Meeting 21st century challenges in Grade 6 mathematics education

By

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In partial fulfilment of the requirements for the degree

Magister Educationis

Department of Humanities Education

University of Pretoria

Supervisor

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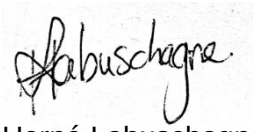
May 2019

Pretoria

DECLARATION

I declare that the dissertation, Meeting 21st century challenges in Grade 6 mathematics education, is my own original work and that to the best of my knowledge and belief it does not contain any material previously published or written by another person where due to reference is not made in the text and by means of a comprehensive list of references. I declare that this dissertation which I hereby submit as partial fulfilment of the degree Magister Educationis at the University of Pretoria has not previously been submitted by me for a degree at this or any other tertiary institution.



Herné Labuschagne

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DEGREE AND PROJECT	M.Ed (CIDD) Meeting the unique 21st century challenges in Grade 6 Mathematics education
INVESTIGATOR	Ms H Labuschagne
DEPARTMENT	Humanities
APPROVAL TO COMMENCE STUDY	27 March /2015
DATE OF CLEARANCE CERTIFICATE	31 January 2018

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The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable ethics approval. The author declares that she observed the ethical standards required in terms of the University of Pretoria's *Code of ethics for researchers* and the *Policy guidelines for responsible research.*

ACKNOWLEDGEMENTS

I would like to dedicate this study to the memory of my father André Labuschagne and uncle Herkie Scheepers, who were the inspiration of this study. They drove me to become what I am today, and I thank them for the footprints that they left behind. I will cherish their belief in me forever.

I would like to thank my Heavenly Father for every grace He brought upon me in order to complete this study. He is my shepherd and anchor.

I would also like to thank my dear supervisor, Prof JA Slabbert, for all his patience and support during difficult times. He has been an inspiration and changed my way of thinking forever.

To my husband who stood by me and supported me through every event, even in the morning hours of hard work, I want to thank him from the bottom of my heart. Without his love, support and belief in me, I would have never been able to come this far.

I would like to give thanks to my colleagues, friends and family for the motivation and support. Their prayers carried me through this journey. To all my participants who enthusiastically participated in this study, I dearly appreciate each one of them.

ABSTRACT

With South Africa being ranked among the lowest of the countries participating in consecutive PIRLS studies, South African mathematics teachers are left frustrated and demotivated in their failed attempts to sufficiently improve the learning quality in mathematics education. As a teacher in Grade 6 mathematics education, I share the experiences of my colleagues in several domains, which includes the learners' relatively poor general mathematics performance and also a serious decline in their general moral behaviour (i.e., disrespect towards others and their teachers). This study has been designed to improve the quality of my own Grade 6 mathematics professional education practice. The questions that I have explored in this study is how the Grade 6 CAPS curriculum is instrumental in enhancing the mathematics learning quality, the challenging demands of the 21st century that Grade 6 learners will have to resolve and how I can improve the quality of my Grade 6 mathematics education practice. The study follows an interpretive qualitative action research approach that focuses on the teacher confronting learners with 21st century real life challenges, which they need to resolve themselves through the professional practice of facilitating learning in an authentic and holistic way. This is where the "Five minds for the future" (disciplined, synthesising, creating, respectful, ethical) (Gardner, 2008) and the factors responsible for the integrity of all inseperable constituents of human individuality, i.e. "*body, mind, soul* and *spirit,* are simultaneously activated" (Dimitrov & Korotkich, 2002, p 42). The Professional practice of facilitating learning, with its purpose of initiating and maintaining learning as well as ensuring the highest possible quality of learning outcome, proved to be much more challenging than anticipated.

The action research approach, though, allowed for its practical implementation and becoming increasingly familiar with its demands. Within the limited experience of this study, my restricted - attempts at executing the particular, purposeful, facilitating of learning functions had my learners much more engaged in the educational event of venturing into resolving the real life challenges themselves. Although I might not have fully taken advantage of them, the opportunities for strengthening the moral foundation of education is inevitably integrated in the professional practice of facilitating learning – that which I am now in pursuit of.

