6.4.4 The language**

The use of appropriate language is an important factor in learning about measurement, as each measurement attribute is described by words and phrases specific to that attribute (Outhred et al., 2003). Anthony and Walshaw (2007, 2009) identified developing mathematical language and mathematical communication as elements of effective teaching. Language helps to promote fluency and transfer (Sullivan, 2011). Hiebert and Carpenter (1992) regarded spoken language as an external representation of understanding. Language also applies to the specific teaching of time. The language of time includes many different aspects of time covering events from the

distant past through to the present time and the future. To assist the students' development of the aspects of time shown on the Framework, the use of relevant terms and phrases was considered important. To achieve this outcome, the students in the study were introduced to new words and phrases throughout the intervention, culminating in a game focussing on the language of time. Words such as succession, duration, rotation and revolution became evident in the students' discussions and written work. Terms such as the little hand and the big hand were viewed by the students as unnecessary when they could call the clock hands the *hour hand* and the *minute hand*.

In Chapter 2, it was suggested that immersing students in the language of time may assist in developing an understanding of time. The responses from the students during and after the intervention supported this view.

#### **6.4.5 Group work and discussion**

Each lesson focus was introduced with the reading of a text and subsequent discussion of the relevant points. The lessons were organised on a whole group, small group, whole group design (Sullivan, 2011). Discussion was encouraged within the whole group, but played an important role within the small groups where students were given tasks to be solved with at least one other person. Effective teachers have been shown to encourage children to listen to, to evaluate and to explain mathematical ideas (Anthony & Walshaw, 2009; Clarke et al., 2002). Interactions between students, a strategy of effective teachers as reported by Sullivan (2011), was encouraged. At the conclusion of each lesson, the students were brought together as a whole group to share their learning with, and to ask questions of, their peers.

#### **6.4.6 Self-reflection**

At the close of the lesson, the students were required to write about the tasks they had completed and what they had learned or gained from their experiences as a means of consolidating their learning, with an emphasis on making connections to previous learning (Clarke et al., 2002; Sullivan, 2011). Prompts were often given to assist in the reflection such as "list three things you remember from the lesson," "give two examples of what you learned," and "write one question you wish to have answered." Writing a self-reflection at the end of a mathematics lesson was a new experience for the students, but was found to be beneficial for the students who were encouraged to consider their learning, and for the teacher-researcher as a further means of assessing the students' understanding of the content of the lessons.



#### **6.4.7 Summary for sub-question 4**

The key principles of effective teachers identified by Sullivan (2011), articulating goals, making connections, fostering engagement, differentiating challenges, structuring lessons, and promoting fluency and transfer (see section 2.10.1) were found to be of benefit when implementing the intervention lessons. The children's literature used as a starting point for the lessons captured the students' interest and gained their attention as the reading of a text was a change from the commencement of their regular mathematics lessons. The texts were instrumental in highlighting the foci of the lessons (articulating goals) and promoting discussion (making connections). At the beginning of each lesson, which started after recess, the students sat on the floor anticipating the reading of a book and subsequent discussion (fostering engagement). The reading aloud of the books introduced, and later reinforced, the language of time. New words were introduced which could be explained by way of the illustrations and the text. As the teacher-researcher attempted to always use the correct terminology throughout the intervention (for example, hour hand, minute hand and duration) the students were encouraged to adopt their use. Chapter 5, Table 5.7 illustrates the increase in words and phrases the sample group of students listed when defining time. Giving the students the opportunity to move around the room drew all of the children into the activities (differentiating challenges). Although the students were accustomed to working in groups for mathematics, being able to move around the classroom to the next group, to model the Earth's movements, or to stretch out on the floor to complete an activity appeared to increase the students' degree of involvement in the lesson (structuring lessons). The use of real clocks that worked was of great benefit to the students as they counted and measured real time. The interest in clock reading by students who had found this task a challenge during the one-to-one interview was observed and recorded by the teacher-researcher (Lesson 3, Section 5.2.3). The movement of the hands of the clock demonstrated to the students the ongoing and continual passing of time (structuring lessons). Reflecting on their learning at the end of each lesson encouraged the students to construct new ideas into their concept of time (promoting fluency and transfer).

#### **6.5 Summary of Chapter 6**

The main focus of this study, the development of children's learning and understanding of time and how it is best described, assessed and supported in the primary school classroom, has been discussed through the sub-questions of the research study. The response to each sub-question has been discussed in relation to the research findings, data sets and results outlined in Chapters 4 and 5.

In the next chapter, the researcher discusses the main research question as stated in Chapter 1. Limitations of the study and recommendations for teachers, curriculum developers and other researchers are outlined and overall conclusions are drawn from the study.

## **Chapter 7. Looking Back, Looking Forward**

### **7.1 Introduction**

There are eight sections in this chapter. The research problem, the purpose of the study and the research questions are restated at the beginning of this chapter. The major findings of the study are then summarised and are used to reflect on the main research question posed in this thesis. Limitations of the study follow, and implications for the learning and teaching of time for researchers, curriculum developers and teachers are proposed. The final section concludes the thesis.

### **7.2 The Research Problem**

This study has demonstrated how understanding and measuring time is an important aspect of society and has been since ancient civilisations such as the Egyptians, Greeks and Romans developed early calendars and sundials. Although our modern time measuring tools have become far more accurate, we are still reliant on clocks and calendars to measure time. Virtual time has become a reality as we communicate around the world 24 hours a day enabling us to work any time in the 168 hours of a week. It therefore follows that time is an important aspect of the mathematics curriculum as students need to develop a deep understanding of this concept which in turn allows them to be able to interpret and use calendars and clocks effectively. Although studies have been undertaken to ascertain what children understand about some aspects of the concept of time, such as the past and the future, prior to this study there was a paucity of research on student learning and deep understanding of time (Burny et al., 2009; Earnest, 2017; Friedman & Laycock, 1989; Kamii & Russell, 2012).

### **7.3 The Purpose of the Study and the Research Questions**

This study sought to investigate student understanding of time in the middle years of primary school. The researcher's interest in this area of the mathematics curriculum, combined with limited previous research into the learning and teaching of time, led to the main research question:

What are the major components of a clear understanding of time and how might these components be described, assessed and supported in the primary school classroom?

Consideration of the available literature relevant to the main research question led to four sub-questions. These were as follows:

1. What are the major components of a clear understanding of time?
2. How can student learning and understanding of time be assessed?
3. What are middle year primary school students' understandings of time?
4. What classroom experiences and pedagogies might support student learning about time?

As each sub-question was answered in Chapter 6 in great detail, the emphasis in this chapter is to report on the key findings to answer at least to some degree the main research question.

#### **7.4 The Main Research Question**

To answer the main research question, the major Components of a clear understanding of time had to be identified before investigating how these major Components could be described, assessed and supported in the primary school classroom.

Informed by the research literature on the purposes for which time was measured over the centuries and the important role the measurement of time played within society, the researcher identified major Components of time. Combining insights from that literature with those gained from a review of the limited research on the teaching and learning of time, a Framework for the Learning and Teaching of Time was proposed. This Framework had four interlinked Components (Awareness of time, Succession, Duration, and Measurement of time), with many key ideas identified for each Component.

Having identified the major Components and their key ideas, a one-to-one task-based interview was developed, in order to assess the understanding of students in Years 3 and 4 in relation to these Components and ideas. Following piloting and refinement of the interview items, 69 items were used with 27 students in a regional primary school in country Victoria. The use of the interview enabled the identification of those Components and key ideas for which student understanding was strong, as well as those areas requiring additional attention.

The areas of need formed the basis of an eight-lesson intervention, involving around 12 hours of classroom time. The unit of work provided further data based on the use of a number of rich assessment tasks, samples of student work and observations by the researcher.

A second round of interviews revealed statistically significant improvement by the students.

Given this impressive improvement in student performance following the intervention, it was reasonable to conclude that the improvement could be attributed largely to the intervention, and in particular to the “active ingredients” of the lessons. These were the use of children’s

literature, physical involvement, manipulative resources, appropriate language, group work involving discussion, and students' self-reflection on their learning.

In addition, drawing upon all forms of data (the literature, interview data, NAPLAN data, and classroom intervention data), a final Framework for the Learning and Teaching of Time was proposed (see Figure 6.9).

In summary, the main research question was answered as follows:

- *The Framework summarises the major Components of a clear understanding of time.* The Framework for the Learning and Teaching of Time is an important step forward for future research, teaching and curriculum development. Prior to this study, the major Components of time, although independently described and commented upon in education research literature, had not all been brought into a useful juxtaposition that allowed overall insight into what a deep understanding of time might entail for students. Hence, in some ways it is no surprise that in both curriculum development and teaching there has been an undue emphasis on just one of these Components, the Measurement of time. With this Framework, future research might find more insightful guidance, the results of which will influence future trends in curriculum development and teaching.
- The Interview provides an important tool to measure student understanding of these Components and the key ideas within each Component. This Interview is also another step forward for both research and teaching. Used as a whole, not only does it allow the investigation of the four individual Components, but it also emphasizes the interdependence of these Components and hence the deep understanding of time by students. In this way, it should be able to be used as an investigative research tool. However, the extensive list of detailed annotated and tested items should also be a valuable resource for teachers. By using carefully chosen groups of items teachers will likely be able to build their own understanding of how their students are gaining insight into the Components of time, and hence the overall concept of time.
- *The insights from the eight-lesson intervention provided insights into how a developing understanding of time can be supported.* In some ways there is little that is new in the individual strategies and supports that the researcher used in the intervention lessons on time. However, bringing these teaching strategies and supports together in the way described provides a template that should be useful for future intervention research studies on time since it is clear from the results here that the overall impact on students was positive. It is probable that this template will also prove to be useful for both

curriculum developers and teachers as they contemplate how these research results should impact on teaching in ordinary classrooms.

## **7.5 Limitations of the Study**

The limitations of this study are principally connected to the methodology of the study, in particular the selection of schools and participants, the data collection tools, the NAPLAN items used and the eight-lesson intervention. Details of these limitations are given in the following sections.

### **7.5.1 The one-to-one task based interview**

The researcher's development of the one-to-one task based interview as an assessment tool was very useful for her study, but the broader use has not been proved. The one-to-one task based interview is an embryonic instrument that seemed to be affected with a limited group. As the items were piloted and the responses from the piloting and the wording of the items were discussed at length with the supervisors, the interview did appear to achieve what it claimed to do. Development of the interview would need to be on a larger scale so that statistical proving such as Rasch modelling, could be carried out. It was not possible to do this with 27 participants.

Awareness of time was deemed to be contained in each item of the interview as the participants were in Years 3 and 4. An interview designed for students in the first years of schooling, Prep and Year 1, would need require a different set of assessment items for all major Components of time, including items to specifically assess an Awareness of time.

### **7.5.2 Participants**

Both the trial school and the main study school are in a regional Victorian city and although the schools have a similar cohort of students, it cannot be assumed that their contexts are transferable to other schools.

The interview and intervention data were collected from students who were all enrolled at the same school and were in the same Year 3 and 4 class. The data collected from individual students with a range of mathematical skills and levels of engagement in the area of time demonstrated that students' apparent skills and abilities can differ from other students of approximately the same age. But it is not known how students from other schools in the state and country or other year levels might perform in the same situations, and so again generalisability to other contexts cannot be assumed.

### **7.5.3 Another researcher**

The researcher in this study developed the one-to-one task based interviews, interviewed the students and analysed the results. The researcher also designed and planned the eight lessons, was the teacher for the intervention, and analysed the data from the intervention. The rich assessment tasks and informal assessment proved to be of benefit to the researcher when planning for individual learning. Although there was strength in the researcher being involved in all these ways within this study as has been argued earlier, it was also a limitation as it is not known if another researcher, for example, conducting the interviews would interpret the students' responses in the same way, come up with the same results applying the same coding system or would have utilised the same rich assessment tasks and informal assessments when planning the lessons. Having said that, all three supervisors were closely involved in checking the interview coding algorithm, with any disagreements discussed and resolved, thereby maximising the chances of consistent coding by others. They were also intimately involved for all other aspects of the study mentioned above.

### **7.5.4 NAPLAN items**

In a perfect world it would have been better to make a selection of the NAPLAN 'time' items from across many more tests. However the number and selection of NAPLAN items was restricted by ACARA. This meant that only six Year 3 items could be used, two of which were also given to Year 5. Using only six items from Year 3 clearly resulted in a ceiling effect, particularly when Year 4 students were part of the student cohort. The analyses of data if the administration of additional Year 5 and even Year 7 items had been possible, may have shown a more substantial improvement for some students after the intervention lessons than was possible using only the items for which permission had been given.

### **7.5.5 The eight-lesson intervention**

The students had not had any lessons on time during the weeks prior to the intervention. The eight-lesson intervention clearly had a major impact on these students. However, having only one teacher use the intervention is a limitation. It is not known if this impact would be as great if the lessons were taught by another teacher with a lesser understanding of the Framework.

Further, the intervention was limited to a Year 3/4 class and was not taught to other year levels. Hence it is not known whether this style of intervention would have as great an impact on students in Years 5/6 although from the researcher's experience she would suggest it would.

The eight-lesson intervention focussed on analogue clocks with little lesson time dealing with digital clocks or digital time. Within the eight lessons, there was insufficient time to include activities on digital time

## **7.6 Implications for Curriculum Developers and Classroom Teachers**

The Framework, which incorporates the four major Components of time, has been designed to inform both teachers and researchers, and to guide curriculum writers and teachers in the planning and implementation of lessons on the concept of time. The Framework double-headed arrows demonstrate how the ideas encapsulated into the concept of time are not learnt in sequence. The major Components of time, Awareness, Succession, Duration and Measurement of time, are recommended to be learned over an extended period in a connected way, ensuring a deep understanding. The Framework is intended to inform curriculum developers in a variety of ways. All components should have an important place in the curriculum with the inter-relationships between each major Component emphasised by curriculum developers. The structure of the Framework with inter-connecting double-headed arrows between each Component both indicates the complex inter-relationships between each major Component and informs the reader that the Components are not necessarily taught or learned in sequence. It is recommended that learning outcomes for the teaching and learning of time be linked to one or more of the major Components. Curriculum documents should include all of the major Components so that emphasis is given not only to the reading of clocks, but also to an Awareness of time, Succession, Duration and the Measurement of time.

In addition it has been noted earlier that the topic of the Earth in space which is an essential part of understanding time, is included in the science curriculum. Consideration should be given to incorporating it into the mathematics curriculum as well.

The one-to-one task based interview was designed to assess children in the middle primary school years on three of the four major Components of the Framework, Succession, Duration and Measurement of time, with Awareness of time deemed to be embedded in each item. An individual child's responses to the 69 items in the interview could be coded to build a profile of that student's apparent strengths and weaknesses in each of the four Components. This tool can be used as assessment of learning as well as assessment for learning (State Government of Victoria, 2017). As not all students are expected to demonstrate a full understanding of each item in Years 3 and 4, the interview should be repeated over time. Although there are 69 items in the complete interview, it would be reasonable to use parts of the interview to assess parts of the Framework, or to use the interview or a section of it with a sample of students, to indicate



common understandings and misconceptions, which could be investigated further during class time.

Classroom experiences and pedagogies that supported the students' learning were identified from the lessons and are recommended for use by teachers when teaching the concepts of time. Giving the students working clocks, focussing the lessons with children's picture books, using correct terminology and language, presenting a variety of experiences, active involvement, and opportunities to draw, write, discuss and share their learning throughout the lessons have been shown to be beneficial to student engagement and learning.

### **7.7 Recommendations for Further Research**

Prior to this study, there was limited research into the learning and teaching of time in primary schools (Earnest, 2017). Further research into this area would increase our understanding of student learning of time. Repeating this study with students from Years 1 and 2 as they are being introduced to early understanding of time Components, and Years 5 and 6 who are deemed to have mastered an understanding of clocks and calendars would certainly complement results from this study.

However, interviews to assess students in years below Year 3 and 4 would require additional items relating specifically to the Awareness of time, which were not required when interviewing Year 3 and 4 students. Further research is required to establish the 'when' and 'how' of learning and teaching the major Components of the Framework. That is, further research would help establish not only the optimum year levels or ages to introduce aspects of the Framework, but would also add to the list of suggested experiences and pedagogies available to teachers.

If time permits, it would be interesting to interview the same students with the same interview one year later, to see whether understandings remain, and misconceptions have been resolved.

In addition, it is clear that while this study has illuminated key Components, provided an assessment tool and offered suggestions on classroom approaches, it does not describe how students' understanding of time develops. This would be an appropriate focus for a very different kind of study.

### **7.8 Looking Back, Looking Forward**

The most valuable resources to emerge from this study are the Framework for the Learning and Teaching of Time, and the one-to-one task based interview. The Framework has the potential to broaden the concepts of time being emphasised in primary schools. The one-to-one task based interview is an important resource for teachers as an assessment *for* learning and an

assessment *of* learning. An additional resource to arise from this study is the set of lessons which emphasises proven experiences and pedagogies for learning. In light of what the students in this study demonstrated as being understood, and in light of the major Components and key ideas in the final Framework, changes to the mathematics curriculum may be necessary.

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## APPENDIX A

### NAPLAN items assessing time showing the percentage of correct responses for Years 3, 5 and 7 from 2008 to 2016

2008 questions	Year 3		Year 5		Year 7	
	Aust	Vic	Aust	Vic	Aust	Vic
Estimate and measure time intervals. <i>Add 1¼ hours digital- digital</i>	50	58				
Compare time on analogue and digital clocks. <i>Quarter hour time.</i>	59	66	89	91		
Interpret timetables in relation to events.			38	43	67	72
Compare Digital & Analogue times.					86	87
Calculate and interpret mean of times.					66	69
Estimate and measure time intervals.					38	40
<b>2009 questions</b>						
Reads time on an analogue clock to half hour. <i>Using hour hand only.</i>	80	85	91	92		
Identifies a date on a calendar.	71	74	88	90		
Reads digital time to the quarter hour. <i>Convert digital time to ¼ hours.</i>	36	46				
Converts minutes to hours. <i>Convert 115 mins to nearest ¼ hour.</i>	31	33				
Locates information on a timetable.			57	63		
Calculates elapsed time.			42	46		
Calculates differences in time across time zones.					47	50
Calculates average speed.					84	87
Solves a problem involving time diffs & analogue to digital conversion.					53	54
Solves a problem involving the addition of digital times.					58	62
<b>2010 questions</b>						
Reads time on the analogue clock to the quarter hour.	53	58	83	86		
Identifies a date on a calendar.	65	69				
Interprets a simple timetable.	45	52				
Converts time units & identifies a difference.			49	53	66	69
Determines a date without using a calendar.			15	16	24	26
Identifies information in a school timetable.					91	92
<b>2011 questions</b>						
Interprets a timetable to locate information.	66	72	88	91		
Matches an analogue time to a digital time.	34	37	68	71		
Solves a multi-step prob involving a pattern of time intervals.			6	7		
Solves a multi-step prob involving add'n & subtract'n of times.					63	66

Solves a word problem involving elapsed times.					30	31
Calculates elapsed time by converting seconds to minutes.					41	43
Solves a multi-step problem involving familiar rates.					21	22
<b>2012 questions</b>						
Identifies the number of minutes in half an hour.	77	82				
Solves a problem involving reading time on an analogue clock.	64	67				
Selects correct information from a calendar.	70	74				
Calculates the diff b/w times on an analogue & a digital clock.	26	32				
Calculates elapsed time in minutes.						
Calculates a time after a given elapsed time.			80	85	86	89
			51	55	71	73
Uses given times to convert between time zones.					44	45
Calculates the number of hours a shop is open.					55	57
<b>2013 questions</b>						
Reads an analogue clock to the half hour.	71	74				
Uses a calendar to determine the date of an event.	33	35	50	53		
Calculates an elapsed time in hours and minutes.			60	62		
Calculates an elapsed time from pm to am in hours and minutes.					49	51
Calculates time from a given speed and a distance.					59	61
<b>2014 questions</b>						
Identifies o'clock time to nearest half hour on digital clock.	70	73	88	91		
Counts back days using a calendar.	47	49	64	66		
Calculates new time given previous time and improvement in minutes and seconds.			15	17		
Reads the time on an analogue clock. (10:11).					90	91
Identifies arrival time given departure time and several elapsed times, with access to a calculator.					41	41
<b>2015 questions</b>						
Determines the day of the week of a date beyond the information shown on calendar.	50	54	68	71		
Converts digital time to words.	43	48				
Uses elapsed time to identify information from a table.			69	72		
Calculates elapsed time using conversion of units.			29	32		
<b>2016 questions</b>						
Identifies the clock that shows half past the hour.	74	77				
Calculates elapsed time from am to pm by converting hours and parts of hours to minutes.			53	54		

**APPENDIX B**  
**Australian Catholic University HREC Approval to conduct research**



Human Research Ethics Committee  
Committee Approval Form

**Principal Investigator/Supervisor:** Prof Doug Clarke    **Co-Investigators:**

**Student Researcher:** : Margaret Thomas

**Ethics approval has been granted for the following project:**

A matter of time: An investigation into the learning and teaching of time in the middle primary years

**for the period:** 30/06/2016

**Human Research Ethics Committee (HREC) Register Number:** 2015-82E

Special Condition/s of Approval

*Prior to commencement of your research*, the following permissions are required to be submitted to the ACU HREC:

- Approval from the Department of Education and Training - Victoria, to conduct research in two Victorian government schools

The data collection of your project has received ethical clearance but the decision and authority to commence may be dependent on factors beyond the remit of the ethics review process and approval is subject to ratification at the next available Committee meeting. The Chief Investigator is responsible for ensuring that outstanding permission letters are obtained, interview/survey questions, if relevant, and a copy forwarded to ACU HREC before any data collection can occur. Failure to provide outstanding documents to the ACU HREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research. Further, this approval is only valid as long as approved procedures are followed.