KEYWORDS

Facilitating learning

21st century learning

Authentic learning

Mathematics education

Improving professional practice

Teaching

LANGUAGE EDITOR

April/May 2019

EDITING CERTIFICATE

This is to certify that the document entitled

Meeting 21st Century challenges in Grade 6 Mathematics education

has been language edited by myself, Tanya Swanepoel, at the request of the author, Herné Zeederberg (née Labuschagne).

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LIST OF ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
AL	Authentic Learning
ANA	Annual National Assessment
ANC	African National Congress
CAPS	Curriculum Assessment Policy Statement
CL	Co-operative learning
C2005	Curriculum 2005
DBE	Department of Basic Education
ELT	Experiential Learning Theory
HOD	Head of Department
ICCS	International Civic and Citizenship Studies
IEA	International Association for the Evaluation of Educational Achievement
IQMS	Integrated Quality Management System
LSA	Large Scale Assessments
LTC	Learning Task Consolidation
LTD	Learning Task Design
LTE	Learning Task Execution
LTF	Learning Task Feedback
LTP	Learning Task Presentation
ML	Meta-learning
NCS	National Curriculum Statement
NDP	National Development Plan
OBE	Outcome Based Education
OECD	Organisation for Economic Co-operation and Development
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment study
RNCS	Revised National Curriculum Statement
SA	South Africa
SACE	South African Council for Educators
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
SAQA	South African Qualification Authority
TERCE	Third Regional Comparative and Explanatory Study
TIMSS	Trends in International Mathematics and Science Studies
TALIS	Teaching and Learning International Survey

CHAPTER 1
Background, rationale, statement of purpose and research challenge

1.1 Introduction

As a child, I always admired teachers for their pursuit in teaching us values, which I made part of my daily life as an adult. The encouragement to do the right thing and to work hard to achieve one's goals, has inspired me to become a teacher myself. Beginning my school career in 1997, I was exposed to the different curriculum changes that were brought by the department of education. Being one of the first matriculants to write the final examinations within the Revised National Curriculum Statement (RNCS) and then trained to teach within the framework of the RNCS as a teacher, I had to come to terms that the curriculum has once again been modified to the Curriculum Assessment Policy Statement (CAPS) once I started working as a teacher.

My experiences as a teacher in the initial years were, like most others, more a matter of getting to grips with what the reality of education in practice really is. It is primarily a period of finding your way in delivering the curriculum as you were taught to do. I had my good and bad times but slowly gained confidence and I was increasingly becoming a relatively competent teacher in that regard. The changes in the curriculum that I (like all other teachers) had to contend with, was a hassle for most of us and for the learners. However, getting on with the job as quickly and as best as possible seemed to always be the primary concern. Just when I felt that I am becoming a more competent teacher with an increasing confidence after the most recent curriculum changes, I noticed an apparent decline in the performance, particularly of my Grade 6 mathematics learners. This on its own, made me question the quality of my education with my learners and this had to be rectified as a matter of urgency.

I firstly started to speculate about the possible relationship between what I experienced to be rapid and frequent curriculum changes, and my learners' decline in performance. Fortunately my exposure to my postgraduate studies heightened my awareness about the curriculum in that it is not only a matter of implementation and delivery, but that it has been constructed in a particular way for a particular purpose and that its construction is thus meant to determine the way in which it should be delivered to achieve a particular outcome – not only in terms of the maintenance but more importantly the improvement of its quality. In this sense, I was wondering how my leaners' performance compared to those of my colleagues. I was both

surprised and relieved that the results of my colleagues did not seem to be completely unlike mine. But to ascertain how my learners were truly doing, I had the fortitude to recall the international studies I was exposed to as a benchmark to determine how my learners possibly could perform – and this became a second aspect that I considered for investigation.

Although I had not initially put any thought to it, virtually without exception the colleagues whom I encountered daily, shared my concern about an increasing deterioration in the behaviour of many of our learners. I was perturbed by my observation of my learners' increased disrespect for things, their peers, their teachers and even themselves through an attitude of carelessness. The disregard of the learners also became the source of more frequent disruptions inside and outside my classroom. The use of smart phones and social media by learners, for purposes way beyond pure communication with others (taking photographs and videos of events unbecoming of learners of all ages and sharing it through social media), was becoming especially concerning. Although there might be no direct relationship between the disruptive behaviours of learners and the consequences of their unbridled exposure to the world through technology, there could be little doubt that the integrity of the curriculum is at stake; this to me, justified further investigation.

Even though I had the intention to further my postgraduate studies, contemplating these events, prompted my engagement with a study with these as focal points and their relationship in terms of its impact on the quality of my professional education in practice.

1.2 Rationale

In view of this brief background the rationale for engaging in this study was to highlight challenges in education.

1.2.1 The contribution of the rapid curriculum changes in SA

South African history of education is characterised by curriculum changes in short succession that would be hard to equal. The pre-apartheid curricula were that of division, prejudice and social injustice. The purpose of the post-apartheid curriculum was to completely abolish whatever its predecessor stood for (Jansen & Christie, 1998). Outcome Based Education (OBE) was chosen to fulfil this purpose because of its absence in prescribed content as well as reference to pedagogy to be used (Chisholm, 2003). This radically different curriculum was recognised as a paradigm shift by the Department of Basic Education (DBE). Traditional OBE (Spady & Marshall, 1991) was adopted under the banner of Curriculum 2005 (C2005) by South Africa in 1997 after which the National Curriculum Statement (NCS) was introduced in 2002.

The Revised National Curriculum Statement (RNCS) then followed in 2007 while the current Curriculum and Assessment Policy Statements (CAPS) was introduced in 2012. Besides these major curriculum shifts within 15 years, many minor adjustments were continually at play. Although there are agreements that curriculum must be about change (Blignaut, 2017)**,** I want to emphasize that the change towards the quality of the education should be an imperative. However, Blignaut (2017) states that the implementation of subsequent curricula has not matched expectations (Govender, 2018). The fact that teachers became "*confused and stressed*" with the consequence that learners tended to underperform (Adu & Ngibe, 2014) indicated potential damage caused by the associated pace setters or curriculum trackers, which forced teachers to teach and assess their learners regardless whether the concepts taught were understood or not. Meanwhile, Goetze (2018) gave five reasons why CAPS was harming our children from their experience:

a. Content too heavy.
b. No time for consolidation.
c. Too rigid.
d. Over assessment of children.
e. Not producing thinkers.

Most of the teachers that I have encountered had not disputed these allegations. Despite these challenges, South Africa's Minister of education (Ms Angie Motshekga) announced on 17 January 2018 that a new curriculum was underway. On Saturday 12 January 2019, the African National Congress (ANC) released its 2019 election manifesto that proposed a number of new changes in the curriculum aimed at shaking up basic education in South Africa (BusinessTech 2019, para. 7). Some of the more notable proposals made by the ANC include:

- Appointing adequately qualified teachers whose subject content knowledge is at required levels;
- Implementing a 'new innovative way' of assessing learners through the National Integrated Assessment Framework for Grades 3, 6 and 9 as a replacement for Annual National Assessments (ANA);
- Amending the curriculum to prepare learners for the fourth industrial revolution;
- Prioritising policies and strategies targeting the achievement of quality teaching and learning outcomes by enhancing the skills and competencies of educators, including the school management team comprising the school principal, deputy principal and subject heads.

- Fast-tracking the promotion and implementation of indigenous language programmes, including finalisation of language legislation in provinces for inclusion in the school curriculum.
- Promoting study of history in schools.

Long before these proposals were made, Govender (2018) studied teachers from Grades 1 to 6 teaching languages and mathematics and finally concluded that what was needed to cope with those challenges was *"…a new and integrated framework offering much-needed effective, systematic, on-going professional development programmes that translate into improved teaching practice and learning success."* (Govender, 2018, p 9). In the meantime, an organization namely, The Partnership for 21st Century Learning, has compiled corresponding skills for the 21st century, most of which were familiar, but there were several of them that were unfamiliar and quite sophisticated. According to Remake Learning (2016) the framework for 21st century learning (Figure 1.1) can be applied inside and outside of school context and across various subjects, making it easy to use as a single framework within education (see Figure 1.1 for detail).