Clinical Trials: You are required to register it in a publicly accessible trials registry prior to enrolment of the first participant (e.g. Australian New Zealand Clinical Trials Registry <http://www.anzctr.org.au/>) as a condition of ethics approval.

It is the Principal Investigators / Supervisors responsibility to ensure that:

1. All serious and unexpected adverse events should be reported to the HREC with 72 hours.
2. Any changes to the protocol must be reviewed by the HREC by submitting a Modification/Change to Protocol Form prior to the research commencing or continuing. <http://research.acu.edu.au/researchersupport/integrity-and-ethics/>
3. Progress reports are to be submitted on an annual basis. <http://research.acu.edu.au/researchersupport/integrity-and-ethics/>
4. All research participants are to be provided with a Participant Information Letter and consent form, unless otherwise agreed by the Committee.
5. Protocols can be extended for a maximum of five (5) years after which a new application must be submitted. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

Researchers must immediately report to HREC any matter that might affect the ethical acceptability of the protocol eg: changes to protocols or unforeseen circumstances or adverse effects on participants.

*K. Pashley*

Signed: .....

..... Date: .... 03/06/2015.....

(Research Services Officer, Australian Catholic University, Tel: 02 9739 2646)



**APPENDIX C**  
**Department of Education and Training approval to conduct research in Victorian government schools**



Department of  
Education & Training

Strategy & Review Group

2 Treasury Place  
East Melbourne, Victoria 3002  
Telephone: +61 3 9637 2000  
DX 210083  
GPO Box 4367  
Melbourne, Victoria 3001

2015\_002679

Mrs Margaret Thomas  
2 Peipers Terrace  
STRATHDALE 3550

Dear Mrs Thomas

Thank you for your application of 13 April 2015 in which you request permission to conduct research in Victorian government schools titled *A matter of time: An investigation into the learning and teaching of time in the middle primary years*.

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.


1. The research is conducted in accordance with the final documentation you provided to the Department of Education and Training.
2. Separate approval for the research needs to be sought from school principals. This is to be supported by the Department of Education and Training approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.
3. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Training for its consideration before you proceed.
4. As a matter of courtesy, you advise the relevant Regional Director of the schools or governing body of the early childhood settings that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.
5. You acknowledge the support of the Department of Education Training in any publications arising from the research.
6. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study's indicative completion date.



7. If the Department of Education Training has commissioned you to undertake this research, the responsible Branch/Division will need to approve any material you provide for publication on the Department's Research and Evaluation Register.

I wish you well with your research. Should you have further questions on this matter, please contact Youla Michaels, Project Support Officer, Insights and Evidence Branch, by telephone on (03) 9637 2707 or by email at [michaels.youla.y@edumail.vic.gov.au](mailto:michaels.youla.y@edumail.vic.gov.au).

Yours sincerely



Eleanor Williams  
Acting Director  
Insights and Evidence Branch

2/06/2015

**APPENDIX D**  
**Trial school information letters and permission forms**  
**PARTICIPANT INFORMATION LETTER**  
**Principal**

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**  
**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**  
**STUDENT RESEARCHER: Margaret Thomas**  
**STUDENT'S DEGREE: PhD**

Dear Principal,

You are invited to participate in the trialling of questions and tasks for a research project described below, through the involvement of your teachers and students.

***What is the project about?***

The purpose of this study is to determine how the development of children's learning and understanding of *time* can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for *time* suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and 4 students will be assessed on their understanding of *time* prior to, and soon after, the teaching of a unit of work taught by the student researcher. The assessment will be in the form of a one-to-one interview, throughout which the students will be asked questions and given tasks to complete relating to the concepts of *time*. Before the interview questions and tasks are used to assess the students who will be participating in the unit of work (an intervention), which is to be conducted in another school, it will be important to trial the interview questions and tasks to ensure their suitability for the selected year levels. This trial stage is the part of the project in which I am hoping your school will be involved.

***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough, and Emeritus Professor Philip Clarkson.

***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration (which incorporates a Working with Children check).

***What will I be asked to do?***

Following provision of permission for the involvement of the teacher and their students, nothing further will be expected of the Principal. The process for the students will be as follows. Students who agree to participate, and have signed permission from their parent or guardian, will be given a one-to-one interview throughout which they will be asked questions and given tasks to complete relating to the concepts of time. The interviews will audio-recorded. Pseudonyms will be given to the student participants and the school in any written reports of the project for confidentiality and privacy purposes.

***How much time will the project take?***

The trialling of the questions and tasks will be conducted between June and August. Each interview is expected to take around 45 minutes.

***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of time concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of *time* concepts. The benefits to the students involved in the trial will be minor, although students may benefit from reflecting on their understanding of *time*, as they work on the tasks. There will be a negligible risk for the participants.

***Can I withdraw from the study?***

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

***Will anyone else know the results of the project?***

This study will be published as a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teachers or the participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resethics.manager@acu.edu.au](mailto:resethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke Margaret Thomas

Handwritten signatures of Doug Clarke and Margaret Thomas. The signature on the left is 'D Clarke' and the signature on the right is 'M Thomas'.

---

PRINCIPAL CONSENT FORM  
*Copy for Researcher*

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Principal*) have read and understood the information provided in the Participant Information Letter (Principal). Any questions I have asked have been answered to my satisfaction. I agree that students from my school may participate in this project with permission from their parents/guardians, in which they will be asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interviews will occur sometime during July and August 2015. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my school in any way.

NAME OF PRINCIPAL: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 9/6/15

---

PRINCIPAL CONSENT FORM  
*Copy for principal to keep*

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Principal*) have read and understood the information provided in the Participant Information Letter (Principal). Any questions I have asked have been answered to my satisfaction. I agree that students from my school may participate in this project with permission from their parents/guardians, in which they will be asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interviews will occur sometime during July and August 2015. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my school in any way.

NAME OF PRINCIPAL: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:

DATE: 9/6/15



# **PARTICIPANT INFORMATION LETTER**

## **Teacher**

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**

Dear Teacher,

You are invited to participate in the trialling of questions and tasks for a research project described below, through the involvement of your students.

### ***What is the project about?***

The purpose of this study is to determine how the development of children's learning and understanding of time can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for time suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and 4 students will be assessed on their understanding of *time* prior to, and soon after, the teaching of a unit of work taught by the student researcher. The assessment will be in the form of a one-to-one interview, throughout which the students will be asked questions and given tasks to complete relating to the concepts of *time*. Before the interview questions and tasks are used to assess the students who will be participating in the unit of work (an intervention), which is to be conducted in another school, it will be important to trial the interview questions and tasks to ensure their suitability for the selected year levels. This trial stage is the part of the project in which I am hoping you will be involved.

### ***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough, and Emeritus Professor Philip Clarkson.

### ***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration (which incorporates a Working with Children check).

### ***What will I be asked to do?***

Following provision of permission for the involvement of the teacher and their students, nothing further will be expected of the Principal or teacher. The process for the students will be as follows. Students who agree to participate, and have signed permission from their parent or guardian, will be withdrawn from the classroom and given a one-to-one interview throughout which they will be asked questions and given tasks to complete relating to the concepts of time. The interviews will audio-recorded. Each interview will be scheduled to minimise disruption to the classroom routine. Pseudonyms will be given to the student participants and the school in any written reports of the project for confidentiality and privacy purposes.



***How much time will the project take?***

The trialling of the questions and tasks will be conducted during July and August. Each interview is expected to take around 45 minutes.

***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of time concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of time concepts. The benefits to the students involved in the trial will be minor, although students may benefit from reflecting on their understanding of time, as they work on the tasks. There will be a negligible risk for the participants.

***Can I withdraw from the study?***

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

***Will anyone else know the results of the project?***

This study will be published as a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teachers or the participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E. If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resethics.manager@acu.edu.au](mailto:resethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke



Margaret Thomas



TEACHER CONSENT FORM  
Copy for Teacher to keep

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Teacher*) have read and understood the information provided in the Participant Information Letter (Teacher). Any questions I have asked have been answered to my satisfaction. I agree that students from my classroom, from the school nominated below, may participate in this project with permission from their parents/guardians. The students will be withdrawn from the classroom and asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interviews will occur sometime during July and August 2015 and scheduled to minimise disruption to the classroom routine. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify me or my classroom in any way.

NAME OF TEACHER: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 9/6/2015

TEACHER CONSENT FORM  
Copy for Researcher to keep

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Teacher*) have read and understood the information provided in the Participant Information Letter (Teacher). Any questions I have asked have been answered to my satisfaction. I agree that students from my classroom, from the school nominated below, may participate in this project with permission from their parents/guardians. The students will be withdrawn from the classroom and asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interviews will occur sometime during July and August 2015 and scheduled to minimise disruption to the classroom routine. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify me or my classroom in any way.

NAME OF TEACHER: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 9/6/2015.....

# **PARTICIPANT INFORMATION LETTER**

## **Parent**

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**

Dear Parent/Guardian,

Your child has been invited to participate in the trialling of questions for a research project described below.

### ***What is the project about?***

The purpose of this study is to determine how the development of children's learning and understanding of time can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for time suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and 4 students will be assessed on their understanding of time prior to, and soon after, the teaching of a unit of work taught by the researcher. The assessment will be in the form of a one-to-one interview, throughout which they will be asked questions and given tasks to complete relating to the concepts of *time*. Before the interview questions and tasks are used to assess the students who will be participating in the unit of work (an intervention), which is to be conducted in another school, it will be important to trial the interview questions and tasks to ensure their suitability for the selected year levels. This trial stage is the part of the project in which I am hoping your child will be involved.

### ***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.

### ***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration (which incorporates a Working with Children check).

### ***What will I be asked to do?***

With your permission, and your child's assent to being a participant in the trialling of questions, he/she will be given a one-to-one interview throughout which they will be asked questions and given tasks to complete relating to the concepts of *time*. The interviews will be audio-recorded. Pseudonyms will be given to the student participants and the school in any written reports of the project for confidentiality and privacy purposes.

***How much time will the project take?***

The trialling of the questions and tasks will take place in July and August. Each interview is expected to take around 45 minutes.

***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of *time* concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of *time* concepts. The benefits to the students involved in the trial will be minor, although students may benefit from reflecting on their understanding of *time*, as they work on the tasks. There will be a negligible risk for the participants.

***Can I withdraw from the study?***

Participation in this study is completely voluntary. Your child is not under any obligation to participate. If they agree to participate, they can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

***Will anyone else know the results of the project?***

This project will be published as the data collection and analysis component of a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may in the future be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teachers or the participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal and interested parents.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resethics.manager@acu.edu.au](mailto:resethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke



Margaret Thomas



# PARTICIPANT INFORMATION LETTER

## STUDENT

**PROJECT TITLE:** A matter of time: An investigation into the learning and teaching of time in the middle primary years  
**PRINCIPAL INVESTIGATOR:** Professor Doug Clarke  
**STUDENT RESEARCHER:** Margaret Thomas  
**STUDENT'S DEGREE:** PhD



Dear Student,

We are inviting you to take part in a trial of questions and tasks for a research project that is investigating children learning about *time*.

### ***What is the project about?***

*Time* is an interesting part of mathematics as it involves knowing about clocks with hands, digital clocks, and also calendars.

The researcher, Margaret Thomas, thinks that some of the schoolwork children do about time may be too difficult because there is so much to learn. She wants to find out what children in Grade 3 and 4 know about time and how they learn about it. Margaret would like to find some better ways for teachers to teach about time.

To find out how children learn about time, Margaret will ask children some questions. This will be a one-to-one interview, which means that she will ask you questions without other children listening to your answers. Margaret has a voice recorder so she can audio-record your answers and listen to them again later.

### ***Who is undertaking the project?***

This project is being done by Margaret Thomas. Margaret was a primary school teacher for many years, but is now a student at Australian Catholic University. The interviews and lessons with children in your school are part of her study for a degree called a Doctor of Philosophy. She has three university teachers, called supervisors, who are helping her. They are Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.



### ***Will anything happen to me if I take part in this project?***

This project will be at your school, so nobody is expecting anything to happen to you. Being a part of this project is voluntary, which means you can choose if you want to do it. You can also choose which questions you want to answer and when you want to stop. If at any time you don't want to be in the project you can leave and go back to your normal work. Nobody will mind if you don't want to stay with the project.

If you decide to leave the project, all of your work, your question answers and pictures will not be used. Everything you have done will be given back to you to keep.



### ***What will I be asked to do?***

You will be asked to do the following:



Answer questions about *time* during a one-to-one interview. This is not a test and the other children will not know what you have said as the information you give to the researcher is private. To keep your information private, you will be given a fictitious name (a pseudonym) our answers will be audio-recorded so the researcher can listen to them later.

***How much time will the project take?***

The trial will take place in July and August. Each interview is expected to take about 45 minutes.

***Will anyone else know the results of the project?***

When this study is finished, Margaret will write a book called a thesis which will be read by other teachers who want to find out what children know about *time*. Margaret may also write some articles for journals for teachers and go to meetings and conferences where she can tell other teachers what she has learned. No-one will know you are in this study because your fictitious name (pseudonym) will always be used.

***Will I be able to find out the results of the project?***

At the end of the research project, a brief report will be sent to the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you can ask one of your parents, your teacher, your principal, or the researcher, Margaret Thomas. Your parents, your teacher and your principal have all the details of the person in charge of the study so they are welcome to ring him up. His name is Professor Doug Clarke and his phone number is 03 9953 3287. His office is at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

If you have any concerns or complaints, you must speak to your parents, your teacher or your principal straight away. They have the phone number of the people to contact. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the assent section on your parent's or guardian's consent form. Your parent or guardian will keep one copy for their records and they will return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

**Professor Doug Clarke**



**Margaret Thomas**



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PARENT AND STUDENT CONSENT FORM  
*Copy for parent to keep*

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of  
time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the parent/guardian*) have read and understood the information provided in the Participant Information Letter (Parent). Any questions I have asked have been answered to my satisfaction. I agree that my child, nominated below, may participate in this project in which he/she will be asked questions regarding knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interview will occur sometime during July and August 2015. I understand that my child's written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my child in any way.

NAME OF PARENT/GUARDIAN: .....

SIGNATURE

.....

DATE:

NAME OF CHILD .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 9/6/2015.....

**ASSENT OF PARTICIPANTS AGED UNDER 18 YEARS**

I ..... (*the participant aged under 18 years*) understand what this research project is designed to explore. What I will be asked to do has been explained to me. I agree to take part in one audio-recorded interview with the researcher, when I will be asked questions about *time*. I will be given a pseudonym so that the information I give will be used in a way that does not identify me. I realise that I can withdraw at any time without having to give a reason for my decision.

NAME OF PARTICIPANT AGED UNDER 18: .....

SIGNATURE: ..... DATE:

SIGNATURE OF PRINCIPAL INVESTIGATOR:

DATE: 9/6/2015.



---

PARENT AND STUDENT CONSENT FORM  
Copy for Researcher

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of  
time in the middle primary years  
PRINCIPAL INVESTIGATOR: Professor Doug Clarke  
STUDENT RESEARCHER: Margaret Thomas

I ..... (*the parent/guardian*) have read and understood the information provided in the Participant Information Letter (Parent). Any questions I have asked have been answered to my satisfaction. I agree that my child, nominated below, may participate in this project in which he/she will be asked questions regarding knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes. The interview will occur sometime during July and August 2015. I understand that my child's written work on the tasks will be collected and that the audio-recorded interviews will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my child in any way.

NAME OF PARENT/GUARDIAN: .....

SIGNATURE.....

DATE:

NAME OF CHILD .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 9/6/2015

**ASSENT OF PARTICIPANTS AGED UNDER 18 YEARS**

I ..... (*the participant aged under 18 years*) understand what this research project is designed to explore. What I will be asked to do has been explained to me. I agree to take part in one audio-recorded interview with the researcher, when I will be asked questions about *time*. I will be given a pseudonym so that the information I give will be used in a way that does not identify me. I realise that I can withdraw at any time without having to give a reason for my decision.

NAME OF PARTICIPANT AGED UNDER 18: .....

SIGNATURE:.....DATE:

SIGNATURE OF PRINCIPAL INVESTIGATOR:

DATE: 9/6/2015.....



**APPENDIX E**  
**Main school information letters and permission forms**  
**PARTICIPANT INFORMATION LETTER**  
**Principal**

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**

Dear Principal,

You are invited to participate in the research project described below, through the involvement of one or more of the year 3/4 teachers and their mathematics class.

***What is the project about?***

The purpose of this study is to determine how the development of children's learning and understanding of *time* can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for *time* suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and 4 students will be assessed on their understanding of *time* prior to, and soon after, the teaching of a unit of work taught by the student researcher. The assessment will be in the form of a one-to-one interview and will incorporate questions relating to the succession and duration of periods of time, the function and reading of analogue and digital clocks, and the function and reading of calendars. The interviews will be audio-recorded for later analysis by the researcher. Following this assessment, the student researcher will teach a series of lessons with the same Year 3/4 class, focussing on the aspects of *time* which were perceived as challenging by the students during the assessment stage. The lessons will be conducted during the students' regular mathematics lessons over a two week period. Audio-recording of the lessons (through a microphone worn by the teacher) will allow for later analysis of the students' responses. Following the intervention, the students in the class will be reassessed to determine progress in their learning. I am hoping your school will be involved in this part of the project.

***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.

***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded during the interviews and mathematics lessons on *time*, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration.

### ***What will I be asked to do?***

Following provision of permission for the involvement of the teachers and their students, nothing further will be expected of the Principal. The process for the students whose parents have given informed consent, and who have given signed assent to being a participant in the project, will be as follows.

- 1: Each participating student in the 3/4 class will be interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The interview questions will be related to the succession and duration of periods of time, such as reading the time from an analogue or digital clock, estimating time to complete a task, and explaining the function of aspects of a clock or calendar. The interviews will be conducted at a convenient location within the school.
- 2: The student researcher will conduct mathematics lessons for the participating students in the 3/4 class over a two week period (8 lessons), focussing on *time*. These lessons will be audio-recorded. The lessons to be conducted during the regularly scheduled mathematics lesson time and will focus on problem-solving tasks related directly to the needs of the children, as evidenced by the one-to-one interview responses. The classroom teacher will be consulted for approval of each lesson to ensure that the planned lessons comply with the school curriculum and AusVELS. Lessons may include the drawing of timelines, an investigation into what constitutes an hour, investigating the movement of the hands of a clock and their relation to the numbers on a digital clock, and the children developing their own calendar. The students' written work from the lessons will be collected by the student researcher. The lessons will be conducted in the students' regular classroom with arrangements being made beforehand with other teachers for non-participating students to attend their classes. The researcher will work closely with the regular classroom teacher and the school principal to make sure that these children are placed in a like-year-level class, and that their academic progress is not hindered in any way. It is expected that only a very small number (if any) will not participate in the research.
- 3: Each participating student in the 3/4 class will be re-interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The questions will relate to *time*, to assess progress in the learning of the students. The interviews will be conducted at a convenient location within the school.

### ***How much time will the project take?***

The project will be conducted from September to December. The first interview stage will commence in September. Each interview is expected to about 45 minutes, with all of the participating students being interviewed over a 3 week period. The lessons will be conducted over a two week period as soon as the interviews have been concluded. The follow-up interviews will begin after the two weeks of lessons on *time* and be completed by the end of term.

### ***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of time concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of *time* concepts. The benefit for the

participants may not be immediate as the learning of all *time* concepts cannot be achieved in two weeks, although it is anticipated that learning will occur during the time lessons. There will be a negligible risk for the participants as they will, with the exception of the interview time, be working in their regular classroom.

***Can I withdraw from the study?***

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

***Will anyone else know the results of the project?***

This study will be published as a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teacher or the participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resetethics.manager@acu.edu.au](mailto:resetethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke



Margaret Thomas



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PRINCIPAL CONSENT FORM  
*Copy for Researcher*

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of  
time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Principal*) have read and understood the information provided in the Participant Information Letter (Principal). Any questions I have asked have been answered to my satisfaction. I agree that students from my school may participate in this project with permission from their parents/guardians, in which (a) they will be asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes, and (b) participate in classroom mathematics lessons on *time*. The project will occur sometime between September 2015 and December 2015. I understand that students' written work will be collected and that the audio-recorded interviews and lessons will be used in the development of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my school in any way.