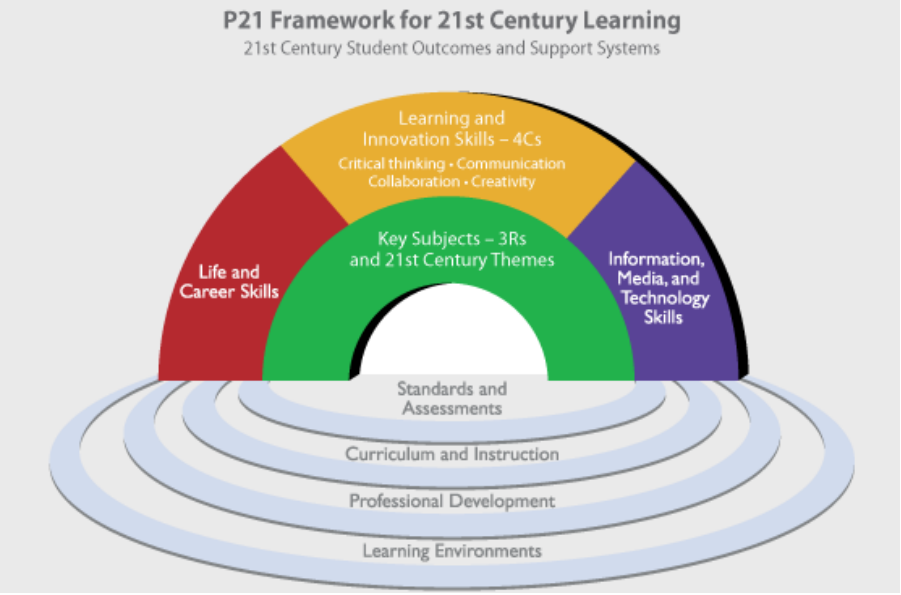


Figure 1.1: Framework for learning in the 21st century
(Remake learning 2016, para. 4)

The framework is focused on preparing students for the innovation-focused complex workforce of the 21st century (Remake learning, 2016), by supporting the teachers to teach these skills. Originally this framework had 18 skills that were viewed as essential for the 21st century, but research showed that only the four Cs were necessary (Zaucha, 2016). The four Cs include the engagement of creativity, communication, critical thinking and collaboration

(see Table 1.1) and with problem solving added as another important skill for the 21st century (Remake learning, 2016). This framework added information, media and technology goals to these skills, with the mindsets and habits of life and career skills that learners would need to adopt when learning these 21st century skills (Remake learning, 2016). The following table illustrates these goals.

Table 1.1: Learning goals for the 21st century.

Learning and Innovation "The 4 C's"	Digital Literacy	Career and Life
Critical thinking & problem solving	Information literacy	Flexibility & adaptability
Creativity and innovation	Media Literacy	Initiative & self-direction
Communication	ICT Literacy	Social & cross-cultural interaction
Collaboration		Productivity & Accountability
		Leadership & responsibility

(Tudor, 2011, p 1)

If these are the requirements for the already existing curriculum, we can but only speculate how the requirements would escalate with the added challenges of a new curriculum, while those of the preceding one have not been resolved yet.

1.2.2 The contribution of South Africa's education ranking

South Africa's quality of education was rated at 139th amongst 142 other countries in 2015 (BusinessTech, 2015a). These rankings and many other were indeed a representation of the quality of our education. Although much could be said about the validity and reliability of these rankings, there were individuals with a justifiable temptation to reject the rankings outright or only selectively present it to provide us with more favourable results. Although the rankings might vary in scientific rigour, they provided a useful indicator of the quality of our education and, perhaps even more important, it indicated what the level of our learners' performance should be and even what was possible. It is within this context that I motivate the above to be a contribution to the rationale for this study.

Galczynski (as cited in Qualities of Education in a Globalised World, 2014) stated that after the annual Comparative and International Education Society meeting held in 2010, it was decided that comparing the education of countries would paint a better picture of education's

global competency. In order to paint this global picture, the Programme for International Student Assessment study (PISA) of the Organisation for Economic Co-operation and Development (OECD) compared global education standards of different countries (Galczynski, 2014). Although PISA was one of the largescale assessments, the Progress in International Reading Literacy Study (PIRLS), Trends in International Mathematics and Science Studies (TIMSS) and International Civic and Citizenship Studies (ICCS), done by the International Association for the Evaluation of Educational Achievement (IEA) also assessed education standards (Galczynski, 2014) as can be seen in Table 1.2.

The ICCS studies revealed trends of civic and citizenship curriculum, school environment, teaching experience and qualifications, community support and teaching practices of 2016, as the previous study was conducted in 2009 (IEA, n.d.). The PISA's longer-term strategy confirms that the PISA, TIMMS and PIRLS studies are major global education surveys, together with the OECD's Survey of adult skills and Teaching and Learning International Survey (TALIS) (OECD, 2016). South Africa only actively participated globally in the PIRLS, TIMSS and the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) assessments (Spaull, 2013).