NAME OF PRINCIPAL: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015



PRINCIPAL CONSENT FORM  
Copy for principal to keep

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Principal*) have read and understood the information provided in the Participant Information Letter (Principal). Any questions I have asked have been answered to my satisfaction. I agree that students from my school may participate in this project with permission from their parents/guardians, in which (a) they will be asked questions regarding their knowledge of *time* concepts in an audio-recorded, one-to-one interview, of around 45 minutes, and (b) participate in classroom mathematics lessons on *time*. The project will occur sometime between September 2015 and December 2015. I understand that students' written work will be collected and that the audio-recorded interviews and lessons will be used in the development of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify my school in any way.

NAME OF PRINCIPAL: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015

# PARTICIPANT INFORMATION LETTER

## Teacher

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**

Dear Teacher,

You are invited to participate in the research project described below, through the involvement of the children in your mathematics class.

### ***What is the project about?***

The purpose of this study is to determine how the development of children's learning and understanding of *time* can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for *time* suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and/or 4 students will be assessed on their understanding of *time* prior to, and soon after, the teaching of a unit of work taught by the student researcher. This assessment will be in the form of a one-to-one interview and will incorporate questions relating to the succession and duration of periods of *time*, the function and reading of analogue and digital clocks, and the function and reading of calendars. The interviews will be audio-recorded for later analysis by the student researcher. Following this assessment the student researcher will teach a series of lessons in the Year 3 and/or 4 classroom, focussing on the aspects of *time* which were perceived as challenging by the students during the assessment stage. The lessons will be conducted during the students' regular mathematics lessons over a two week period. Audio-recording of the lessons (through a microphone worn by the teacher) will allow for later analysis of the students' responses. Following the intervention, the students in the class will be reassessed to determine progress in their learning. I am hoping the students in your classroom will be involved in this part of the project.

### ***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.

### ***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded during the interviews and mathematics lessons on *time*, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration.

### ***What will I be asked to do?***

Following provision of permission for the involvement of the teacher and their students, nothing further will be expected of the classroom teacher. The process for the students whose parents have given informed consent, and who have given signed assent to being a participant in the project, will be as follows.

- 1: Each participating student in the 3/4 class will be interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The interview questions will be related to the succession and duration of periods of *time*, such as reading the time from an analogue or digital clock, estimating time to complete a task, and explaining the function of aspects of a clock or calendar. The interviews will be conducted at a convenient location within the school.
- 2: The student researcher will conduct mathematics lessons for the participating students in the 3/4 class over a two week period (8 lessons), focussing on *time*. These lessons will be audio-recorded. The lessons to be conducted during the regularly scheduled mathematics lesson time and will focus on problem-solving tasks related directly to the needs of the children, as evidenced by the one-to-one interview responses. The classroom teacher will be consulted for approval of each lesson to ensure that the planned lessons comply with the school curriculum and AusVELS. Lessons may include the drawing of timelines, an investigation into what constitutes an hour, investigating the movement of the hands of a clock and their relation to the numbers on a digital clock, and the children developing their own calendar. The students' written work from the lessons will be collected by the student researcher. The lessons will be conducted in the students' regular classroom with arrangements being made beforehand with other teachers for non-participating students to attend their classes. The researcher will work closely with the regular classroom teacher and the school principal to make sure that these children are placed in a like-year-level class, and that their academic progress is not hindered in any way. It is expected that only a very small number (if any) will not participate in the research.
- 3: Each participating student in the 3/4 class will be re-interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The questions will relate to *time*, to assess progress in the learning of the students. The interviews will be conducted at a convenient location within the school.

***How much time will the project take?***

The project will be conducted from September to December. The first interview stage will commence in September. Each interview is expected to about 45 minutes, with all of the participating students being interviewed over a 3 week period. The lessons will be conducted over a two week period as soon as the interviews have been concluded. The follow-up interviews will begin after the two weeks of lessons on *time* and be completed by the end of term.

***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of time concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of *time* concepts. The benefit for the participants may not be immediate as the learning of all *time* concepts cannot be achieved in two weeks, although it is anticipated that learning will occur during the time lessons. There will be a negligible risk for the participants as they will, with the exception of the interview time, be working in their regular classroom.

***Can I withdraw from the study?***

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

***Will anyone else know the results of the project?***

This study will published as a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teacher or the

participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resethics.manager@acu.edu.au](mailto:resethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke



Margaret Thomas



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TEACHER CONSENT FORM  
*Copy for Researcher*

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Teacher*) have read and understood the information provided in the Participant Information Letter (Teacher). Any questions I have asked have been answered to my satisfaction. I agree that students from my classroom may participate in this project with permission from their parents/guardians, in which (a) they will be given pre-and post-assessments regarding their knowledge of *time* concepts in audio-recorded, one-to-one interviews of around 45 minutes each, scheduled to minimise disruption to the classroom routine, and (b) participate in an 8-lesson unit of work on *time*, taught by the researcher, and conducted during the students' scheduled mathematics time. The interviews and lessons will occur sometime between September and December 2015. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews and lessons will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify me or my classroom in any way.

NAME OF TEACHER: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015

TEACHER CONSENT FORM  
Copy for teacher to keep

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the Teacher*) have read and understood the information provided in the Participant Information Letter (Teacher). Any questions I have asked have been answered to my satisfaction. I agree that students from my classroom may participate in this project with permission from their parents/guardians, in which (a) they will be given pre-and post-assessments regarding their knowledge of *time* concepts in audio-recorded, one-to-one interviews of around 45 minutes each, scheduled to minimise disruption to the classroom routine, and (b) participate in an 8-lesson unit of work on *time*, taught by the researcher, and conducted during the students' scheduled mathematics time. The interviews and lessons will occur sometime between September and December 2015. I understand that students' written work on the tasks will be collected and that the audio-recorded interviews and lessons will be used only for the clarification of students' responses. The project will form the basis of a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews (without adverse consequences). I agree that research data collected for the study will not identify me or my classroom in any way.

NAME OF TEACHER: .....

SIGNATURE

.....

DATE:

NAME OF SCHOOL: .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015

# PARTICIPANT INFORMATION LETTER

## Parent

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**

Dear Parent/Guardian,

Your child has been invited to participate in the research project described below.

### ***What is the project about?***

We are inviting your child to take part in a research project that aims to improve the learning and teaching of *time* in mathematics. Your child's teacher and principal have elected to be part of this project. The purpose of this study is to determine how the development of children's learning and understanding of time can be best explained, assessed and supported in the primary school classroom with the intention of developing a learning trajectory for time suitable for primary school classrooms. To achieve these aims the research project will investigate the learning of concepts of *time* by children in middle primary school. Year 3 and 4 students will be assessed on their understanding of *time* prior to, and soon after, the teaching of a unit of work taught by the student researcher. The assessment will be in the form of a one-to-one interview and will incorporate questions relating to the succession and duration of periods of time, the function and reading of analogue and digital clocks, and the function and reading of calendars. The interviews will be audio-recorded for later analysis by the researcher. Following this assessment, the student researcher will teach a series of lessons with the same Year 3 and/or 4 class, focussing on the aspects of time which were perceived as challenging by the students during the assessment stage. The lessons will be conducted during the students' regular mathematics lessons over a two week period. Audio-recording of the lessons (through a microphone worn by the teacher) will allow for later analysis of the students' responses. Following the intervention, the students in the class will be reassessed to determine progress in their learning. I am hoping that your child will be involved in all stages of the project.

### ***Who is undertaking the project?***

This project is being conducted by Margaret Thomas and will form the basis for the degree of Doctor of Philosophy at Australian Catholic University under the supervision of Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.

### ***Are there any risks associated with participating in this project?***

There are no foreseeable risks with the project. The students may experience some anxiety about being questioned and audio-recorded, but each student's participation will be voluntary and he/she can withdraw from the project at any time. The student researcher is an experienced teacher with over twenty years' experience working in classrooms in primary schools and has current VIT registration.

### ***What will I be asked to do?***

- Part 1: Each participating student in the 3/4 class will be interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The interview questions will be related to the succession and duration of periods of time, such as reading the time from an analogue or digital clock,

estimating time to complete a task, and explaining the function of aspects of a clock or calendar. The interviews will be conducted at a convenient location within the school.

- Part 2: The student researcher will conduct mathematics lessons for the participating students in the 3/4 class over a two week period (8 lessons), focussing on *time*. These lessons will be audio-recorded. The lessons to be conducted during the regularly scheduled mathematics lesson time and will focus on problem-solving tasks related directly to the needs of the children, as evidenced by the one-to-one interview responses. The classroom teacher will be consulted for approval of each lesson to ensure that the planned lessons comply with the school curriculum and AusVELS. Lessons may include the drawing of timelines, an investigation into what constitutes an hour, investigating the movement of the hands of a clock and their relation to the numbers on a digital clock, and the children developing their own calendar. The students' written work from the lessons will be collected by the student researcher. The lessons will be conducted in the students' regular classroom with arrangements being made beforehand with other teachers for non-participating students to attend their classes. The researcher will work closely with the regular classroom teacher and the school principal to make sure that these children are placed in a like-year-level class, and that their academic progress is not hindered in any way.
- Part 3: Each participating student in the 3/4 class will be re-interviewed by the student researcher on a one-to-one basis with the questions asked and the responses given, audio-recorded. The questions will relate to *time*, to assess further learning of the students. The interviews will be conducted at a convenient location within the school.

#### ***How much time will the project take?***

The project will be conducted from September to December. The interviews will commence in September. Each interview is expected to take about 45 minutes, with all of the participating students being interviewed over a 3 week period. The mathematics lessons on *time* in will be conducted over a two week period as soon as the interviews have been concluded. The follow-up interviews will be held after the two weeks of lessons and be completed by the end of term.

#### ***What are the benefits of the research project?***

A key benefit of the research project will be an increased understanding of Year 3 and 4 students' knowledge and understanding of time concepts, and the development of a possible learning trajectory for *time*. The results of the research project are anticipated to inform teachers about student learning and the teaching of *time* concepts. The benefit for the participants may not be immediate as the learning of all *time* concepts cannot be achieved in two weeks, although it is anticipated that learning will occur during the time lessons. There will be a negligible risk for the participants as they will, with the exception of the interview time, be working in their regular classroom.

#### ***Can I withdraw from the study?***

Participation in this study is completely voluntary. Your child is not under any obligation to participate. If they agree to participate, they can withdraw from the study at any time without adverse consequences. Data collected from a participant prior to his/her withdrawal from this study will be returned to the withdrawing participant and will not be used in the study.

#### ***Will anyone else know the results of the project?***

This project will be published as the data collection and analysis component of a research thesis to be submitted for the degree of Doctor of Philosophy. Findings of this research may



in the future be published in mathematics journals, conference proceedings and books. Information will be published in a manner that will not identify the school, the teacher or the participants, as pseudonyms will be used for the school and each participant. The written data will be de-identified when stored electronically. Audio-recordings of each participant's interaction with the student researcher will be transcribed and a pseudonym given to the interviewee. To ensure privacy and confidentiality, data will be stored according to university guidelines.

***Will I be able to find out the results of the project?***

At the conclusion of the research project, a brief report will be prepared for the principal.

***Who do I contact if I have questions about the project?***

If you have any questions about the project, you are welcome to contact the principal investigator, Professor Doug Clarke on 03 9953 3287 at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

***What if I have a complaint or any concerns?***

The study has been reviewed by the Human Research Ethics Committee at Australian Catholic University (review number 2015-82E). If you have any complaints or concerns about the conduct of the project, you may write to the Manager of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Manager, Ethics  
c/o Office of the Deputy Vice Chancellor (Research)  
Australian Catholic University  
North Sydney Campus  
PO Box 968  
NORTH SYDNEY, NSW 2059  
Ph.: 02 9739 2519  
Fax: 02 9739 2870  
Email: [resethics.manager@acu.edu.au](mailto:resethics.manager@acu.edu.au)

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to participate in this project, please sign both copies of the consent form, retain one copy for your records and return the other copy to Professor Doug Clarke.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke

Margaret Thomas



# PARTICIPANT INFORMATION LETTER

## STUDENT

**PROJECT TITLE: A matter of time: An investigation into the learning and teaching of time in the middle primary years**

**PRINCIPAL INVESTIGATOR: Professor Doug Clarke**

**STUDENT RESEARCHER: Margaret Thomas**

**STUDENT'S DEGREE: PhD**



Dear Student,

A research project is going to be done in your grade and we would like you to be a part of it. This project will be investigating how children learn about *time*.

### ***What is the project about?***

*Time* is an interesting part of mathematics as it involves knowing about clocks with hands, digital clocks, and also calendars.

The researcher, Margaret Thomas, thinks that some of the schoolwork children do about time may be too difficult because there is so much to learn. She wants to find out what children in Grade 3 and 4 know about time and how they learn about it. Margaret would like to find some better ways for teachers to teach about time.

To find out how children learn about time, Margaret will ask children some questions. This will be a one-to-one interview, which means that she will ask you questions without other children listening to your answers. Margaret has a voice recorder so she can audio-record your answers and listen to them again later.

When all the children have been interviewed, Margaret will be your mathematics teacher for two weeks, teaching lessons on *time*. When the two weeks of lessons have ended, she will interview you again, in the same way as the first interview. The questions will be about *time* and your answers will again be audio-recorded so she can listen to them later.



### ***Who is doing the project?***

This project is being done by Margaret Thomas. Margaret was a primary school teacher for many years, but is now a student at Australian Catholic University. The interviews and lessons with children in your school are part of her study for a degree called a Doctor of Philosophy. She has three university teachers, called supervisors, who are helping her. They are Professor Doug Clarke, Dr Andrea McDonough and Emeritus Professor Philip Clarkson.

### ***Will anything happen to me if I take part in this project?***



This project will be at your school, so nobody is expecting anything to happen to you. Being a part of this project is voluntary, which means you can choose if you want to do it. You can also choose which questions you want to answer and when you want to stop. If at any time you don't want to be in the project, you can leave and go back to your normal work. Nobody will mind if you don't want to stay with the project. If you decide to leave the project, all of your work, your question answers and pictures will not be used by anyone. Everything you have done will be given back to you to keep.

### ***What will I be asked to do?***

You will be asked to do the following:

1. Answer questions about *time* during a one-to-one interview. This is not a test and the other children will not know what you have said as the information you give to the researcher is private. To keep your information private, you will be given a fictitious name (a pseudonym) our answers will be audio-recorded so the researcher can listen to them later.
2. Join in the mathematics lessons for two weeks. The lessons will be in your classroom and Margaret Thomas will be your teacher. Her lessons will be about *time*.
3. Be interviewed a second time to answer questions about *time*.

### ***How much time will the project take?***

Margaret will be in your school from September to December.

- The interviews will start in September. Each interview will be about 45 minutes.
- The mathematics lessons on *time* in will be over a two weeks
- The second interviews will be after the two weeks of lessons.

### ***Will anyone else know the results of the project?***

When this study is finished, Margaret will write a book called a thesis which will be read by other teachers who want to find out what children know about *time*. Margaret may also write some articles for journals for teachers and go to meetings and conferences where she can tell other teachers what she has learned. No-one will know you are in this study because your fictitious name (pseudonym) will always be used.

### ***Will I be able to find out the results of the project?***

At the end of the research project, a brief report will be sent to the principal.

### ***Who do I contact if I have questions about the project?***

If you have any questions about the project, you can ask one of your parents, your teacher, your principal, or the researcher, Margaret Thomas. Your parents, your teacher and your principal have all the details of the person in charge of the study so they are welcome to ring him up. His name is Professor Doug Clarke and his phone number is 03 9953 3287. His office is at Australian Catholic University (Melbourne Campus), 115 Victoria Parade, Fitzroy 3056.

### ***What if I have a complaint or any concerns?***

If you have any concerns or complaints, you must speak to your parents, your teacher or your principal straight away. They have the phone number of the people to contact.

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

***I want to participate! How do I sign up?***

If you agree to be a part of this project, please sign both copies of the assent section on your parent's or guardian's consent form. Your parent or guardian will keep one copy for their records and they will return the other copy to Professor Doug Clarke via the student researcher.

Yours sincerely,

**RESEARCHER NAME/S AND SIGNATURE/S**

Professor Doug Clarke



Margaret Thomas



PARENT AND STUDENT CONSENT FORM  
Copy for Researcher

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (*the parent/guardian*) have read and understood the information provided in the Participant Information Letter for parents. Any questions I have asked have been answered to my satisfaction. I agree that my child, nominated below, may participate in this project in which (a) he/she will be asked questions regarding knowledge of *time* concepts, in two audio-recorded one-to-one interviews of around 45 minutes each, and (b) participate in classroom mathematics lessons on *time*. The project will occur sometime between September 2015 and December 2015. I understand that my child's written work will be collected and that the audio-recorded interviews and lessons will be used in a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews or lessons (without adverse consequences). I agree that research data collected for the study will form the basis for the degree of Doctor of Philosophy for the student researcher in a form that does not identify my child in any way.

NAME OF PARENT/GUARDIAN: .....

SIGNATURE .....

DATE:

NAME OF CHILD .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015

**ASSENT OF PARTICIPANTS AGED UNDER 18 YEARS**

I ..... (*the participant aged under 18 years*) understand what this research project is designed to explore. What I will be asked to do has been explained to me. I agree to take part in two audio-recorded interviews with the researcher, when I will be asked questions about *time*. I also agree to participate in mathematics lessons taken by the researcher and that my mathematics written work may be used by the researchers in a way that does not identify me. I realise that I can withdraw at any time without having to give a reason for my decision. I understand that if my parent/guardian or I do not agree to my involvement in the eight audio-taped lessons, I will be placed in another class for the duration of these lessons.

NAME OF PARTICIPANT AGED UNDER 18: .....

SIGNATURE: DATE:.....

SIGNATURE OF PRINCIPAL INVESTIGATOR:



DATE: 12/06/2015

PARENT AND STUDENT CONSENT FORM  
Copy for parent to keep

TITLE OF PROJECT: A matter of time: An investigation into the learning and teaching of time in the middle primary years

PRINCIPAL INVESTIGATOR: Professor Doug Clarke

STUDENT RESEARCHER: Margaret Thomas

I ..... (the parent/guardian) have read and understood the information provided in the Participant Information Letter for parents. Any questions I have asked have been answered to my satisfaction. I agree that my child, nominated below, may participate in this project in which (a) he/she will be asked questions regarding knowledge of *time* concepts, in two audio-recorded one-to-one interviews of around 45 minutes each, and (b) participate in classroom mathematics lessons on *time*. The project will occur sometime between September 2015 and December 2015. I understand that my child's written work will be collected and that the audio-recorded interviews and lessons will be used in a research thesis to be submitted for the degree of Doctor of Philosophy, and for presentations to teachers and researchers. I realise that I can withdraw my consent at any time prior to the interviews or lessons (without adverse consequences). I agree that research data collected for the study will form the basis for the degree of Doctor of Philosophy for the student researcher in a form that does not identify my child in any way.

NAME OF PARENT/GUARDIAN: .....

SIGNATURE

.....

DATE:

NAME OF CHILD .....

SIGNATURE OF PRINCIPAL INVESTIGATOR:

DATE: 12/06/2015

**ASSENT OF PARTICIPANTS AGED UNDER 18**



**YEARS**

I ..... (the participant aged under 18 years) understand what this research project is designed to explore. What I will be asked to do has been explained to me. I agree to take part in two audio-recorded interviews with the researcher, when I will be asked questions about *time*. I also agree to participate in mathematics lessons taken by the researcher and that my mathematics written work may be used by the researchers in a way that does not identify me. I realise that I can withdraw at any time without having to give a reason for my decision. I understand that if my parent/guardian or I do not agree to my involvement in the eight audio-taped lessons, I will be placed in another class for the duration of these lessons.

NAME OF PARTICIPANT AGED UNDER 18: .....

SIGNATURE: DATE:.....

SIGNATURE OF PRINCIPAL INVESTIGATOR: .....



DATE: 12/06/2015

**APPENDIX F**

**Distribution of Succession, Duration and Measurement of time items in the one-to-one task based interview**

Item N°	S	D	M
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			

Item N°	S	D	M
36			
37a			
37b			
37c			
37d			
37e			
38a			
38b			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48a			
48b			
48c			
48d			
48e			
49			
50			
51a			
51b			
51c			
52			
53a			
53b			
53c			
54c			
54d			
55			
<b>Total</b>			
	<b>28</b>	<b>31</b>	<b>49</b>

## **APPENDIX G**

### **The one-to-one task based interview**

#### **Requisites**

- A timeline (Attachment A).
- Three pictures depicting annual events appropriate for the interview location. For example, a child swimming, a child in winter clothing, and Bendigo's Chinese dragon, Sun Loong (Attachment B).
- A calendar displaying one month to an A4 page. Pages stapled together with January as the first page (Attachment C).
- Sheets of paper at least size A5 on which to draw analogue and digital clocks. (Extra paper may be required if students want to improve their drawing or think they have made a mistake.)
- A clock with a round face. (Not a drawing.)
- Clocks (not drawings) large enough to be read by students. Six clocks with pre-set times will prevent having to reset the time for each question.
- A date card showing 24/9/2015. (Attachment D).
- A picture of a digital clock with the last minute number set at 7 (Attachment E).
- The Bendigo to Melbourne train timetable (Attachment F).
- A copy of the classroom weekly timetable, including start and finish times for each lesson, recess and lunch breaks.