Since the focus of this study is on Grade 6 learners and particularly in mathematics, I will focus on the PIRLS and TIMSS Large Scale Assessments (LSAs), as described in Table 1.2.

Table 1.2: Comparing the four international Large Scale Assessments.

Sponsoring organisation	**Organisation for Economic Co-operation and Development**	**International Association for the Evaluation of Education Achievement**		
Assessment	**PISA** = Programme for International Student Assessment	**TIMSS** = Trends in International Mathematics and Science Study	**PIRLS** = Progress in International Reading Literacy Study	**ICCS** = International Civic and Citizenship Education Study
Target content areas	Reading, Mathematics, Science	Mathematics, Science	Reading	Civics
Target student population	15-year-olds	Grade 4 & Grade 8	Grade 4	Grade 8
Rationale for target student population	To review the extent to which students nearing the end of compulsory education in most OECD countries have acquired essential knowledge and skills for full participation in modern societies	To provide information about relative progress across grades as the cohort of Grade 4 students advances to Grade 8, in alignment with each cycle of assessment	To monitor children's development at the point when they have already learnt to read and are transitioning to read for the purpose of learning	To investigate how young people nearing the end of secondary education (the stage of schooling with the greatest similarity in organisational contexts across countries) are prepared to undertake their role as citizens
Administration frequency	3-year cycle	4-year cycle	5-year cycle	9-year cycle
Completed administrations	2000 , 2003, 2006, 2009, 2012, 2015	1995, 1999, 2003, 2007, 2011, 2015	2001, 2006, 2011, 2016	1971, 1999, 2009, 2016, 2018
Next administration	2021	2019	2021	2027
Number of countries participating in most recently completed administration	64	63	49	38

(Galczynski, 2014, p 21)

South Africa was ranked second last in an internationally combined assessment conducted with fifteen year olds of 76 countries (BusinessTech, 2015a). In April 2015, South Africa was also ranked last in terms of mathematics and science education, according to the World Economic Forum's Global Information Technology Report 2015 (BusinessTech, 2015a). These results were based on the OECD PISA test, TIMMS test and the Third Regional Comparative and Explanatory Study (TERCE) (BusinessTech, 2015a). Within these studies, OECD claimed that this was the *"…first time we have a truly global scale of the quality of education"* (BusinessTech, 2015a, para. 5). It is however important to realise that these LSAs gave a general overview of the education system of a country that covers only a narrow part of curricular content, but it does make the educational quality of the country easier to discern (Galczynski, 2014).

According to the TIMSS reports of 2011, South African Grade 9 learners were ranked as one of the bottom three in comparison with the Grade 8 learners of 42 other countries (Human Sciences Research Council, 2012). Figure 1.2 below shows the average test scores of Grade 8 mathematics candidates of middle-income countries such as South Africa that took part in the TIMSS of 2011:

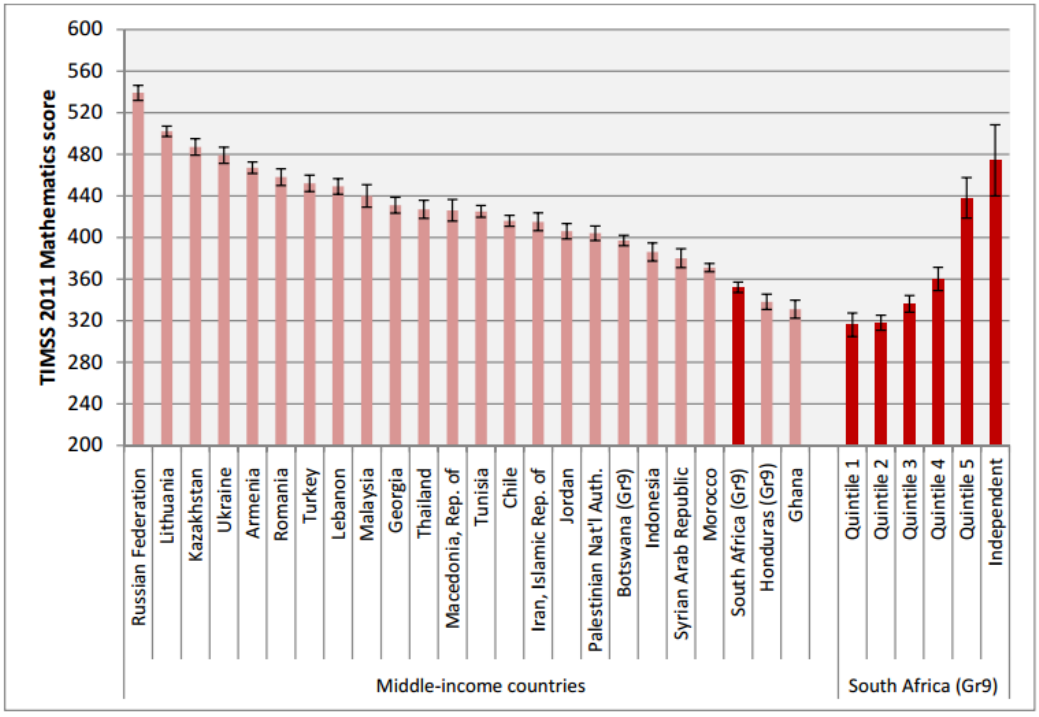


Figure 1.2: TIMSS results 2011
(Spaull 2013, p 18)

In the PIRLS 2011 and 2016 results, the South African Grade 5 learners achieved the same results as Grade 4 learners internationally (Nkosi, 2012). Figure 1.3 shows the 2016 PIRLS results as presented in the South African Highlights Report (Howie et al., 2017).

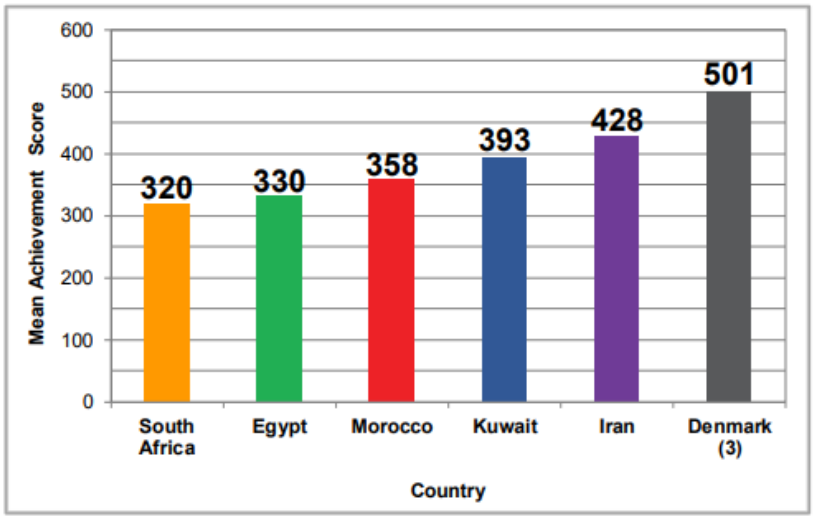


Figure 1.3: PIRLS Literacy results 2016
(Howie et al, 2017, p 2)

Both Figure 1.2 and Figure 1.3 illustrates that South Africa's science and mathematics education as well as its literacy performance, which is the foundation of mathematics and science literacy, is much lower than international standards.

The SACMEQ assessments of Grade 6 numeracy and literacy levels took place during 2000 and 2007 (Spaull, 2013). Using analysis of the SACMEQ results, a study conducted by Spaull (2011) found that South African schools were still divided with high quintiles that outperformed the lower quintiles, leaving unevenly spread data and challenging South Africa as a multi-levelled country within its education. With the exception of the wealthy minority in South Africa, most of the Grade 6 learners were illiterate and innumerate, with a remarkable 50% of pupils in Limpopo falling within this category (Spaull, 2013).

Spaull's study of the SACMEQ conducted in 2013 found that the top 5% of South Africa's mathematics pupils scored higher than the bottom 20% of teachers on the same mathematics test. This emphasises that the quality of South Africa's teachers may have an influence on the efficiency of its education system. My concern was additionally aggravated by the unprecedented and rapid changes taking place in the world that increase the complexity of

our lives and the inevitable uncertainty that goes along with it. According to Professor Linda Hammond from Stanford University, who is the President and CEO of the Learning Policy Institute, 65% of the young adults of today will be working in careers that do not exist yet (Hammond, 2015). Information is now being produced and applied at a rapid pace, so instead of only expecting students to consume information from distinct sources, the education system is now obliged to teach students how to learn and to adapt to being life-long learners (OECD, 2016).