#### **Attachments are at the end of the record sheet.**

- Attachment A. A timeline with pictures to indicate waking up and going to bed. Q. 7 and Q. 8.
- Attachment B. Pictures showing summer holidays, The Bendigo Chinese dragon and winter. Q. 26.
- Attachment C. A 12 month calendar. Qs. 27 - 31. Q. 33.
- Attachment D. Card with the date 24/9/2015 written on it. Q. 35.
- Attachment E. A picture of a digital clock with the last minute number being 7. Q. 52.
- Attachment F. A train timetable. Q. 53 and Q. 54.
- Attachment G. A timeline showing hours to be used for assessment of Questions 7, 8 and 9.



### **Prior to the interview commencing**

- Prepare materials for all questions to be asked and tasks to be done. (Attachments, class timetable, location appropriate pictures for Q26.)
- Print a copy of the question and response sheet for each student being interviewed.
- Select an appropriate space in the school in which to interview the student which allows the interviewer and student to be seen but not distracted.
- Ensure clocks and calendars in the interview room are neither visible to, nor can be heard by, the students.
- Sit the student beside the interviewer to prevent distraction caused by the student viewing the record sheet.
- Introduce yourself to the student and ensure they are comfortable to commence.
- Read instructions before asking each question. Questions must be asked exactly as written on the question sheet.

*At the outset of the interview, the interviewer introduces herself to the student and explains that she will be asking questions about time by saying the following. [Note any questions asked by the student.]*

“I am going to talk to you about **time** because I want to find out what you have learned about **time** and **measuring time**. I will ask you some questions which I would like you to answer the best way that you can. Some of the questions may be easy and some of the questions may be hard because you haven’t learned about that item yet. Some of the questions will make you think about time in a way that you haven’t done before. This is not a test but I will record your answers so I can recall your responses. Some important things to remember are:

- Try to answer each question.
- If you are not sure of a question, you can ask me to repeat it.
- If a question is too difficult, you are allowed to say ‘pass’ or ‘I don’t know’.
- Do you have any questions to ask me before we start?”

### **Notes regarding the questions/tasks and responses**

1. Each question has a range of anticipated responses or answers. Select the most appropriate response for each question. All responses should be written verbatim for analysis of understanding.
2. All responses will be given a score of 2, 1 or 0 as indicated by the response sheet.
3. No response (zero score) includes responses such as:
  - a. The student giving no response to the question or task.
  - b. The student saying, “I don’t know” or “Pass”.
  - c. The student shrugging their shoulders.
  - d. Any other incorrect responses or answers.

**Coding for questions.**

**S: Succession. D: Duration. M: Measurement of time.** (An Awareness of time is deemed to be incorporated into all questions in some way.)

**Coding for responses.**

**Bold text:** Demonstrated understanding.

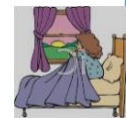
Underlined text: Demonstrated some or partial understanding.

Plain text: No understanding demonstrated.

Attachment A. Timeline. Q. 7 and Q. 8. Enlarge to A3. (*Select most appropriate illustration for each student.*)

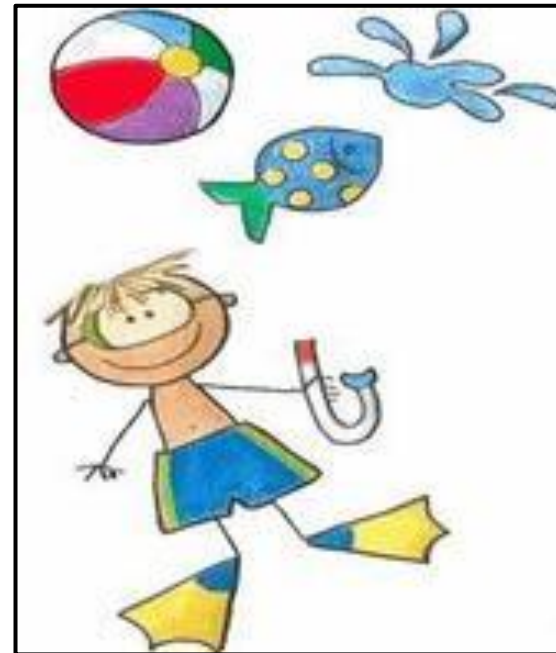


Wake up.



Go to bed.

Attachment B. Pictures showing summer holidays, The Bendigo Chinese dragon and winter. Q. 26.



Attachment C. 12 month calendar. Qs. 27-31, 33. Photocopy and enlarge each month of a calendar onto A4 sized paper. Staple pages together to make a year. An example is given below showing the first four months of 2015.

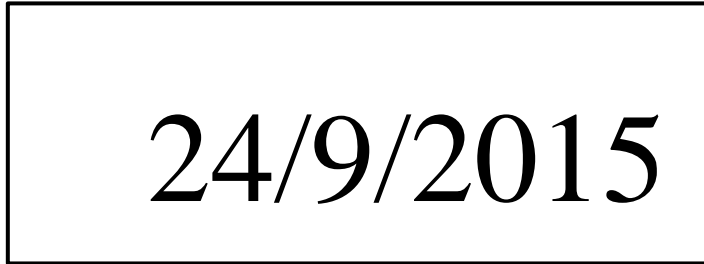
January 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

February 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

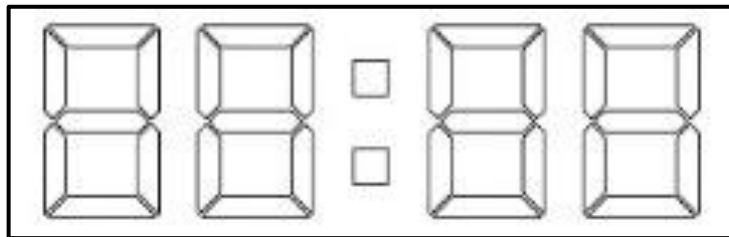
March 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Attachment D. Date card. Q. 35.



Template for digital clock display.



Attachment E. Digital clock. Q. 52.



Numerals to be coloured as shown (above) for Q.52.

Attachment F. Train timetable. Q. 53 and Q. 54.

	MONDAY – FRIDAY									
Service	TRAIN 1	TRAIN 2	TRAIN 3	TRAIN 4	TRAIN 5	TRAIN 6	TRAIN 7	TRAIN 8	TRAIN 9	TRAIN 10
EPSOM STATION dep				05:58				08:23		
Eaglehawk			05:33	—	06:22			—	09:10	
BENDIGO arr			05:41	06:06	06:30			08:33	09:21	
BENDIGO dep		05:07	05:43	06:08	06:32		07:45	08:45	09:24	10:30
Kangaroo Flat		05:11	—	06:12	06:36		07:49	08:49	—	10:34
Castlemaine		05:28	06:02	06:29	06:53		08:06	09:08	09:48	10:51
Malmsbury		05:40	—	06:41	—		—	09:22	—	11:03
Kyneton	05:18	05:48	—	06:49	07:11	07:21	08:25	09:30	10:13	11:11
Woodend	05:26	05:56	—	06:57	07:19	07:29	08:33	09:39	10:24	11:20
Macedon	05:32	06:02	—	07:03	07:25	07:35	—	09:45	—	11:26
Gisborne	05:36	06:06	06:29	07:07	07:29	07:39	08:41	09:49	10:35	11:30
Riddells Creek	05:41	06:11	—	07:12	07:34	07:44	—	09:54	—	11:35
Clarkefield	05:46	06:16	—	07:17	07:39	07:49	—	09:59	—	11:40
Sunbury	05:57d	06:28d	—	—	—	07:58d	08:58d	10:11d	—	11:52d
Watergardens	—	—	—	07:38d	07:56d	—	—	—	11:06d	—
Footscray	06:20d	06:50d	07:09d	07:56d	08:14d	08:30d	09:18d	10:33d	11:24d	12:13d
SOUTHERN CROSS arr	06:29	06:59	07:18	08:08	08:23	08:39	09:27	10:42	11:33	12:22

Attachment G. Assessment timeline for Qs 7, 8 and 9. **Adjust second row of boxes to suit the school timetable.** Enlarge to A3.

6 :30	7 :30	8 :00	8 :30	9 :00	1 0:00	1 1:00	1 1:30	1 2:00	1 3:00	1 4:00	1 5:00	1 6:00	1 7:00	1 8:00	1 9:00	2 0:00	2 0:30		
Rise. Breakfast. Prepare for school.				School commences 8:45.  Session 1. 8:45 – 11:00				Recess 11:00 – 11:30		2. Session 11:30 – 13:00		Supervised eating. 13:00 – 13:10. Play. 13:00 – 14:00		3. Session 14:00 – 15:15		School concludes 15:15.  After school activities. Dinner/Tea. Retire to bed at end of day.			

<b>The one-to-one task based interview response sheet</b>	
	<b>Student's name/pseudonym:                      Age:      DOB:                      Year:                      Date of interview:                      Time of interview.</b>
<b>S</b>	<p style="text-align: center;"><i>Greet the student with the appropriate greeting. 'Good morning' or 'Good afternoon'.</i></p> <p><b>1. How do I know it is morning/afternoon?</b></p> <ul style="list-style-type: none"> <li>• <b>Identifies morning as between 12 o'clock midnight (12am) and 12 o'clock midday (12pm) OR afternoon as after 12 o'clock midday (12pm).</b></li> <li>• <u>Provides partial information, but is incomplete. (Identified morning and afternoon by an event or events which have occurred or will occur such as recess, music lesson; identifies morning as before 12 o'clock midday (12pm); refers to am or pm but no further information is given.)</u></li> <li>• Response does not identify whether it is morning/afternoon OR other incorrect response OR no response.</li> </ul> <p>Response:</p>
<b>S/D</b>	<p><b>2. Today is Wednesday*. When did Wednesday* start? *State the actual day you are talking to the student.</b></p> <ul style="list-style-type: none"> <li>• <b>Starts at midnight or 12 o'clock in the night/night-time or 12am.</b></li> <li>• <u>Gives a time that is within an hour of midnight or 12 o'clock (between 11pm and 11:59pm inclusive; or between 12:01am and 1:00am inclusive) OR says 12 o'clock without specifying when the 12 o'clock occurs.</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
<b>S/D</b>	<p><b>3. When will Wednesday* finish? State the actual day as above.</b></p> <ul style="list-style-type: none"> <li>• <b>Finishes at midnight or 12 o'clock in the night/night time or 12am.</b></li> <li>• <u>Gives a time that is within an hour of midnight or 12 o'clock (between 11pm and 11:59pm inclusive; or between 12:01 am and 1:00am inclusive) OR says 12 o'clock without specifying when the 12 o'clock occurs.</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>



S/D/M	<p>4. Tell me when it is am and when it is pm?</p> <ul style="list-style-type: none"> <li>• <b>States that am is from 12 o'clock midnight to 12 o'clock midday and pm is from 12 o'clock midday to 12 o'clock midnight.</b></li> <li>• <u>Provides some correct information but is incomplete. (For example, says that am is the morning and pm is the afternoon)</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
S/D/M	<p>5. When does am change to pm?</p> <ul style="list-style-type: none"> <li>• <b>Midday or 12 o'clock in the daytime or 12pm.</b></li> <li>• <u>Gives a time within an hour of midday (between 11:00am and 11:59am inclusive; or between 12:01pm and 1:00pm inclusive) OR says 12 o'clock without specifying when the 12 o'clock occurs.</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
D/M	<p><i>* Before the interview, refer to the school timetable to ascertain whether recess or lunch is the shorter time or if they are equal. If times are equal, select more appropriate durations such as school assembly and lunch time which differ in length by at least 30 minutes.</i></p> <p><i>Say to the student, Think about recess and lunchtime. Is recess longer or shorter than lunchtime?</i></p> <p>Response: <b>N.B. No marks awarded for this response.</b></p> <p>6. How do you know that your recess* is shorter/longer than your lunchtime? <i>Use the response given by the student.</i></p> <ul style="list-style-type: none"> <li>• <b>Gives an answer related to the number of hours or minutes for recess and lunch. (Examples: recess is from 11 o'clock until 11:30 and lunch is from 1:30 until 2:30, or we have half an hour for recess and an hour for lunch.)</b></li> <li>• <u>Gives an answer related to how long the durations of recess and lunch feel, or what can be done in the given time. (For example: More people can have a bat in cricket at lunchtime than recess.)</u></li> <li>• <u>Some correct information but incomplete. (For example recess is 5 minutes OR lunch is one and a half hours.)</u></li> <li>• Response does not clearly explain why recess* is shorter than lunchtime OR other incorrect response OR no response.</li> </ul> <p>Response:</p>

S/D/M	<p>7. Say to the student, I have a timeline here. Do you know what a timeline is? Show the student the timeline (Attachment A). This is a timeline of a school day. Point to the picture at the start. It starts with you getting out of bed in the morning and finishes with you going to bed at night. Point to the picture at the end. In between are all the things you do in a day including coming to school.</p> <p><b>Retain the timeline for assessment. To assess this item, adhere attachment G to the bottom of the student's timeline so that the beginning and end of the day align. Mark on attachment G the beginning and end of lunchtime according to the school timetable.</b></p> <p>Say to the student, I want you to think of your favourite day of school. Which day is that? Response:</p> <p>I want you to make this a timeline of that day. Mark on your timeline when you start lunch and when you finish lunch on your favourite day?</p> <ul style="list-style-type: none"> <li>• <b>Marked the beginning AND end of lunchtime within an hour of the beginning and end times shown on attachment G AND the duration does not exceed 2 hours from beginning to end.</b></li> <li>• <u>Marked the beginning OR end of lunchtime within an hour of the beginning and end times shown on attachment G AND the duration does not exceed 2 hours from beginning to end.</u></li> <li>• Marked lunch at any other time OR the duration exceeds 2 hours OR other incorrect response OR no response.</li> </ul> <p>8. I want you to think of two things that you do between getting out of bed and having lunch and mark them on your timeline. Pause for the student to complete. Now think of two things you do between having lunch and going to bed on your favourite day. Mark when you do each one on your timeline.</p> <ul style="list-style-type: none"> <li>• <b>All 4 events marked on the timeline are correctly sequenced.</b></li> <li>• <u>2 or 3 items of the items marked on the timeline are correctly sequenced.</u> Circle the number of items sequenced. 2 3</li> <li>• Marked items are incorrectly sequenced OR no items marked.</li> </ul>
D	<p>9. Note whether the student marked the duration (beginning and end) of each event on the timeline.</p> <ul style="list-style-type: none"> <li>• <b>Marked the duration (beginning and end) of the 4 events (lunch not included).</b></li> <li>• <u>Marked the beginning and end of some events.</u> Circle the number of events showing duration. 1 2 3</li> <li>• Marked each event with a single line or other mark.</li> </ul> <p>Comments on timeline.</p>

<p><b>D</b></p>	<p><b>10.</b> What is something that takes a long time to do? Response:  <i>The interviewer will need to make a judgement as to the reasonableness of the response before asking the second part of Q10.</i>          What is something that takes a <b>very</b> long time to do? Response:  <i>The interviewer can ask for further information to clarify the length of the time taken for the events given as responses.</i></p> <ul style="list-style-type: none"> <li>• <b>Names an activity that could conceivably take a long time and a second activity that could conceivably take a very long time to do relative to the first activity.</b></li> <li>• <u>Names two activities that could conceivably take a long time and a very long time but the relativity is incorrect OR names two events with correct relativity but one or two of the events could not conceivably take a long time or a very long time.</u></li> <li>• Names an activity/activities that is/are difficult to judge OR no response.</li> </ul> <p>Response:</p>
<p><b>D</b></p>	<p><b>11.</b> What is something that takes a <b>very</b> short time to do? Response:  <i>The interviewer will need to make a judgement as to the reasonableness of the response before asking the second part of Q11.</i>          What is something that can happen in an even shorter time? Response:  <i>The interviewer can ask for further information to clarify the length of the time taken for the events given as responses.</i></p> <ul style="list-style-type: none"> <li>• <b>Names an activity that could conceivably take a very short time and a second activity that could conceivably take an even shorter time to do relative to the first activity.</b></li> <li>• <u>Names two activities that could conceivably take a short time and an even shorter time but the relativity is incorrect OR names two events with correct relativity but one or two of the events could not conceivably take a short time or an even shorter time.</u></li> <li>• Names an activity/activities that is/are difficult to judge OR no response.                      Response:</li> </ul>
<p><b>M</b></p>	<p><b>12.</b> We measure length in small units such as centimetres and very large units such as kilometres. What units to measure time do you know?  <i>Record what the students say.</i>          Minutes.    Hours.    Days.    Weeks.    Months.    Years.    Decade.    Century.    Other units of time.....          .....</p> <ul style="list-style-type: none"> <li>• <b>Lists 4 or more units. (Circle the units named.)</b></li> <li>• <u>Lists 1 to 3 units of time. (Circle the units named.)</u></li> <li>• States only given times such as half past and a quarter past OR other incorrect response OR no response.</li> </ul>

D/M	<p><b>13.</b> What is the shortest unit of time that you know?</p> <ul style="list-style-type: none"> <li>• <b>Second or shorter unit such as nanosecond or millisecond.</b></li> <li>• <u>Names a unit of time longer than one second OR names a second or shorter unit with prompting.</u></li> </ul> <p>Prompt: Can you think of a shorter period of time than ... <i>repeat the student's answer to the question?</i></p> <ul style="list-style-type: none"> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
D/M	<p><b>14.</b> I am going to get to estimate one minute. When I say 'Go', put your head on the desk.* When you think one minute is up, you have to say 'Stop'.</p> <p><i>Allow the student to choose whether to put their head down, close their eyes or turn away from the interviewer.</i></p> <p><i>Record the time in seconds that the student's head is down. Record any response from the student (physical or verbal). Number of seconds.....</i></p> <ul style="list-style-type: none"> <li>• <b>50 to 70 seconds, inclusive.</b></li> <li>• <u>40- 49 seconds inclusive or 71-80 seconds inclusive.</u></li> <li>• Less than 40 seconds. More than 80 seconds. Does not participate.</li> </ul> <p><i>How did you work that out? Do it for me. If the student counted, record the counting method such as one thousand and one, one thousand and two, etc. or one cat and dog, two cat and dog, etc. For the assessor's record. No marks are given.</i></p>
M	<p><b>15.</b> One way we measure time is with a clock. Tell me some other ways or things we use to measure time. <i>Circle the items given.</i></p> <p>Sundial.      Stopwatch.      Mobile phone.      Metronome.      Calendar.      Diary.      Other.....</p> <p><i>Select <b>three</b> of the student's response. Ask the student how <b>each of the 3 responses</b> measures time. For example, 'Tell me how a metronome measures time'.</i></p> <ul style="list-style-type: none"> <li>• <b>One or more items to measure time are given with an explanation of how each item is used to measure time.</b></li> <li>• <u>One or more items to measure time are given but with no explanation OR inappropriate explanation given of how each item is used to measure time.</u></li> <li>• Other incorrect response OR no response.      Response:</li> </ul>



S	<p>20. What are the names of the days of the week? <i>Circle the days given and note the order that the days are given.</i></p> <p>Monday. Tuesday. Wednesday. Thursday. Friday. Saturday. Sunday.</p> <ul style="list-style-type: none"> <li>• Gives all days of the week in order.</li> <li>• Gives all days of the week but not in order.</li> <li>• <u>Gives some days of the week.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>21. How many days are in a week?</p> <ul style="list-style-type: none"> <li>• Answers 7.</li> <li>• <u>Answers 6 or 8.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>22. Tell me the names of the months. <i>Circle the months given and note the order that the months are given.</i></p> <p>January. February. March. April. May. June. July. August. September. October. November. December.</p> <ul style="list-style-type: none"> <li>• Names all of the months in order.</li> <li>• Names all of the months but not in order.</li> <li>• <u>Names some months.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>23. How many months are in one year? <i>Note whether the student gives an automatic response or counts each month.</i></p> <ul style="list-style-type: none"> <li>• Answers 12.</li> <li>• <u>Answers 10 or 11 or 13 or 14. Circle the student's response.</u></li> <li>• Other incorrect response OR no response.</li> </ul>

S	<p>24. For this question you need to listen to a short story. My neighbour gave me some eggs. I was given enough eggs to have one egg for breakfast every morning for exactly one week. If I ate the first egg on Wednesday, and one egg each day, which day would I eat the last egg?</p> <ul style="list-style-type: none"> <li>• <b>Tuesday.</b></li> <li>• <u>Monday or Wednesday.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>25. Which season is July in?</p> <ul style="list-style-type: none"> <li>• <b>Winter.</b></li> <li>• <u>Spring or Autumn or Summer. Circle the student's response.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>26. Here are three events that happen each year. <i>Before the interview, prepare pictures of three annual events appropriate to school's location. [For example, Bendigo Easter Fair (the dragon, Sun Loong), winter (student in winter clothing), and the summer holidays (a child swimming).] Place the three pictures on the table in front of the student.</i> Which one will come next? Which one will be after that? Which one will come last?</p> <ul style="list-style-type: none"> <li>• <b>Places the event cards in order with the first card showing the next event following the interview date.</b></li> <li>• <u>Places the event cards in order but the first card is not the next event following the interview date.</u></li> <li>• The event cards are not placed in sequential order from any date OR other incorrect response OR no response.</li> </ul> <p>Response:</p>
S/M	<p><i>Hand the student a calendar of the current year.</i></p> <p>27. Find today's date and point to it. <i>When found, ask, Tell me the full date including the day?</i></p> <ul style="list-style-type: none"> <li>• <b>Gives the day, the date, the month and the year. (e.g. Wednesday, 15th July 2015)</b></li> <li>• <u>Gives the full date with prompting</u></li> </ul> <p><u>Prompts used.</u>  What else can you tell me?      What day is it?      What is the number of the day?      What month is it?</p> <ul style="list-style-type: none"> <li>• Other incorrect response OR no response.</li> </ul>

S	<p>28. Today's date is .....<i>Give the full date even if the student has incorrectly answered Q. 27.</i> What was the date the day before yesterday?</p> <ul style="list-style-type: none"> <li>• <b>Correctly identifies the date of the day before yesterday.</b></li> <li>• <u>Gives yesterday's date.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>29. What will the date be the day after tomorrow? <i>Note whether the student referred to the calendar to find the answer.</i></p> <ul style="list-style-type: none"> <li>• <b>Correctly identifies the date of the day after tomorrow.</b></li> <li>• <u>Gives tomorrow's date.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p><i>Open the calendar to the current month.</i></p> <p>30. What will next month be? <i>Note whether the student needs to turn the page.</i></p> <ul style="list-style-type: none"> <li>• <b>Identifies correct month.</b></li> <li>• <u>Names the previous month or the following month.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S	<p>31. Without turning the page, look at this month and tell me, what day of the week will be the first of next month?</p> <ul style="list-style-type: none"> <li>• <b>Names the correct day (e.g. Wednesday) without turning the page.</b></li> <li>• <u>Names the correct day but had to turn the page.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
S/M	<p><i>Remove the calendar.</i></p> <p>32. Today's date is .....<i>Give the full date irrespective of the student's response to Q. 27..</i> What was the date exactly one month ago?</p> <ul style="list-style-type: none"> <li>• <b>Names the date (the number of the day, such as 14<sup>th</sup>) AND the month.</b></li> <li>• <u>Names the date (the number of the day, such as 14<sup>th</sup>) OR the month.</u></li> <li>• Names both incorrect date and month OR other incorrect response OR no response. Response: <i>Did the student require the calendar? Yes/No (circle).</i></li> </ul>



S/M	<p>33. If the date is 24th October, what will the date be in 3 weeks?</p> <ul style="list-style-type: none"> <li>• <b>Locates and states the date (number of day and month) 3 weeks from 24th October. (14<sup>th</sup> November.)</b></li> <li>• <u>Locates and states a date (number of day and month) within 3 days (inclusive) of the correct date. (Circle the date given. November 11. Nov 12. Nov 13. Nov 15. Nov 16. Nov 17)</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response: <i>Did the student use the calendar? Yes. No.</i></p> <p><i>How did the student use the calendar?</i></p>
S/M	<p>Today's date is the..... (Give the date as the day number, the month and the year. For example, today's date is the 29<sup>th</sup> of July, 2015.)</p> <p>34. What will the date be two years from now?</p> <ul style="list-style-type: none"> <li>• <b>Correctly identifies the day number, the month and the year. (The day number and the month will be the same, but 2 will be added to the year.)</b></li> <li>• <u>Correctly identifies the year but the day number or the year are incorrect.</u></li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
S/M	<p>35. Show student the card with 24/9/2015 written on it. When people write the date like this, what do the different numbers mean?</p> <ul style="list-style-type: none"> <li>• <b>Identifies and names the day, month and year.</b></li> <li>• <u>Identifies and names one and/or two of the numbers (day and month; day and year; month and year).</u></li> <li>• Did not identify or name any of the numbers (day, month or year) OR no response.</li> </ul> <p>Response:</p>

D/M	<p>36. If you had a calculator, how would you work out how old you are in days? (<i>*For students in years 3 and 4, it is sufficient to calculate their age in days to their last birthday. Note if the student is able to calculate a more detailed answer by including the months and days since their last birthday.</i>)</p> <ul style="list-style-type: none"> <li>• <b>*Gives a response calculated using repeated addition or multiplication to calculate the years in days, [for example for a student aged 9 (365 x 9) or (365 + 365 + 365 + 365 + 365 + 365 + 365 + 365 + 365)], AND adds the days since their last birthday.</b></li> <li>• Gives a response with some accurate elements AND calculates using multiplication or repeated addition (For example, explains the process [my age times the number of days in a year], but does not state correctly the numbers required [how many days in a year].) OR does not include the days since their last birthday.</li> <li>• Other incorrect response OR no response.</li> </ul> <p>Response:</p>
	<p><i>Say to the student, <b>The next group of questions relates to clocks. Some of them may be difficult and some of them will be easy. Answer the ones you can.</b></i></p>
	<p>37. <i>Say to the student:</i> Draw an analogue clock for me. Put in all the features that you know are on a clock. Choose a time to draw on your clock. <i>Retain the clock for later analysis.</i></p> <p><i>Ask the student the following questions:</i></p> <ul style="list-style-type: none"> <li>Have you drawn all the features you could see on a clock?</li> <li>What is the time on your clock?</li> <li>What is the name of the big hand and what does it tell us?</li> <li>What is the name of the small or little hand and what does it tell us?</li> <li>What else can you tell me about your clock?</li> </ul> <p><i>Note the items drawn and/or mentioned by the student. Add any items drawn or mentioned that are not already listed here.</i></p>

M	<p>(a) Positioning of the 12 numbers.</p> <ul style="list-style-type: none"> <li>• <b>Places numbers evenly around the face starting at the top with 12 at 0°, 3 at 90°, 6 at 180°, and 9 at 270°.</b></li> <li>• <u>Places numbers in order around the clock face, but unevenly distributed</u></li> <li>• Numbers missing from the clock face.</li> </ul>
M	<p>(b) Positioning of the minute markers.</p> <ul style="list-style-type: none"> <li>• <b>Positions 60 minute markers evenly around the clock face, with every 5<sup>th</sup> minute marker corresponding with a number.</b></li> <li>• <u>Incorrect number of minute markers on the clock face.</u></li> <li>• No minute markers drawn onto the clock face.</li> </ul>
M	<p>(c) Positioning of the hands of the clock to indicate a time.</p> <ul style="list-style-type: none"> <li>• <b>Positions the hour and the minute hands to accurately indicate a time.</b></li> <li>• <u>The hour hand <b>or</b> the minute hand are in the correct position to indicate a time given by the student but not both hands.</u></li> <li>• The minute hand and hour hand are incorrectly positioned to indicate the time the student said he/she had drawn.</li> </ul>
M	<p>(d) Understanding the purpose of the minute hand.</p> <ul style="list-style-type: none"> <li>• <b>The big hand is the minute hand and tells us the minutes.</b></li> <li>• <u>The big hand tells us the minutes. OR The big hand is the minute hand.</u></li> <li>• Incorrectly identifies the minute hand.</li> </ul>
M	<p>(e) Understanding the purpose of the hour hand.</p> <ul style="list-style-type: none"> <li>• <b>The small hand is the hour hand and tells us the hours.</b></li> <li>• <u>The small hand tells us the hours. OR The small hand is the hour hand.</u></li> <li>• Incorrectly identifies the hour hand.</li> </ul>

	<p>(f) <b>N.B. For the assessor's record. No marks given.</b> <i>Set the time on a real clock (batteries removed to stop the clock) to the same time as the student's drawn clock.</i></p> <p>Look at my clock. Does my clock have any features that make it the same as your drawn clock? Tell me how they are the same. Does my clock have any features that make it different from your drawn clock? Tell me how they are different. <i>List the similarities and differences noted by the student. Are any mistakes discovered on drawn clock, such as incorrect positioning of minute hand for half past?</i></p>
<p>M</p> <p>M</p>	<p><b>38. (a)</b> <i>Say to the student:</i> Now I want you to draw a digital clock for me. Choose a time to write on your clock. <i>If not sure of the meaning of the term 'digital clock', tell the student it is the sort of clock on the oven, DVD player or microwave oven that uses numbers only. Retain the drawing for later analysis.</i></p> <ul style="list-style-type: none"> <li>• <b>A digital clock is drawn with 3 or 4 numbers on the display. Writes an appropriate time on the clock with a colon or full stop between the hours and the minutes.</b></li> <li>• <u>A digital clock is drawn with 3 or 4 numbers but does not separate the hours and the minutes with a colon or full stop.</u></li> <li>• A digital clock is drawn with 3 or 4 number sections but writes an unrealistic time such as 9:75 OR unable to draw a digital clock.</li> </ul> <p><b>38. (b)</b> Tell me which numbers tell you the hours and which numbers tell you the minutes.</p> <ul style="list-style-type: none"> <li>• <b>Identifies the hour number/s and minute numbers.</b></li> <li>• <u>Indicates the hours or the minutes but not both.</u></li> <li>• Does not identify any numbers as the hours and minutes.</li> </ul>
	<p><i>Put all the drawn and real clocks away so the student is unable to see them or be distracted by them.</i></p> <p><i>Say to the student,</i></p> <p>Questions in the next group have short answers but you will need to listen carefully in case I trick you.</p>

D/M	<p>39. How many seconds in a minute?</p> <ul style="list-style-type: none"> <li>• <b>60 seconds.</b></li> <li>• <u>Answers with a number between 40 and 59 (inclusive) or between 61 and 80 (inclusive).</u></li> <li>• Other incorrect response OR no response.</li> </ul>
D/M	<p>40. How many minutes in an hour?</p> <ul style="list-style-type: none"> <li>• <b>60 minutes.</b></li> <li>• <u>Answers with a number between 40 and 59 (inclusive) or between 61 and 80 (inclusive).</u></li> <li>• Other incorrect response OR no response.</li> </ul>
D/M	<p>41. How many minutes in half an hour?</p> <ul style="list-style-type: none"> <li>• <b>30 minutes.</b></li> <li>• <u>Answers with a number between 20 and 29 (inclusive) or between 31 and 40 (inclusive).</u></li> <li>• Other incorrect answer OR no response.</li> </ul>
D/M	<p>42. How long does it takes for the minute hand to go once around the clock?</p> <ul style="list-style-type: none"> <li>• <b>One hour or 60 minutes.</b></li> <li>• <u>Answers with a number between 50 and 59 (inclusive) or between 61 and 70 minutes (inclusive).</u></li> <li>• Other incorrect answer OR no response.</li> </ul>
D/M	<p>43. How many minutes does it take for the minute hand to move from the 2 to the 3?</p> <ul style="list-style-type: none"> <li>• <b>5 minutes.</b></li> <li>• <u>4 minutes OR 6 minutes.</u></li> <li>• Other incorrect answer OR no response.</li> </ul>

D/M	<p>44. How long does it takes for the hour hand to go once around the clock?</p> <ul style="list-style-type: none"> <li>• <b>12 hours.</b></li> <li>• <u>24 hours.</u></li> <li>• Other incorrect answer OR no response.</li> </ul>
D/M	<p>45. How long does it take the hour hand to move from the 8 to the 9?</p> <ul style="list-style-type: none"> <li>• <b>60 minutes or one hour.</b></li> <li>• <u>5 minutes (confuses hour and minute hand.)</u></li> <li>• Other incorrect answer OR no response.</li> </ul>
D	<p>46. Can you tell me something that would take about an hour to do?</p> <ul style="list-style-type: none"> <li>• <b>Names an event that would take between 50 and 70 minutes (inclusive) to do.</b></li> <li>• <u>Names an event that would take between 30 minutes and 49 minutes (inclusive) OR between 71 minutes and 90 minutes (inclusive).</u></li> <li>• Other incorrect answer OR no response.</li> </ul>
D	<p>47. Can the length of an hour change? Why? Or Why not?</p> <ul style="list-style-type: none"> <li>• <b>Answers ‘No’ and gives a reasonable explanation (e.g. an hour is always 60 minutes).</b></li> <li>• <u>Answers ‘No’ but cannot give an explanation for the answer.</u></li> <li>• Answers ‘Yes’* OR no response.</li> </ul> <p>*If the student answers ‘yes’, ensure they understand that the question relates to an hour’s duration, not the time changing for example, from 3 o’clock to 4 o’clock.</p> <p>Response:</p>

M	<p><b>48.</b> Show the student a real analogue clock set at 11 o'clock. Tell me what time this analogue clock shows.</p> <p>(a) 11 o'clock.      Time given:      <b>Correct time given.</b>      Incorrect time given.</p> <p style="text-align: center;"><i>For the following times, show the student one clock at a time and repeat the instruction, Tell me what time this analogue clock shows.</i></p> <p>(b) ½ past 5.      <b>Correct time given.</b>      <u>States half past but gives the incorrect hour.</u>      Other incorrect time given.</p> <p>(c) ¼ to 6.      <b>Correct time given.</b>      <u>States ¼ to but gives the incorrect hour.</u>      Other incorrect time given.</p> <p>(d) 25 past 8.      <b>Correct time given.</b>      <u>States 25 past, but gives the incorrect hour.</u>      Other incorrect time given.</p> <p>(e) 7 minutes past 6.      <b>Correct time given.</b>      <u>States 7 minutes past, but gives the incorrect hour.</u>      Other incorrect time given.</p>
S/D/M	<p><b>49.</b> Which of these times comes first in a day? A quarter to 8. A quarter past 8. Tell me why that time comes first.</p> <ul style="list-style-type: none"> <li>• <b>Correctly states a quarter to 8 and explains the reason that this time comes first.</b></li> <li>• <u>Correctly states a quarter to 8 but does not satisfactorily explain the reason that this time comes first.</u></li> <li>• Incorrect response OR no response.</li> </ul>
D/M	<p><b>50.</b> Imagine the clock is now telling me it is 10 past 2. What time will it be in an hour?</p> <ul style="list-style-type: none"> <li>• <b>Correct answer. 10 past 3 or 3:10.</b></li> <li>• <u>Gives the time as 11 minutes past 2. (Adds 1 minute instead of 1 hour.)</u></li> <li>• Other incorrect response OR no response.</li> </ul>
M M M	<p><b>51.</b> Show the student an analogue clock displaying 2 o'clock. I want you to write this time as it would appear on a digital clock? Repeat for ½ past 5 and ¼ to 6. Write the student's answer beside each time. Retain the written responses for records.</p> <p>(a) 2 o'clock.      <b>Correct digital time written.</b>      Incorrect time given.</p> <p>(b) ½ past 5.      <b>Correct digital time written.</b>      <u>The minute numbers are correct (30) but the hour number (5) is incorrect.</u>      Other incorrect response.</p> <p>(c) ¼ to 6.      <b>Correct digital time written.</b>      <u>The minute numbers are correct (45) but the hour number (5) is incorrect.</u>      Other incorrect response.</p>

S/M	<p>52. Look at this digital clock display. <i>Point to the last minute number on the digital clock.</i> Imagine that this number has just changed to 7. How long will it take for this number to change to 8 on a digital clock?</p> <ul style="list-style-type: none"> <li>• <b>Correct answer. One minute or 60 seconds.</b></li> <li>• <u>59 or 61 seconds.</u></li> <li>• Other incorrect response OR no response.</li> </ul>
D/M	<p>53. <i>Show the student the Epsom to Melbourne train timetable (attachment F). Say to the student, Look at this train timetable. Can you find Bendigo on the timetable? Point to Bendigo if the student is unable to read the word. Point to the left hand column of names. Say to the student, These are the towns where the train stops between from Bendigo to Melbourne, which is the last stop. The Melbourne station is called Southern Cross Station. Point to the next column and say. In this column, ‘arr’ means arrive, and ‘dep’ means depart.</i></p> <p><i>Point to the columns of numbers moving from the top of a column to the bottom. These are the times that the train departs from each station. I want you to point to the time that train 4 leaves Bendigo.</i></p> <p>(a) What time does train 4 leave Bendigo for Southern Cross station? (6:08).</p> <ul style="list-style-type: none"> <li>• <b>Locates AND states the correct departure time.</b></li> <li>• <u>Locates AND states the arrival time for train 4 at the Bendigo station.</u></li> <li>• Incorrect response OR no response.</li> </ul> <p>(b) What time does train 4 arrive at Southern Cross station in Melbourne? (8:08).</p> <ul style="list-style-type: none"> <li>• <b>Locates AND states the correct arrival time.</b></li> <li>• <u>Locates AND states an arrival time at a different stop/station.</u></li> <li>• Incorrect response OR no response.</li> </ul> <p>(c) How long does the journey take? (2 hours).</p> <ul style="list-style-type: none"> <li>• <b>Calculates 2 hours.</b></li> <li>• <u>Calculates an answer by addition or subtraction result is incorrect. Give details of response.</u></li> <li>• Other incorrect response OR no response.</li> </ul>



<p><b>D/M</b></p> <p><b>D/M</b></p>	<p><b>54.</b> I want you to point to the time that train 2 leaves Bendigo. <b>N.B. No marks awarded for 54 (a) and 54 (b).</b></p> <p>(a) What time does train 2 leave Bendigo? (5:07). Response:</p> <p>(b) What time does train 2 get to Southern Cross station? (6:59) Response:</p> <p>(c) Does train 2 take more or less time to get to Southern Cross station than train 4? (5:07 – 6:59. 1 hour and 52 minutes).</p> <ul style="list-style-type: none"> <li>• <b>Answers ‘less’.</b></li> <li>• Answers ‘the same time’.</li> <li>• Other incorrect response OR no response.</li> </ul> <p>(d) How did you work that out?</p> <ul style="list-style-type: none"> <li>• <b>Student deduces the journey time for train 2 is less by calculating the travel time in hours and minutes (1 hour 52 minutes).</b></li> <li>• <u>Student deduces the journey time for train 2 is less by calculating the travel time in hours (5 to 6 = 1 hour; 6 to 8 = 2 hours).</u></li> <li>• <u>Student explains how the travel time is calculated but errors are made in the calculation.</u></li> </ul> <p>Other incorrect response OR no response</p> <p><i>Note how the student solved the problem.</i></p>
<p><b>S/D/M</b></p>	<p><b>55.</b> People say that time has something to do with the rotation and revolution of the Earth. Do you know anything about that? What can you tell me?</p> <ul style="list-style-type: none"> <li>• <b>Gives specific details of the rotation [The Earth takes 24 hours (one day) to rotate on its axis] and the revolution [The Earth takes 365 days (one year) to revolve around the Sun].</b></li> <li>• <u>Does not give the specific details as above but can recall some details about the rotation or the revolution of the Earth. For example, the Earth moves around the Sun. The Earth spins.</u></li> <li>• Does not give any details about the Earth’s rotation on its axis or the Earth’s revolution around the Sun. Response:</li> </ul>
	<p><b>56.</b> Tell me how you measure time. <i>No points given for this question.</i></p>
	<p><b>57.</b> What is your favourite time? <i>No points given for this question.</i></p>

**APPENDIX H**  
**Pre-intervention interview scores for all students for all items**

	01B4	02G3	03G3	04G4	05G3	06B3	07G4	08B3	09G3	10B4	11B3	12G4	13B3	14G4	15B4	16G4	17B3	18B4	19B4	20B3	21B4	22B3	23B4	24B3	25G4	26B3	27G3	Class score
1	0	0	1	1	1	1	1	1	0	1	1	0	1	1	0	0	1	1	0	1	0	1	0	1	0	1	0	16
2	2	1	0	2	1	2	2	1	2	2	1	2	0	1	1	1	2	1	1	0	2	0	1	2	1	0	0	31
3	1	1	1	1	0	2	2	1	0	1	1	0	0	1	1	0	0	2	0	0	1	0	1	1	1	0	1	19
4	0	1	0	1	1	2	1	1	1	2	1	1	0	1	1	1	0	0	1	1	0	1	0	0	1	1	0	20
5	1	0	0	1	0	1	1	1	1	1	0	1	0	2	1	2	0	1	1	1	1	0	0	0	1	1	1	20
6	2	1	1	2	1	2	2	2	2	2	0	2	2	2	2	2	2	1	2	2	1	2	0	2	2	2	1	44
7	2	0	0	1	0	0	1	2	0	1	0	2	0	2	1	0	0	2	2	0	0	0	0	0	2	0	2	20
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
9	0	0	0	1	0	0	2	0	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0	2	0	11
10	2	2	0	2	0	2	0	0	1	2	0	2	0	1	2	2	2	0	2	1	0	0	2	2	2	0	0	29
11	2	0	0	2	0	2	0	0	2	2	0	0	2	0	0	2	0	2	0	2	0	2	2	2	2	0	0	26
12	2	1	1	1	0	1	2	2	2	2	1	0	0	0	1	1	1	1	0	0	2	1	0	1	2	2	0	27
13	2	0	0	2	0	2	2	2	2	2	2	0	0	0	2	2	0	2	0	2	2	2	0	2	2	1	0	33
14	0	0	1	2	2	2	2	2	0	2	2	0	2	1	0	2	2	2	1	2	0	1	0	1	1	0	1	31
15	1	1	0	1	2	1	1	1	1	1	0	0	0	1	1	2	1	1	0	1	1	2	1	1	1	1	0	24
16	1	0	0	1	0	0	1	0	1	1	0	0	0	0	2	1	0	0	0	1	1	0	0	1	0	0	0	11
17	0	2	0	0	0	0	2	1	0	1	0	0	0	0	2	0	1	1	1	1	2	2	0	0	1	1	0	18
18	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	50
19	2	1	2	1	0	1	2	2	2	2	2	1	2	1	1	0	2	1	2	2	2	1	0	2	2	2	2	40
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	53
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	2	1	1	2	2	2	2	47
23	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	0	2	2	2	2	48
24	1	1	1	1	2	2	1	1	2	1	0	1	2	1	1	1	1	1	2	1	1	1	0	0	2	2	2	32
25	2	2	0	2	2	1	2	2	1	2	2	2	1	2	1	1	1	1	1	2	2	1	1	2	2	2	1	41
26	1	2	0	2	2	1	2	2	2	2	2	2	0	2	2	2	0	0	1	1	1	1	0	2	2	2	38	
27	2	2	1	1	1	1	2	1	1	0	0	1	1	1	1	2	2	1	0	2	2	1	0	2	1	1	2	32
28	2	0	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	1	1	2	1	2	1	2	2	1	45
29	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	1	2	2	50
30	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	51
31	2	2	2	2	0	2	2	0	2	2	0	2	2	2	2	2	0	0	0	0	2	2	0	2	2	2	2	38
32	0	2	0	2	2	2	2	2	0	2	2	0	2	2	2	2	2	0	0	0	0	0	0	1	2	0	0	29
33	1	2	0	2	2	2	2	2	1	2	2	0	2	1	2	2	2	0	2	0	0	0	0	1	2	2	0	34