Thus, the 21st century is posing many challenges to education in general, and it seems as though our education system is currently not making provision for coping with them.

1.2.3 The contribution of a moral decline in SA

It seems that the complexities and uncertainties concerning morals (beliefs of what is right and wrong) presented by the 21st century, have also penetrated the world of mathematics: an apparent loss of a highly-valued source of stability may create general confusion about values and value systems and may place them in jeopardy, both in our everyday lives and in education, which fundamentally revolves around values. This thought made me realise that curriculum development and implementation is currently not enabling the education system to improve the quality of education in practice.

What is highly important, though, is the fact that I am experiencing an escalation in a general kind of disrespect of learners that filters through on various levels and to practically all domains where learners function. The problem of discipline, particularly violence of teachers on learners and vice versa, as well as learners on one another, with the clear intention of inflicting grievious bodily harm and even deaths, are now becoming part of the increasing reports received. Moreover, learners participate in these events and record it on their cellphanes without interference and distribute it through social media often to a quick viral status effectively condoning what they have captured as an achievement and something to be excited about. It seems to me that the emphasis of curricula on acquiring knowledge and skills has abandoned the third element in the curriculum mantra, namely values, to oblivion. Bayaga and Jaysveree (2011, p 199) even alluded to the crisis of moral degeneration in SA schools and the place of morals and values in SA education. The objective of their study:

> "…was drawn from the fact that one cannot speak of values without implicitly referring to morality and moral development, neither can one mention morality without having values in mind …The findings revealed that, to an alarming extent, the moral code in South African Society is on the decline. Currently education in the home, school and

> community does not convey a positive value system to learners - thus perpetuating the problem of a society in decline. The recommendation is that the mindset of children needs to be changed that they become morally clear-sighted and responsible" (Bayaga & Jaysveree, 2011, p 199).

Although the research of Bayaga and Jaysveree (2011) is a study in the context of South Africa, the challenge regarding ethics, morality and values seem to be of global concern. Claxton (2012) made the general announcement: *"We live in a morally bashful age ... Trying to 'adopt the moral high ground' sounds, to modern ears, arrogant or hubristic. You risk becoming a figure of fun … Education colludes with this squeamishness …"* (Claxton, 2012, p 1). However, our tests and examination results effectively assess the retention and recall of knowledge and skills that our learners must acquire through our education, which they may forget within weeks after the assessment. But what we must realise, is that these results are not the ends of our education. They are, in fact, the indication of the embodiment of the values we intend to foster within our learners. In view of Einstein's quotation: "*Education is what remains after you have forgotten everything you learnt in school"* (Claxton, 2012, p 2), where then, are the enduring remains that our learners must attain if our experience and research shows a general moral decline in society?

It is Barnett (2007) who addressed this critical issue of a probably eschewed notion of having first to know things (knowledge) that will then enable one to do things (skills) which will 'result' (how) in the attainment of values. Barnett (2007) provided a new perspective on this 17th century idea of education: he reiterated that knowledge can be forgotten (as it does) and skills can deteriorate without use and with time (as it does) and both may become quickly out-dated. But that which is durable in its nature (what remains after everything learnt in school is forgotten) and is thus of enduring value and of vital concern for education, are human dispositions and qualities. In essence, these are values which form the foundation from which the child could find his way to live a meaningful life in this 21st century filled with perplexity. Barnett (2007) provided a new order to the traditional education mantra when he said that knowledge and skills cannot begin to offer us a framework for education in the 21st century. *"At best … they offer just two pillars of an educational project. By themselves, these two pillars, which we may label the epistemological and practical pillars, will topple over: they need (at least) a third pillar - the ontological pillar – to ensure any kind of stable structure"* (Barnett, 2007, p 7). Then Barnett (2007) pronounces the significance of this third pillar – the pillar that contains what it means to be a learner who has the responsibility of becoming fully human. Barnett (2007) further states the (attainment of) human dispositions and qualities (values or virtues): *"constitute the student's pedagogical being. It is they that have to be the focus of*

'teaching'…" (Barnett, 2007, p 7). Education in the 21st century is not primarily an epistemological task of the acquisition of knowledge and skills, but it is fundamentally an ontological challenge of the transformation of the human being through the development of human qualities and dispositions.