34	0	1	0	2	2	1	2	2	2	2	1	0	2	1	2	2	0	0	0	2	2	2	0	2	2	2	2	36	
35	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	52	
36	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0	10	
37a	1	1	1	2	2	2	2	1	0	2	2	2	2	2	2	2	1	2	1	1	2	2	1	2	2	2	1	43	
37b	1	1	0	1	2	0	2	0	0	1	1	0	1	1	0	2	0	0	2	1	2	1	1	0	1	0	0	21	
37c	2	2	2	2	1	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	50	
37d	2	2	0	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	44	
37e	2	2	0	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	44	
38a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	52	
38b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	53	
39	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	53	
40	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50	
41	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50	
42	0	2	0	2	2	0	2	0	2	2	2	2	2	2	2	0	0	2	2	2	0	2	0	2	2	2	0	36	
43	0	2	0	2	0	0	2	2	1	2	2	2	2	2	2	2	0	2	2	0	2	2	0	2	0	2	0	35	
44	0	0	0	2	0	1	1	2	0	2	2	0	0	2	1	0	0	2	0	0	2	2	0	2	2	0	2	25	
45	0	1	0	0	2	2	2	2	0	2	2	1	0	0	2	2	2	2	0	2	0	0	2	2	0	2	32		
46	1	1	1	1	2	2	2	2	1	2	2	0	2	2	2	2	1	1	2	1	0	1	2	1	1	1	1	37	
47	2	0	1	2	2	2	2	2	1	2	1	1	0	1	1	2	0	1	0	0	1	0	0	0	2	1	0	27	
48a	2	2	2	2	0	2	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	0	2	2	2	2	2	46	
48b	2	2	2	2	2	2	2	2	2	1	2	2	2	1	0	2	2	2	2	1	2	0	1	2	2	2	0	44	
48c	2	0	0	2	2	2	2	2	0	2	2	1	0	1	2	2	1	2	0	0	2	1	0	2	1	2	0	33	
48d	1	2	0	0	2	2	0	2	0	2	2	2	0	2	0	2	2	2	0	0	2	0	0	2	2	2	0	31	
48e	0	0	0	2	0	2	2	2	0	2	2	2	0	2	2	2	0	2	0	0	2	0	0	2	2	2	0	30	
49	2	2	0	2	2	1	2	2	2	2	0	0	2	1	2	2	2	0	2	1	2	2	0	2	2	0	1	38	
50	0	2	0	2	2	2	2	2	0	2	2	1	0	1	2	2	2	2	2	2	2	0	0	2	2	2	0	38	
51a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	2	2	0	2	2	2	2	48	
51b	2	2	0	2	2	2	2	2	0	2	2	2	0	0	2	2	2	2	0	0	2	0	1	2	2	2	0	37	
51c	2	0	0	2	2	2	2	2	0	2	1	1	0	1	1	2	1	2	0	0	2	0	0	1	2	2	0	30	
52	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50	
53a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54	
53b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	52	
53c	2	2	0	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	0	0	1	2	0	2	1	1	0	39	
54c	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54	
54d	0	1	0	1	2	1	2	2	1	2	1	1	0	0	0	1	1	1	0	0	2	2	0	2	1	1	0	25	
55	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	6
Total	95	92	54	114	91	108	122	109	81	124	99	87	79	96	106	112	89	99	77	71	99	87	48	109	111	101	61		

### APPENDIX I

#### Pre-intervention interview scores for all students for Succession items

S	01B4	02G3	03G3	04G4	05G3	06B3	07G4	08B3	09G3	10B4	11B3	12G4	13B3	14G4	15B4	16G4	17B3	18B4	19B4	20B3	21B4	22B3	23B4	24B3	25G4	26B3	27G3	Class score
1	0	0	1	1	1	1	1	1	0	1	1	0	1	1	0	0	1	1	0	1	0	1	0	1	0	1	0	16
2	2	1	0	2	1	2	2	1	2	2	1	2	0	1	1	1	2	1	1	0	2	0	1	2	1	0	0	31
3	1	1	1	1	0	2	2	1	0	1	1	0	0	1	1	0	0	2	0	0	1	0	1	1	0	1	0	19
4	0	1	0	1	1	2	1	1	1	2	1	1	0	1	1	1	0	0	1	0	1	1	0	0	1	1	0	20
5	1	0	0	1	0	1	1	1	1	1	0	1	0	2	1	2	0	1	1	1	1	0	0	0	1	1	1	20
7	2	0	0	1	0	0	1	2	0	1	0	2	0	2	1	0	0	2	2	0	0	0	0	0	0	2	0	20
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
18	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	50
19	2	1	2	1	0	1	2	2	2	2	2	1	2	1	1	0	2	1	2	2	2	1	0	2	2	2	2	40
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	53
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	1	1	1	2	1	1	2	2	2	47
23	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	0	2	2	2	2	48
24	1	1	1	1	2	2	1	1	2	1	0	1	2	1	1	1	1	1	2	1	1	1	0	0	2	2	2	32
25	2	2	0	2	2	1	2	2	1	2	2	2	1	2	1	1	1	1	1	2	2	1	1	2	2	2	1	41
26	1	2	0	2	2	1	2	2	2	2	2	2	0	2	2	2	0	0	1	1	1	1	0	2	2	2	38	
27	2	2	1	1	1	1	2	1	1	0	0	1	1	1	1	2	2	1	0	2	2	1	0	2	1	1	2	32
28	2	0	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	1	1	1	2	1	2	2	2	1	45
29	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	2	1	2	2	50
30	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	51
31	2	2	2	2	0	2	2	0	2	2	0	2	2	2	2	2	0	0	0	0	2	2	0	2	2	2	2	38
32	0	2	0	2	2	2	2	2	0	2	2	0	2	2	2	2	2	0	0	0	0	0	0	1	2	0	0	29
33	1	2	0	2	2	2	2	2	1	2	2	0	2	1	2	2	2	0	2	0	0	0	0	1	2	2	0	34
34	0	1	0	2	2	1	2	2	2	2	1	0	2	1	2	2	0	0	0	2	2	2	0	2	2	2	2	36
49	2	2	0	2	2	1	2	2	2	2	0	0	2	1	2	2	2	0	2	1	2	2	0	2	2	0	1	38
52	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50
55	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	6
<b>Total</b>	<b>39</b>	<b>38</b>	<b>26</b>	<b>44</b>	<b>33</b>	<b>41</b>	<b>48</b>	<b>43</b>	<b>39</b>	<b>46</b>	<b>35</b>	<b>35</b>	<b>37</b>	<b>41</b>	<b>40</b>	<b>40</b>	<b>33</b>	<b>31</b>	<b>31</b>	<b>31</b>	<b>37</b>	<b>32</b>	<b>15</b>	<b>40</b>	<b>43</b>	<b>40</b>	<b>34</b>	

**APPENDIX J**  
**Pre-intervention interview scores for all students for Duration items**

	01B4	02G3	03G3	04G4	05G3	06B3	07G4	08B3	09G3	10B4	11B3	12G4	13B3	14G4	15B4	16G4	17B3	18B4	19B4	20B3	21B4	22B3	23B4	24B3	25G4	26B3	27G3	Class score
2	2	1	0	2	1	2	2	1	2	2	1	2	0	1	1	1	2	1	1	0	2	0	1	2	1	0	0	31
3	1	1	1	1	0	2	2	1	0	1	1	0	0	1	1	0	0	2	0	0	1	0	1	1	0	1	0	19
4	0	1	0	1	1	2	1	1	1	2	1	1	0	1	1	1	0	0	1	0	1	1	0	0	1	1	0	20
5	1	0	0	1	0	1	1	1	1	1	0	1	0	2	1	2	0	1	1	1	1	0	0	0	1	1	1	20
6	2	1	1	2	1	2	2	2	2	2	0	2	2	2	2	2	2	1	2	2	1	2	0	2	2	2	1	44
7	2	0	0	1	0	0	1	2	0	1	0	2	0	2	1	0	0	2	2	0	0	0	0	0	2	0	2	20
9	0	0	0	1	0	0	2	0	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0	2	0	11
10	2	2	0	2	0	2	0	0	1	2	0	2	0	1	2	2	2	0	2	1	0	0	2	2	2	0	0	29
11	2	0	0	2	0	2	0	0	2	2	0	0	2	0	0	2	0	2	0	2	0	2	2	2	2	0	0	26
13	2	0	0	2	0	2	2	2	2	2	2	0	0	0	2	2	0	2	0	2	2	2	0	2	2	1	0	33
14	0	0	1	2	2	2	2	2	0	2	2	0	2	1	0	2	2	2	1	2	0	1	0	1	1	0	1	31
16	1	0	0	1	0	0	1	0	1	1	0	0	0	0	2	1	0	0	0	1	1	0	0	1	0	0	0	11
17	0	2	0	0	0	0	2	1	0	1	0	0	0	0	2	0	1	1	1	1	1	2	2	0	0	1	0	18
36	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0	10
39	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	53
40	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50
41	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50
42	0	2	0	2	2	0	2	0	2	2	2	2	2	2	2	0	0	2	2	2	0	2	0	2	2	2	0	36
43	0	2	0	2	0	0	2	2	1	2	2	2	2	2	2	2	0	2	2	0	2	2	0	2	0	2	0	35
44	0	0	0	2	0	1	1	2	0	2	2	0	0	2	1	0	0	2	0	0	2	2	0	2	2	0	2	25
45	0	1	0	0	2	2	2	2	0	2	2	1	0	0	2	2	2	2	2	0	2	0	0	2	2	0	2	32
46	1	1	1	1	2	2	2	2	1	2	2	0	2	2	2	2	1	1	2	1	0	1	2	1	1	1	1	37
47	2	0	1	2	2	2	2	2	1	2	1	1	0	1	1	2	0	1	0	0	1	0	0	0	2	1	0	27
49	2	2	0	2	2	1	2	2	2	2	0	0	2	1	2	2	2	0	2	1	2	2	0	2	2	0	1	38
50	0	2	0	2	2	2	2	2	0	2	2	1	0	1	2	2	2	2	2	2	2	0	0	2	2	2	0	38
53a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
53b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	52
53c	2	2	0	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	0	0	1	2	0	2	1	1	0	39
54c	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
54d	0	1	0	1	2	1	2	2	1	2	1	1	0	0	0	1	1	1	0	0	2	2	0	2	1	1	0	25
55	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	6
<b>Total</b>	<b>34</b>	<b>33</b>	<b>13</b>	<b>47</b>	<b>33</b>	<b>43</b>	<b>51</b>	<b>43</b>	<b>33</b>	<b>54</b>	<b>36</b>	<b>31</b>	<b>30</b>	<b>37</b>	<b>45</b>	<b>43</b>	<b>33</b>	<b>43</b>	<b>35</b>	<b>29</b>	<b>38</b>	<b>35</b>	<b>20</b>	<b>43</b>	<b>42</b>	<b>32</b>	<b>18</b>	

**APPENDIX K**  
**Pre-intervention interview scores for all students for Measurement items**

	01B4	02G3	03G3	04G4	05G3	06B3	07G4	08B3	09G3	10B4	11B3	12G4	13B3	14G4	15B4	16G4	17B3	18B4	19B4	20B3	21B4	22B3	23B4	24B3	25G4	26B3	27G3	Class score
4	0	1	0	1	1	2	1	1	1	2	1	1	0	1	1	1	0	0	1	0	1	1	0	0	1	1	0	20
5	1	0	0	1	0	1	1	1	1	1	0	1	0	2	1	2	0	1	1	1	1	0	0	0	1	1	1	20
6	2	1	1	2	1	2	2	2	2	2	0	2	2	2	2	2	2	1	2	2	1	2	0	2	2	2	1	44
7	2	0	0	1	0	0	1	2	0	1	0	2	0	2	1	0	0	2	2	0	0	0	0	0	0	2	0	20
12	2	1	1	1	0	1	2	2	2	2	1	0	0	0	1	1	1	1	0	0	2	1	0	1	2	2	0	27
13	2	0	0	2	0	2	2	2	2	2	2	0	0	0	2	2	0	2	0	2	2	2	0	2	2	1	0	33
14	0	0	1	2	2	2	2	2	0	2	2	0	2	1	0	2	2	2	1	2	0	1	0	1	1	0	1	31
15	1	1	0	1	2	1	1	1	1	1	0	0	0	1	1	2	1	1	0	1	1	2	1	1	1	1	0	24
16	1	0	0	1	0	0	1	0	1	1	0	0	0	0	2	1	0	0	0	1	1	0	0	1	0	0	0	11
17	0	2	0	0	0	0	2	1	0	1	0	0	0	0	2	0	1	1	1	1	2	2	0	0	1	1	0	18
18	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	50
19	2	1	2	1	0	1	2	2	2	2	2	1	2	1	1	0	2	1	2	2	2	1	0	2	2	2	2	40
27	2	2	1	1	1	1	2	1	1	0	0	1	1	1	1	2	2	1	0	2	2	1	0	2	1	1	2	32
32	0	2	0	2	2	2	2	2	0	2	2	0	2	2	2	2	2	0	0	0	0	0	0	1	2	0	0	29
33	1	2	0	2	2	2	2	2	1	2	2	0	2	1	2	2	2	0	2	0	0	0	0	1	2	2	0	34
34	0	1	0	2	2	1	2	2	2	2	1	0	2	1	2	2	0	0	0	2	2	2	0	2	2	2	2	36
35	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	52
36	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0	10
37a	1	1	1	2	2	2	2	1	0	2	2	2	2	2	2	2	1	2	1	1	2	2	1	2	2	2	1	43
37b	1	1	0	1	2	0	2	0	0	1	1	0	1	1	0	2	0	0	2	1	2	1	1	0	1	0	0	21
37c	2	2	2	2	1	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	50
37d	2	2	0	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	44
37e	2	2	0	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	44
38a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	52
38b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	53
39	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	53
40	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50
41	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50

42	0	2	0	2	2	0	2	0	2	2	2	2	2	2	2	0	0	2	2	2	0	2	0	2	2	2	0	36	
43	0	2	0	2	0	0	2	2	1	2	2	2	2	2	2	2	0	2	2	0	2	2	0	2	0	2	0	35	
44	0	0	0	2	0	1	1	2	0	2	2	0	0	2	1	0	0	2	0	0	2	2	0	2	2	0	2	25	
45	0	1	0	0	2	2	2	2	0	2	2	1	0	0	2	2	2	2	2	0	2	0	0	2	2	0	2	32	
48a	2	2	2	2	0	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	0	2	0	2	2	2	2	46	
48b	2	2	2	2	2	2	2	2	1	2	2	2	1	0	2	2	2	2	2	1	2	0	1	2	2	2	0	44	
48c	2	0	0	2	2	2	2	2	0	2	2	1	0	1	2	2	1	2	0	0	2	1	0	2	1	2	0	33	
48d	1	2	0	0	2	2	0	2	0	2	2	2	0	2	0	2	2	2	2	0	0	2	0	0	2	2	2	0	31
48e	0	0	0	2	0	2	2	2	0	2	2	2	0	2	2	2	0	2	0	0	2	0	0	2	2	2	0	30	
49	2	2	0	2	2	1	2	2	2	2	0	0	2	1	2	2	2	0	2	1	2	2	0	2	2	0	1	38	
50	0	2	0	2	2	2	2	2	0	2	2	1	0	1	2	2	2	2	2	2	2	0	0	2	2	2	0	38	
51a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	2	2	0	2	2	2	2	48
51b	2	2	0	2	2	2	2	2	0	2	2	2	0	0	2	2	2	2	0	0	2	0	1	2	2	2	0	37	
51c	2	0	0	2	2	2	2	2	0	2	1	1	0	1	1	2	1	2	0	0	2	0	0	1	2	2	0	30	
52	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	50
53a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
53b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	52
53c	2	2	0	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	0	0	1	2	0	2	1	1	0	39	
54c	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
54d	0	1	0	1	2	1	2	2	1	2	1	1	0	0	0	1	1	1	0	0	2	2	0	2	1	1	0	25	
55	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	6
Total	63	66	31	79	66	74	88	81	51	88	73	59	51	66	79	81	65	74	56	49	75	63	29	78	80	71	38		

## APPENDIX L

### One-to-one task based pre-intervention interview scores for each key idea on the Framework

#### Succession key idea items

<b>Two or more different events are organised sequentially.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>7</b>	I have a timeline here. Show beginning and end of lunchtime.	8	4	15
<b>8</b>	I want you to think of 2 things that you do between getting out of bed and having lunch and mark them on your timeline. Now think of 2 things you do between having lunch and going to bed on your favourite day. Mark when you do each one on your timeline.	27	0	0
<b>27</b>	Find today's date and point to it. <i>When found, ask, Tell me the full date including the day?</i>	9	14	4
<b>31</b>	Look at this month and tell me what day of the week will be the first of next month?	19	0	8
<b>Total</b>		<b>63</b>	<b>18</b>	<b>27</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 4 questions) x 100/1.</b>		<b>58</b>	<b>17</b>	<b>25</b>

<b>An understanding of succession &amp; seriation is needed to iterate units of time.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>2</b>	Today is Wednesday*. When did Wednesday* start?	10	11	6
<b>3</b>	When will Wednesday* finish? <i>State the actual day as above.</i>	3	13	11
<b>32</b>	Today's date is ..... <i>Give the full date.</i> What was the date exactly one month ago?	14	1	12
<b>49</b>	Which of these times comes first in a day? A quarter to 8. A quarter past 8. Tell me why that time comes first.	17	4	6
<b>Total</b>		<b>44</b>	<b>29</b>	<b>35</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 4 questions) x 100/1.</b>		<b>41</b>	<b>27</b>	<b>32</b>

<b>Simultaneity and synchronisation are related to succession.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>1</b>	How do I know it is morning/afternoon?	0	16	11
<b>4</b>	Tell me when it is am and when it is pm?	2	16	9
<b>5</b>	When does am change to pm?	2	16	9
<b>25</b>	Which season is July in?	15	11	1
<b>52</b>	Look at this digital clock display. <i>Point to the last minute number on the digital clock.</i> Imagine that this number has just changed to 7. How long will it take for this number to change to 8 on a digital clock?	25	0	2
<b>Total</b>		<b>44</b>	<b>59</b>	<b>32</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 5 questions) x 100/1.</b>		<b>33</b>	<b>44</b>	<b>24</b>



<b>Years are arranged in succession in numerical order.</b>		<b>2</b>	<b>1</b>	<b>0</b>
19	What year were you in Prep?	16	8	3
18	What year is it this year?	27	0	0
23	How many months are in one year?	24	0	3
34	Today's date is the..... ( <i>Give the date as the day number, the month and the year. For example, today's date is the 29<sup>th</sup> of July, 2015.</i> ) What will the date be two years from now?	16	4	7
35	<i>Show student the card with 24/9/2015 written on it. When people write the date like this, what do the different numbers mean?</i>	25	2	0
<b>Total</b>		<b>108</b>	<b>14</b>	<b>13</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 4 questions) x 100/1.</b>		<b>80</b>	<b>10</b>	<b>10</b>

<b>Days, weeks and months are arranged in succession in a cyclical pattern.</b>		<b>2</b>	<b>1</b>	<b>0</b>
21	How many days are in a week?	25	0	2
20	What are the names of the days of the week?	26	1	0
22	Tell me the names of the months.	20	7	0
30	What will next month be?	24	3	0
<b>Total</b>		<b>95</b>	<b>11</b>	<b>2</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 5 questions) x 100/1.</b>		<b>88</b>	<b>10</b>	<b>2</b>

<b>Succession involves the past, the present, and future.</b>		<b>2</b>	<b>1</b>	<b>0</b>
24	For this question you need to listen to a short story. My neighbour gave me some eggs. I was given enough eggs to have one egg for breakfast every morning for exactly one week. If I ate the first egg on Wednesday, which day would I eat the last egg?	8	16	3
26	Here are three events that happen each year. <i>Place the three pictures on the table in front of the student.</i> Bendigo Easter Fair (the dragon, Sun Loong), winter (student in winter clothing), and the Summer holidays (a child swimming). Which one will come next? Which one will be after that? Which one will come last?	16	6	5
28	Today's date is ..... <i>Give the full date even if the student has incorrectly answered Q. 30 or Q. 31.</i> What was the date the day before yesterday?	19	7	1
29	What will the date be the day after tomorrow?	23	4	0
<b>Total</b>		<b>81</b>	<b>37</b>	<b>17</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 4 questions) x 100/1.</b>		<b>60</b>	<b>27</b>	<b>13</b>

<b>Rotation and revolution of the Earth.</b>		<b>2</b>	<b>1</b>	<b>0</b>
55	People say that time has something to do with the rotation of the Earth. Do you know anything about that? What can you tell me?	0	6	21
<b>Total</b>		<b>0</b>	<b>6</b>	<b>21</b>
<b>Percentage of students who gained 2, 1 or 0 points. Total score divided by (27 students x 4 questions) x 100/1.</b>		<b>0</b>	<b>22</b>	<b>78</b>

## Duration key idea items

<b>Duration is the interval of time between two successive events.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>2</b>	Today is Wednesday*. When did Wednesday* start? *State the actual day you are talking to the student.	10	11	6
<b>3</b>	When will Wednesday* finish?	3	13	11
<b>6a/b</b>	Think about recess and lunchtime. Is recess longer or shorter than lunchtime? How do you know?	19	6	2
<b>42</b>	How long does it takes for the minute hand to go once around the clock?	18	0	9
<b>44</b>	How long does it takes for the hour hand to go once around the clock?	11	3	13
<b>Total</b>		<b>61</b>	<b>33</b>	<b>41</b>
<b>Percentage</b>		<b>45</b>	<b>24</b>	<b>30</b>

<b>To add, subtract, multiply and divide units of time requires an understanding of the links between the units.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>36</b>	If you had a calculator, how would you work out how old you are in days?	0	10	17
<b>39</b>	How many seconds in a minute?	26	1	0
<b>40</b>	How many minutes in an hour?	25	0	2
<b>41</b>	How many minutes in half an hour?	25	0	2
<b>54c</b>	Does train 2 take more or less time to get to Southern Cross station than train 4?	27	0	0
<b>Total</b>		<b>103</b>	<b>11</b>	<b>21</b>
<b>Percentage</b>		<b>76</b>	<b>8</b>	<b>16</b>

<b>Simultaneity, synchronisation, isochronism and seriation relate to duration.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>16</b>	We know clocks tell us the time. Tell me how we use clocks to measure time.	1	9	17
<b>17</b>	We use a calendar to find the date. How can we use a calendar to measure time?	5	8	14
<b>49</b>	Which of these times comes first? $\frac{1}{4}$ to 8 or $\frac{1}{4}$ past 8?	17	4	6
<b>53a</b>	What time does train 4 leave Bendigo for Southern Cross station? (6:08).	27	0	0
<b>53b</b>	What time does train 4 arrive at Southern Cross station in Melbourne? (8:08).	26	0	1
<b>Total</b>		<b>76</b>	<b>21</b>	<b>38</b>
<b>Percentage</b>		<b>56</b>	<b>16</b>	<b>28</b>

<b>Duration is continual.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>7</b>	Timeline. Beginning and end of lunch	8	4	15
<b>9</b>	I want you to think of 2 things that you do between getting out of bed and having lunch and mark them on your timeline. Now think of 2 things you do between having lunch and going to bed on your favourite day. Mark when you do each one on your timeline.	4	3	20
<b>50</b>	Imagine the clock is now telling me it is 10 past 2. What time will it be in an hour?	18	2	7
<b>53c</b>	How long does the journey take? (2 hours).	17	5	5

<b>54d</b>	How did you work that out?	7	11	9
<b>Total</b>		<b>54</b>	<b>25</b>	<b>56</b>
<b>Percentage</b>		<b>40</b>	<b>19</b>	<b>41</b>

<b>A unit of time is constant, being equal in length of time to any other unit of time bearing the same name.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>13a/b</b>	What is the shortest unit of time that you know? What is a shorter period of time than.....?	16	1	10
<b>14a/b</b>	Put your head on the desk* for one minute and look up when you think one minute is up. (How did you work that out? Do it for me.)	12	7	8
<b>43</b>	How many minutes does it take for the minute hand to move from the 2 to the 3?	21	0	6
<b>45</b>	How many minutes does it take for the hour hand to move from the 8 to the 9?	15	2	10
<b>47</b>	Can the length of an hour change? Why? Or Why not?	9	9	9
<b>Total</b>		<b>73</b>	<b>19</b>	<b>43</b>
<b>Percentage</b>		<b>54</b>	<b>14</b>	<b>32</b>

<b>The duration of an event can be measured in units of time from the very small to the very large.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>4</b>	Tell me when it is am and when it is pm?	2	16	9
<b>5</b>	When does am change to pm?	2	16	9
<b>10a/b</b>	What is something that takes a long time to do? What is something that takes a <b>very</b> long time to do?	13	3	11
<b>11a/b</b>	What is something that takes a <b>very</b> short time to do? Is there anything that can happen in an even shorter time?	13	0	14
<b>46</b>	Can you tell me something that would take about an hour to do?	12	13	2
<b>Total</b>		<b>42</b>	<b>48</b>	<b>45</b>
<b>Percentage</b>		<b>31</b>	<b>35</b>	<b>33</b>

### Measurement key idea items

<b>The passage of time is measured in specific units.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>4</b>	When is it am and when is it pm?	2	16	9
<b>5</b>	When does am change to pm?	2	16	9
<b>6a/b</b>	How do you know that your recess is longer than lunchtime?	19	6	2
<b>12</b>	We measure length in small units such as centimetres and very large units such as kilometres. What units to measure time do you know?	8	11	8
<b>13a/b</b>	What is the shortest unit of time that you know?	16	1	10
<b>18</b>	We use a calendar to find the date. How can we use a calendar to measure time?	25	0	2
<b>35</b>	Card 24/9/15. When the date is written like this, what do the different numbers mean?	25	2	0
<b>36</b>	If you had a calculator, how would you work out how old you are in days?	0	10	17
<b>Total</b>		<b>97</b>	<b>62</b>	<b>57</b>
<b>Percentage</b>		<b>45</b>	<b>29</b>	<b>26</b>

<b>Units of time based on natural phenomena (days, years) are reliant on the movement of the Earth in space.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>7</b>	Mark the beginning and end of your lunchtime on your timeline.	8	4	15
<b>14a</b>	Estimate one minute.	12	7	8
<b>15a/ b</b>	One way we measure time is with a clock. Tell me some other ways or things we use to measure time.	3	18	6
<b>17</b>	We use a calendar to find the date. How can we use a calendar to measure time?	5	8	14
<b>19</b>	What year were you in Prep?	16	8	3
<b>32</b>	Today's date is... What was the date exactly one month ago?	14	1	12
<b>33</b>	If the date is the 24 <sup>th</sup> October, what will be the date in 3 weeks?	15	4	8
<b>34</b>	Today's date is... What will the date be 2 years from now?	16	4	7
<b>Total</b>		<b>89</b>	<b>54</b>	<b>73</b>
<b>Percentage</b>		<b>41</b>	<b>25</b>	<b>34</b>

<b>Manufactured units of time (second, minute, hour, week) are entrenched in our culture.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>48a</b>	Tell me what time this analogue clock shows. 11 o'clock.	23	0	4
<b>48b</b>	Tell me what time this analogue clock shows. ½ past 5.	20	4	3
<b>48c</b>	Tell me what time this analogue clock shows. ¼ to 6.	14	5	8
<b>48d</b>	Tell me what time this analogue clock shows. 25 past 8.	15	1	11
<b>48e</b>	Tell me what time this analogue clock shows. 7 minutes past 6.	15	0	12
<b>51a</b>	I want you to write this time as it would appear on a digital clock? 2 o'clock	24	0	3
<b>51b</b>	I want you to write this time as it would appear on a digital clock? ½ past 5.	18	1	8
<b>51c</b>	I want you to write this time as it would appear on a digital clock? ¼ to 6.	12	6	9
<b>Total</b>		<b>141</b>	<b>17</b>	<b>58</b>
<b>Percentage</b>		<b>65</b>	<b>8</b>	<b>27</b>

<b>A point in time is meaningful when its position is located on the time continuum.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>16</b>	We know clocks tell us the time. Tell me how we use clocks to measure time.	1	9	17
<b>37a</b>	Draw an analogue clock for me. Positioning of the 12 numerals	17	9	1
<b>37b</b>	Draw an analogue clock for me. Positioning of the minute markers.	5	11	11
<b>37c</b>	Draw an analogue clock for me. Positioning of the hands of the clock.	23	4	0
<b>37d</b>	What is the name of the big hand and what does it tell us?	22	0	5
<b>37e</b>	What is the name of the small or little hand and what does it tell us?	22	0	5

<b>38a</b>	Draw a digital clock for me.	26	0	1
<b>38b</b>	Now I want you to draw a digital clock for me. Tell me which numbers tell you the hours and which numbers tell you the minutes.	26	1	0
<b>Total</b>		<b>142</b>	<b>34</b>	<b>40</b>
<b>Percentage</b>		<b>66</b>	<b>16</b>	<b>19</b>

<b>Time measuring devices (for example, the atomic clock) have become extremely sophisticated.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>27</b>	Find today's date and point to it. <i>When found, ask,</i> Tell me the full date including the day?	9	14	4
<b>39</b>	How many seconds in a minute?	26	1	0
<b>40</b>	How many minutes in an hour?	25	0	2
<b>41</b>	How many minutes in half an hour?	25	0	2
<b>42</b>	How long does it takes for the minute hand to go once around the clock?	18	0	9
<b>43</b>	How many minutes does it take for the minute hand to move from the 2 to the 3?	17	1	9
<b>44</b>	How long does it takes for the hour hand to go once around the clock?	11	3	13
<b>45</b>	How many minutes does it take for the hour hand to move from the 8 to the 9?	15	2	10
<b>Total</b>		<b>146</b>	<b>21</b>	<b>49</b>
<b>Percentage</b>		<b>68</b>	<b>10</b>	<b>22</b>

<b>The learning and teaching of time is incorporated into the school curriculum, with emphasis on measuring time with clocks and calendars.</b>		<b>2</b>	<b>1</b>	<b>0</b>
<b>53a</b>	What time does train 4 leave Bendigo for Southern Cross station?	27	0	0
<b>53b</b>	What time does train 4 arrive at Southern Cross station in Melbourne?	26	0	1
<b>49</b>	Which of these times comes first in a day, a quarter to 8 or a quarter past 8? Tell me <i>why</i> that time comes first.	17	4	6
<b>50</b>	Imagine the clock is now telling me it is 10 past 2. What time will it be in an hour?	18	2	7
<b>52</b>	Look at this digital clock. Imagine that the last number has just changed to 7. How long before it changes to 8?	25	0	2
<b>53c</b>	<i>Show the student the Bendigo to Melbourne train timetable.</i> Look at the train timetable. <i>Point to the left hand column of names.</i> These are the towns that the train travels through from Bendigo to Melbourne (Southern Cross) where it stops. How long does the journey take?	17	5	5
<b>54c</b>	Does train 2 take more or less time to get to Southern Cross station than train 4?	27	0	0
<b>54d</b>	How did you work that out?	7	11	9
<b>Total</b>		<b>164</b>	<b>22</b>	<b>30</b>
<b>Percentage</b>		<b>76</b>	<b>10</b>	<b>14</b>

## APPENDIX M

### The frequencies of 2, 1, and 0 scores for each key idea assessed in the pre-intervention interview

<b>Succession key ideas</b>	<b>2</b>	<b>1</b>	<b>0</b>
Two or more different events are organised sequentially.	63	18	27
An understanding of succession is needed to iterate units of time, seriation.	44	29	35
Simultaneity and synchronisation are related to succession.	44	59	32
Years are arranged in succession in numerical order.	108	14	13
Days, weeks and months are arranged in succession in a cyclical pattern.	95	11	2
Succession involves the past, the present, and future.	81	37	17
Rotation and revolution of the Earth.	0	6	21
<b>Total</b>	<b>435</b>	<b>174</b>	<b>147</b>
<b>Total as a percentage</b>	<b>58%</b>	<b>23%</b>	<b>19%</b>

<b>Duration key ideas</b>	<b>2</b>	<b>1</b>	<b>0</b>
Duration is an unbroken interval of time between two successive events.	61	33	41
To add, subtract, multiply and divide units of time requires an understanding of the duration of the units.	103	11	21
Simultaneity, synchronisation, isochronism and seriation relate to duration.	76	21	38
Duration is continual.	54	25	56
A unit of time is constant, being equal in length of time to any other unit of time bearing the same name.	73	19	43
The duration of an event can be measured in units of time from the very small to the very large.	42	48	45
Rotation and revolution of the Earth.	0	6	21
<b>Total</b>	<b>409</b>	<b>163</b>	<b>265</b>
<b>Total as a percentage</b>	<b>49%</b>	<b>19%</b>	<b>32%</b>

<b>Measurement key ideas</b>	<b>2</b>	<b>1</b>	<b>0</b>
The passage of time is measured in specific units.	97	62	57
Units of time based on natural phenomena (days, years) are reliant on the movement of the Earth in space.	89	54	73
Manufactured units of time (second, minute, hour, week) are entrenched in our culture.	141	17	58
A point in time is meaningful when its position is located on the time continuum.	142	34	40
Time measuring devices (for example, the atomic clock) have become extremely sophisticated.	146	21	49
The learning and teaching of time is incorporated into the school curriculum, with emphasis on measuring time with clocks and calendars.	164	22	30
Rotation and revolution of the Earth.	0	6	21
<b>Total</b>	<b>779</b>	<b>216</b>	<b>328</b>
<b>Total as a percentage</b>	<b>59%</b>	<b>16%</b>	<b>25%</b>

## APPENDIX N

### Scores for all pre-intervention interview items ranked from lowest to highest score

Q N <sup>o</sup>	Question	Score
55	What do you know about the rotation and revolution of the Earth?	6
36	If you had a calculator, how would you work out your age in days?	10
9	Student marked the duration (beginning and end) of each event on the timeline	11
16	Tell me how we use clocks to measure time.	11
1	How do I know it is morning/afternoon?	16
17	How can we use a calendar to measure time?	18
3	When will Wednesday* finish?	19
4	Tell me when it is am and when it is pm?	20
5	When does am change to pm?	20
7	Mark on your timeline when you start lunch and when you finish lunch	20
37b	Draw a clock. Minute markers.	21
15	Tell me some other ways or things we use to measure time.	24
44	How long does it takes for the hour hand to go once around the clock?	25
54d	Calculate the train journey. 1 hr and 52 minutes.	25
11	Compares activities that take a short and a very short time to do.	26
12	What units to measure time do you know?	27
47	Can the length of an hour change? Why? Why not?	27
32	What was the date exactly one month ago?	29
10	Compares activities that take a long and a very long time to do.	29
51c	Write this digital time as seen on an analogue clock. 1/4 to 6.	30
48e	Read the time. 7 minutes past 6.	30
48d	Read the time. 25 past 8.	31
14	Estimate 1 minute.	31
2	Today is Wednesday*. When did Wednesday* start?	31
24	If I ate the first egg on Wednesday, which day would I eat the last egg?	32
27	Tell me the full date including the day.	32
45	How long does it take for the hour hand to move from the 8 to the 9?	32
13	What is the shortest unit of time that you know?	33
48c	Read the time. ¼ to 6.	33
33	If the date is 24th October, what will the date be in 3 weeks?	34
43	How many minutes does it take for the minute hand to move from the 4 to the 5?	35
34	What will the date be 2 years from now?	36
42	How long does it takes for the minute hand to go once around the clock?	36

46	What would take about an hour to do?	37
51b	Write this digital time as seen on an analogue clock. $\frac{1}{2}$ past 5.	37
26	Place three annual events in order.	38
31	What day of the week is the first of next month?	38
49	Which time come first? $\frac{1}{4}$ to 8. $\frac{1}{4}$ past 8.	38
50	10 past 2. What time will it be in an hour?	38
53c	How long does the train journey take? 2 hours.	39
19	What year were you in Prep?	40
25	Which season is July in?	41
37a	Draw a clock. Numbers positioned evenly.	43
6	How do you know that your recess* is shorter/longer than your lunchtime?	44
37d	Draw a clock. What is the name of the big hand and what does it tell us?	44
37e	Draw a clock. What is the name of the small or little hand and what does it tell us?	44
48b	Read the time. $\frac{1}{2}$ past 5.	44
28	The day before yesterday.	45
48a	Read the time. 11 o'clock.	46
22	Tell me the names of the months.	47
23	How many months in one year?	48
51a	Write this digital time as seen on an analogue clock. 2 o'clock.	48
18	What year is it this year?	50
29	The date the day after tomorrow.	50
37c	Draw a clock. Position hands to tell a time.	50
40	How many minutes in an hour?	50
41	How many minutes in half an hour?	50
52	How long does it take for the last digit to change on a digital clock?	50
30	What will next month be?	51
35	24/9/2015. What do the different numbers mean?	52
38a	Write an appropriate time on a digital clock.	52
53b	What time does train 4 arrive at Southern Cross station (8:08)?	52
20	What are the names of the days of the week?	53
38b	Which numbers tell you the hours and minutes on a digital clock?	53
39	How many seconds in a minute?	53
8	4 events marked on the timeline are correctly sequenced	54
21	How many days are in a week?	54
53a	What time does train 4 leave Bendigo for Southern Cross station? (6:08)	54
54c	Does train 2 take more or less time? Less.	54



## APPENDIX O

### Letters from all participating students detailing the learning in the past 7 lessons

01B4

Dear Mum,

In maths we have been learning about time. Today we did the most interesting thing, a time game! The name was suggested by me. The name is Time Warpers! Here are some interesting words I learnt: rotation, revolution, succession and duration.

02G3

To Mr T (Principal's name here),

In math with Mrs T we learnt ... duration, hour, minutes, [and] seconds. We did calendars. That was my favourite. We did revolution, rotation. It takes 365 days to go around the sun that is a year. That's all I remember, I'm sorry.

P. Bye. Oooops. The Earth takes 24 hours a day to spin once. Bye.

03G3

Dear Mr T (Principal's name here),

Thank you for organising Miss T to help us with time.

We learnt that the Earth takes 365 days to go around the Sun once, the duration, hours and minutes. We learnt how to read time on a clock by reading minutes and then read the number the hour hand is on.

Thank you for your time.

Kind regards,

L.

04G4

Dear Mum,

I'm writing to tell you about maths with Mrs T and it's AMAZING. It's really helping me, like all the different clocks like the sundial, water clock and hour glass.

Thanks for signing the note.

A.

05G3

Dear Dad,

I missed u. I hope you enjoy my letter. In math my class learnt time with a lovely lady called Mrs T. We had a great time.

 from S. xoxo. Lots of love. Xoxoxoxo.

P.S. I learnt that the earth goes around the sun for 365 days.

06B3

Dear Easter Bunny,

Today I learnt that calendars are really useful to time and that there are lots of time inventions like sundial, water clock, and lots of other stuff.

07G4

Dear Mum,

I'm writing to tell you about Mrs T's classes. I've liked learning about the following: duration, succession, revolution, rotation, [and] different ways to measure time, games and so on.

From E.

08B3

Dear Dave,

I have learnt some new [words] like revolution and other words.

09G3

Dear Mum and Dad,

This is the things that I did with Mrs T: learning about rotation, making a calendar with A, me and I, learning how to tell the time and today we played a game called Time Warps.

10B4

Dear Santa and your Elfs,

I have learnt more about duration and I know about Earth rotation and revolution before.

I found interesting the game Mrs T invented, named Tomorrow is a New Day. I found the game hard and love the challenge.

From H.

P.S. I learnt new types of clocks.

11B3.

Dear Easter Bunny,

I learnt how to use calendars well. I found the game really interesting. I found it hard to play the animal calendar game. I liked doing the world going around the sun and on its axis.

12G4.

Dear Mum,

I learnt about time with Mrs T. Some things were hard but I still gave it a go. We learnt about duration, hours, minutes and seconds, calendars, a game we learnt and a lot more.

From E.

13B3

Dear Santa,

I have learned about duration of hours, minutes and seconds. And we also learned about revolution and rotation. After that we learned that there's 365 days in a year.

Cheers,

L.

14G4

Dear Aunty Sandra and Uncle Tim,

In maths the last week we have had a special maths teacher called Mrs T. a normal year for the Earth to rotate ... (unfinished).

15B4

Dear Santa,

I am writing to tell you about maths with Mrs T. We have been playing a game A day before Tomorrow that I really liked. We have been learning about time. I really like Mrs T.

16G4

Dear Mrs B (classroom teacher),

I learned about duration in these maths sessions. The interesting things were finding out who I was born near and grade 3s that should be grade 4s and guess what? Tom and Lucy are older than me! I liked reading the book 'Grandmother's clock'. I liked the way to measure time.

17B3

Dear Mum,

In special maths with M, we have been learning about clocks [and] earth. Some of the stuff we learned was how long it took for the earth to spin around once which is one night and day.

18B4

Dear Mum,

In maths I have been learning about time. The new words I know is duration, revolution and succession. I loved all the activities and it was easy.

19B4

Dear Dad,

How has your day been?

We have been learning about time. This is what I can remember.

We learnt about minutes, seconds, duration, hours, succession, calendars, revolution, different ways to measure time, a new game and rotation.

From P.

20B3

Dear Santa,

I have learnt so much from Mrs T. Sand clocks. Water clocks.

From L.

PS. I'm awesome.

21B4

Dear Mrs T,

Today we learnt duration, succession, revolution, rotation, [a] game, and different ways to measure time.

I found reading books was interesting.

Finding out what "time is" is a little bit hard.

From A.

22B3

To Santa Paws,

We have been learning about time. Today we played a game that had months in it. We learned about duration.

From T.

23B4

Dear Mum,

We have been learning about clocks, time and the Earth. We learnt that the Earth takes one year to go around the Sun. it takes 24 hours to turn around in a circle. The Earth. A Leap Year is 366 days, normal year is 365 days.

24B3

Dear A,

I have learnt about duration which is the length of time. Mrs T showed us how to play a game that involved a calendar.

25G4

Dear Mum,

In maths we have been learning a lot of new things. Some of my favourite activities were the game and when we got taught that the world always faces the sun and it takes one year to go around the sun. I never knew it takes 1,000 milliseconds to make one second. Do you know what duration is? It is the time in between ... [unfinished].

26B3

Dear Mum,

I have learnt so much thing with Mrs T.

I've learnt what duration means, how long things take. I've learnt how calendars work. I know what rotation and revolution means and how to make a timeline. I know that when the Earth spins it is a new day. And when the Earth moves around the Sun once, a year has gone.

By N.

27G3

Dear Aunty Viky,

Mrs T. Mrs T was teaching math and time. it was very interesting learning about duration. Some stuff was very hard. I fiddled with my name tag. I enjoyed it.

From I.

**APPENDIX P**  
**Post-intervention interview scores for all students**

	01B4	02G3	03G3	04G4	05G3	06B3	07G4	08B3	09G3	10B4	11B3	12G4	13B3	14G4	15B4	16G4	17B3	18B4	19B4	20B3	21B4	22B3	23B4	24B3	25G4	26B3	27G3	Class score	
1	0	1	0	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	1	1	1	0	0	13	
2	1	0	2	2	1	1	2	0	2	1	0	2	1	1	2	1	1	1	1	1	2	2	2	2	2	2	2	1	36
3	1	1	1	1	1	1	2	1	0	2	1	1	0	1	2	1	1	1	0	1	1	1	1	2	1	2	1	29	
4	1	1	0	1	1	1	2	1	1	1	1	1	0	1	1	2	2	1	1	0	0	1	0	2	2	1	0	26	
5	2	1	0	2	1	1	2	0	2	1	2	2	0	1	2	2	2	2	0	2	2	2	0	2	2	2	1	38	
6	1	1	1	2	1	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	47
7	2	0	0	2	2	1	2	2	2	2	0	1	0	1	2	2	2	0	0	2	2	0	2	0	2	0	0	31	
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	53
9	0	0	0	0	0	0	1	0	1	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	2	0	9
10	2	2	2	0	2	2	2	2	2	2	0	2	2	0	2	2	2	2	0	2	2	0	2	2	2	0	2	2	42
11	2	2	0	0	0	2	2	2	0	2	2	2	2	2	2	2	2	2	2	1	2	0	2	2	2	2	2	2	43
12	2	2	1	2	0	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	1	47
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54
14	0	0	2	2	2	2	2	1	0	2	2	2	1	2	2	2	0	1	1	1	0	0	2	0	2	2	0	33	
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21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54

22	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	1	1	1	1	2	1	1	2	2	2	2	46	
23	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	0	2	2	2	2	48	
24	1	1	2	1	2	2	1	2	2	2	0	1	1	1	1	1	2	1	1	1	1	1	2	2	2	2	2	38	
25	2	2	0	2	2	1	2	2	2	2	2	2	2	2	1	2	2	1	1	2	2	1	1	1	2	2	1	44	
26	2	2	1	2	2	2	2	2	2	2	1	2	1	2	2	2	0	2	1	2	1	1	2	2	2	2	2	46	
27	2	2	2	2	2	2	2	2	0	2	1	2	1	2	0	2	2	0	0	1	1	1	0	2	2	2	1	38	
28	1	1	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	1	1	2	0	2	2	1	2	45	
29	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	0	2	1	2	2	50	
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31	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	52	
32	2	2	2	2	1	1	2	2	2	1	2	2	2	2	2	2	1	2	0	2	2	1	0	1	2	2	2	44	
33	0	2	2	2	2	2	2	2	2	2	2	0	2	0	2	1	2	2	2	2	2	2	1	1	0	2	0	0	39
34	0	0	1	2	0	0	2	2	0	2	2	2	2	0	2	2	2	2	2	2	2	1	0	2	2	2	2	38	
35	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	52	
36	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	1	1	0	0	0	1	1	0	1	0	1	0	12	
37a	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	2	2	2	2	2	2	2	49	
37b	1	2	2	1	1	2	2	2	1	2	2	1	1	1	2	1	1	2	2	1	0	2	2	2	2	2	1	41	
37c	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	51	
37d	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	53	
37e	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	53	
38a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54	
38b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54	
39	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	54	
40	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	52	
41	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	52	

42	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	0	2	2	0	0	2	2	0	0	2	2	0	40
43	0	2	0	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	0	2	2	0	2	2	2	0	42
44	0	1	0	2	0	1	2	2	0	2	2	0	1	0	2	0	1	0	2	2	2	0	0	0	0	0	0	0	22
45	2	0	0	2	2	2	2	2	1	2	2	1	0	0	2	2	2	2	2	2	2	0	0	2	2	2	2	2	40
46	1	2	2	1	2	1	2	2	2	2	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2	2	1	1	45
47	2	1	2	2	2	2	2	2	2	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	1	49
48a	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	50
48b	2	2	2	2	2	2	2	2	0	2	2	2	1	2	2	2	2	2	2	2	2	2	1	0	2	2	2	2	48
48c	2	2	2	2	2	2	2	2	1	2	2	2	0	0	2	2	1	2	1	0	0	1	0	2	1	1	0	36	
48d	2	2	2	2	1	2	2	2	0	2	2	0	0	2	2	2	2	2	2	0	2	0	0	2	2	0	0	37	
48e	2	0	2	2	0	2	2	2	0	2	0	0	0	0	0	2	2	2	2	0	0	0	0	2	2	0	0	26	
49	1	2	0	2	2	2	2	2	2	2	2	0	0	1	2	2	2	0	1	1	0	2	0	2	2	1	2	37	
50	2	2	0	2	2	2	2	2	1	2	2	2	0	1	2	2	2	2	1	1	1	1	0	2	2	1	0	39	
51a	2	0	2	2	2	2	2	2	0	2	2	2	2	2	0	2	2	2	2	0	2	0	0	2	2	2	2	42	
51b	2	2	2	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0	2	2	0	2	2	2	2	46	
51c	2	1	1	2	2	2	2	1	0	2	2	2	0	0	1	2	2	2	1	0	2	1	0	2	2	2	0	36	
52	2	2	2	2	2	2	2	2	2	2	0	2	0	2	2	2	2	2	2	2	0	2	0	2	2	2	2	46	
53a	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	0	2	2	2	0	48
53b	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	52
53c	2	2	0	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	50
54c	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	1	2	50
54d	1	2	0	2	1	2	2	2	0	2	1	1	1	0	1	1	1	2	2	0	1	1	0	2	1	1	0	30	
55	2	2	1	2	1	2	2	1	1	2	2	2	1	2	2	2	1	2	0	1	2	2	1	2	2	2	2	1	43
<b>Total</b>	<b>109</b>	<b>105</b>	<b>97</b>	<b>119</b>	<b>103</b>	<b>118</b>	<b>133</b>	<b>121</b>	<b>96</b>	<b>130</b>	<b>112</b>	<b>112</b>	<b>88</b>	<b>97</b>	<b>120</b>	<b>117</b>	<b>115</b>	<b>115</b>	<b>102</b>	<b>94</b>	<b>110</b>	<b>99</b>	<b>63</b>	<b>122</b>	<b>123</b>	<b>112</b>	<b>85</b>		

**APPENDIX Q**  
**Crosstabulations for all items from the pre-and post- intervention interviews**

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	6	5	0	11
	1	8	8	0	16
	2	0	0	0	0
	Total	14	13	0	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	3	3	6
	1	3	5	3	11
	2	0	4	6	10
	Total	3	12	12	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	3	8	0	11
	1	0	9	4	13
	2	0	2	1	3
	Total	3	19	5	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	5	2	2	9
	1	1	12	3	16
	2	0	2	0	2
	Total	6	16	5	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	3	2	4	9
	1	2	3	11	16
	2	0	1	1	2
	Total	5	6	16	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	2	0	2
	1	0	3	3	6
	2	0	2	17	19
	Total	0	7	20	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	7	1	7	15
	1	0	0	4	4
	2	3	2	3	8
	Total	10	3	14	27

		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	0	0
	2	0	1	26	27
	Total	0	1	26	27

9	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	17	3	0	20
	1	1	1	1	3
	2	2	1	1	4
	Total	20	5	2	27

10	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	3	0	8	11
	1	1	0	2	3
	2	2	0	11	13
	Total	6	0	21	27

11	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	2	0	12	14
	1	0	0	0	0
	2	3	1	9	13
	Total	5	1	21	27

12	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	1	2	5	8
	1	0	2	9	11
	2	0	1	7	8
	Total	1	5	21	27

13	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	0	0	10	10
	1	0	0	1	1
	2	0	0	16	16
	Total	0	0	27	27

14	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	4	0	4	8
	1	3	1	3	7
	2	1	4	7	12
	Total	8	5	14	27

15	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	0	2	4	6
	1	0	8	10	18
	2	0	1	2	3
	Total	0	11	16	27

16	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	4	11	2	17
	1	1	4	4	9
	2	0	0	1	1
	Total	5	15	7	27

17	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	0	9	5	14
	1	1	4	3	8
	2	1	1	3	5
	Total	2	14	11	27

18	Post-intervention interview				
		0	1	2	Total
Pre-intervention Interview	0	2	0	0	2
	1	0	0	0	0
	2	0	0	25	25
	Total	2	0	25	27



19		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	2	1	3
	1	0	6	2	8
	2	0	5	11	16
	Total	0	13	14	27

20		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	1	0	1
	2	0	0	26	26
	Total	0	1	26	27

21		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	0	0
	2	0	0	27	27
	Total	0	0	27	27

22		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	6	1	7
	2	0	2	18	20
	Total	0	8	19	27

23		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	0	1	3
	1	0	0	0	0
	2	1	0	23	24
	Total	3	0	24	27

24		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	2	3
	1	0	12	4	16
	2	0	2	6	8
	Total	1	14	12	27

25		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	0	1
	1	0	7	4	11
	2	0	1	14	15
	Total	1	8	18	27

26		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	2	2	5
	1	0	3	3	6
	2	0	1	15	16
	Total	1	6	20	27

27		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	1	1	4
	1	3	2	9	14
	2	0	3	6	9
	Total	5	6	16	27

28		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	1	0	1
	1	1	2	4	7
	2	0	4	15	19
	Total	1	7	19	27

29		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	1	1	2	4
	2	0	1	22	23
	Total	1	2	24	27

30		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	3	0	3
	2	0	0	24	24
	Total	0	3	24	27

31		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	7	8
	1	0	0	0	0
	2	0	0	19	19
	Total	1	0	26	27

32		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	1	9	12
	1	0	1	0	1
	2	0	4	10	14
	Total	2	6	19	27

33		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	2	4	8
	1	3	0	1	4
	2	1	1	13	15
	Total	6	3	18	27

34		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	1	4	7
	1	3	0	1	4
	2	2	1	13	16
	Total	7	2	18	27

35		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	1	1	2
	2	0	1	24	25
	Total	0	2	25	27

36		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	14	3	0	17
	1	1	9	0	10
	2	0	0	0	0
	Total	15	12	0	27

37a		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	1	1
	1	0	5	4	9
	2	0	0	17	17
	Total	0	5	22	27

37b		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	4	7	11
	1	0	5	6	11
	2	1	2	2	5
	Total	1	11	15	27

37c		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	1	1	2	4
	2	0	0	23	23
	Total	1	1	25	27

37d		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	5	5
	1	0	0	0	0
	2	0	1	21	22
	Total	0	1	26	27

37e		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	5	5
	1	0	0	0	0
	2	0	1	21	22
	Total	0	1	26	27

38a		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	1	1
	1	0	0	0	0
	2	0	0	26	26
	Total	0	0	27	27

38b		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	1	1
	2	0	0	26	26
	Total	0	0	27	27

39		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	1	1
	2	0	0	26	26
	Total	0	0	27	27

40		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	1	2
	1	0	0	0	0
	2	0	0	25	25
	Total	1	0	26	27

41		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	1	2
	1	0	0	0	0
	2	0	0	25	25
	Total	1	0	26	27

42		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	3	0	6	9
	1	0	0	0	0
	2	4	0	14	18
	Total	7	0	20	27

43		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	5	0	4	9
	1	0	0	1	1
	2	1	0	16	17
	Total	6	0	21	27

44		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	8	3	2	13
	1	0	1	2	3
	2	6	0	5	11
	Total	14	4	9	27

45		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	5	1	4	10
	1	1	1	0	2
	2	0	0	15	15
	Total	6	2	19	27

46		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	1	1	2
	1	0	4	9	13
	2	0	4	8	12
	Total	0	9	18	27

47		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	3	6	9
	1	0	1	8	9
	2	0	1	8	9
	Total	0	5	22	27

48a		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	3	4
	1	0	0	0	0
	2	1	0	22	23
	Total	2	0	25	27

48b		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	1	2	3
	1	2	1	1	4
	2	0	0	20	20
	Total	2	2	23	27

48c		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	4	2	2	8
	1	1	3	1	5
	2	1	1	12	14
	Total	6	6	15	27

48d		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	6	0	5	11
	1	0	0	1	1
	2	2	1	12	15
	Total	8	1	18	27

48e		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	8	0	4	12
	1	0	0	0	0
	2	6	0	9	15
	Total	14	0	13	27

49		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	4	1	1	6
	1	0	2	2	4
	2	2	2	13	17
	Total	6	5	16	27

50		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	4	2	1	7
	1	0	1	1	2
	2	0	4	14	18
	Total	4	7	16	27

51a		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	2	0	1	3
	1	0	0	0	0
	2	4	0	20	24
	Total	6	0	21	27

51b		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	3	0	5	8
	1	1	0	0	1
	2	0	0	18	18
	Total	4	0	23	27

51c		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	5	4	0	9
	1	1	1	4	6
	2	0	1	11	12
	Total	6	6	15	27

52		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	2	2
	1	0	0	0	0
	2	4	0	21	25
	Total	4	0	23	27

53a		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	0	0
	2	3	0	24	27
	Total	3	0	24	27

53b		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	1	1
	1	0	0	0	0
	2	1	0	25	26
	Total	1	0	26	27

53c		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	0	4	5
	1	0	0	5	5
	2	1	0	16	17
	Total	2	0	25	27

54c		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	0	0	0	0
	1	0	0	0	0
	2	0	4	23	27
	Total	0	4	23	27

54d		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	5	3	1	9
	1	1	6	4	11
	2	0	3	4	7
	Total	6	12	9	27

55		Post-intervention interview			
		0	1	2	Total
Pre-intervention Interview	0	1	8	12	21
	1	0	1	5	6
	2	0	0	0	0
	Total	1	9	17	27

## APPENDIX R

### A synopsis of the books read and discussed during the intervention lessons

Baker, J. (1991). *Window*. London, Great Britain: Julia MacRae Books.

Jeannie Baker's picture books are artworks which are miniature collage constructions. *Window* follows the life of a boy as he grows from a baby to adulthood, becoming a father himself. We watch him grow up by noticing the changes occurring around him. Each page focusses on his bedroom window; what he can see through his window and what we can see on his window sill. Although this book has no written text, the detail in the illustrations are wonderful as a focus for discussion on succession and duration. Each page advances two years in real time. The lack of text allows the students to put their thoughts into their own words to describe what is occurring over time.

Catherall, E. (1982). *Clocks and time*. Hove, Great Britain: Wayland Publishers.

This book looks at different ways time has been measured over the years. Included are a variety of experiments that help to explain some different aspects of time. This book would be a useful one to have on the classroom library shelves although the older style is not very appealing.

Formichelli, L. (2012). *Timekeeping*. White River Junction, VT: Nomad Press.

This book includes a lot of information about time keeping inventions and the measuring of time. Each chapter focusses on a different aspect of time measurement, commencing from the earliest inventions up to modern day. Significant words are written in a bold font within the text with a glossary of terms at the end of the book. Additional information is given throughout the book by way of drawings, 'Did you know' questions, and boxes as a sideline to the text. Each chapter concludes with an activity to reinforce learning, some examples of which are making a sundial and an easy escapement.

Graham, B. (2013). *Silver buttons*. London, Great Britain: Walker Books.

At 9.59 on Thursday morning, Jodie draws a duck. Just as she is about to add one final silver button to the duck's boots, her little brother takes his first step. At this exact same moment, we are able to see outside Jodie's house to experience many synchronal events such as a man buying bread, a soldier leaving home, and a baby being born. A delightful story for all ages, this text can be read as a focus on synchronicity, duration and succession.

Hutchins, P. (1970). *Clocks and more clocks*. London, Great Britain: The Bodley Head.

Mr Higgins finds a clock in his attic. To ascertain whether this clock shows the correct time, Mr Higgins buys another clock and places it in a different room of his house. Mr Higgins cannot decide which clock is correct as his clocks show different times. He continues to buy clocks

from the clockmaker, placing them in different rooms. As he moves from room to room, the clocks display different times. He eventually buys a watch which he carries from room to room enabling him to match each clock time to the watch time. This is an excellent book to discuss the duration of time and the measurement of minutes taken to complete an activity.

Karas, G. B. (2005). *On Earth*. New York, NY: Puffin Books.

Simple text and clear illustrations make this book a good introductory text for learning about the rotation and revolution of the Earth. Relevant words are listed in the back of the book to be reviewed when the reading is completed. Although the text was simple, the response to the book indicated that the concept of the Earth's regular movement was still confusing for some students. There are several websites that explain the movement of the Earth around the Sun, but the most effective way to explain this concept is for the children to act out the Earth's rotation and revolution after reading the book. Large blow-up beach balls make excellent props and are light and easy for children to carry.

Koscielniak, B. (2004). *About time: A first look at time and clocks*. New York, NY: Sandpiper. As time is mentioned frequently in our lives, Koscielniak poses the question, 'What is time?' Although this question is not answered in the book, it gives children something to consider as they progress through the history of time-measuring inventions from sundial and water clocks to the clocks of today. The text is enhanced by the plentiful use of diagrams and illustrations. This book has a lot of information about the history of time. The language is simple enough for this year level and would be a good resource to leave in the classroom on the reading shelf. It deals with the development of time measuring devices but not how to tell the time.

Matthews, P., & McLean, A. (2002). *A year on our farm*. Gosford, Australia: Omnibus books. Following the life on a farm over a year is meaningful for Australian children as this book is set in Australia. The book begins with January, when it is summer and the weather is hot, and continues in chronological order with each page focussing on a different month of the year. Each month something different occurs on the farm, such as the arrival of kittens. This is an engaging book for children, and with the information on the months and seasons, a useful book to read when learning about succession, duration, and the measurement of time.

Matthews, T. (2011). *Waiting for later*. Sydney, Australia: Walker Books.

While Nancy is told she is big, she feels small. She asks family members in turn, her mother, her brother, her cousin, her aunt and her grandfather, to play with her. As they are all busy they give the same reply, *later*. As later is too slow to arrive, Nancy imagines playing games in a tree in the backyard. When *later* arrives, she comes down from the tree for dinner. Children of



all ages can often be told to wait for later so this is a good story to introduce discussion on psychological time, the meaning of *later*, and how different people choose to use their time.

McCaughrean, G. (2002). *My grandmother's clock*. London, Great Britain: HarperCollins.

Grandma has an interesting view on time and has no need for a clock. In her house she only has one clock, and it doesn't work. Grandma uses the clock for storage. When asked by her grandchild how she tells the time, Grandma explains how she measures the passing of time by the events around her, such as Grandpa reading the paper, the changes of the seasons, and the movement of the people in the street. This book promotes discussion on the notions of succession and duration as Grandma determines these notions, without a clock, but through unconventional ways.

Robinson, R. (1987). *It's about time: A history of clocks and calendars*. Melbourne, Australia: The Macmillan Company of Australia.

We are ruled by time throughout each day as we wake up, go to school, eat meals, and play sport. Today we know the time to the precise second but this understanding and measurement of time has taken centuries to achieve. This book explains the development of the clock and the calendar and how both are used to measure time.