1.3 Statement of purpose

After my journey in facilitating learning during my honours studies, I have decided to utilise it to improve my Grade 6 mathematics teaching practice. The decision was based on the study by Barnett (2007), as facilitating learning includes the third pillar of Barnett's educational project.

It is a fact that we encounter mathematics everyday and everywhere we go. Mathematics penetrates every domain and every level of our lives, e.g., following a recipe in order to cook food, planning travels for the day, telling the time to be able to follow the daily schedule or just to do the necessary calculations to function effectively in life. But it is also experienced in more complicated and facinating areas of life like the Fibonacci sequence that has been derived from phenomena in nature. Also called the Golden Ratio, it formulates the sequences that are observed in the spiral pattern arrangement of flower petals, seed heads, snail shells and many more natural creations (Dvorsky, 2013). The nature and structure of mathematics is, in its own right, at the same time captivating and indispensible for living our lives. The utility value of its knowledge and skills is indisputable. Even so, in the same vein as the reference to Einstein's quotation earlier, we have to heed the admonishment of that of Oscar Wilde when he says the following: *"Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught"* (Wilde, 1891, p 7). This aparent paradox about our traditional perception of education, reiterates the suggestion that, even though acquiring the knowledge and skills of mathematics is non-negotiable in education, it is the remaining values that are durable in their nature that ultimately determine the quality of education.

Several international studies have revealed the poor quality of education in South Africa as a systemic phenomenon, however, the information was utilised in this study not to discredit any individual or institution, but to serve as one of my motivations to improve the quality of my own mathematics education practice. Despite the systemic state of the poor quality of South African education in general and in mathemtics in particular, in the final analysis, it remains the professional obligation of each and every individual teacher to ensure that his or her education practice is of the highest possible quality. Fulfilling this individual obligation may well have the collective effect of a sytemic change when collaboration becomes a priority.

The preceding paragraphs have prompted my research. During my BEd Honours studies, I have been exposed to authentic learning and its accompanying professional practice of facilitating learning as proposed by Slabbert, De Kock and Hattingh (2009) of which the singular purpose is to ensure the highest possible quality of learning. Not being able to exploit my experience in my short lived Grade 4 Science education practice, my transfer to mathematics education provided the opportunity to do so. I enrolled for a Med degree, of which the purpose was to improve the quality of my mathematics education practice within the context of the demanding challenges of 21st century education, by means of facilitating learning.

In this study, not only the curriculum will be investigated. Facilitating learning and real-life challenges will form a large part of this study, enhancing the value of true education by focusing on the learners in totality.

1.4 The research challenge

From the rationale and statement of purpose in the preceding paragraphs, the research challenge was identified in the form of research questions:

1.4.1 The primary research question

Derived from the statement of purpose in the preceding paragraph, the primary research question for this study was formulated as follows:

> *How can I improve my Grade 6 mathematics education practice to the highest possible quality to meet the challenging demands of the 21st century world?*

1.4.2 The subsidiary research questions

To find the answer to the primary research question above, I had to work through the following subsidiary research questions:

a. *What educational quality improvements are envisaged in the CAPS curriculum in Grade 6 mathematics in comparison with its predecessor, namely the RNCS?*
b. *What are the challenging demands of 21st century education in general, and in Grade 6 mathematics education in particular?*
c. *How can I improve the quality of my Grade 6 mathematics professional classroom practice to meet the demands of 21st century education?*

1.5 Outline of this study

The first chapter discusses the rationale and problem statement, providing the reader with the necessary background that underpins the study. In chapter one, the research question and subsidiary questions have been formulated.

Chapter 2 provides a literature overview of curriculum in general, as well as its history and modifications in South Africa. Chapter 2 unravels the challenges of education in the 21st century. Facilitating learning is also discussed in this chapter.

Chapter 3 describes the research design of this study. This chapter includes the methodology, sample, research premises and data collection techniques. This chapter also contains the data analysis and verification, the role of the researcher and the possible limitations of this study.

Chapter 4 includes the empirical study that is the collection, analysis and interpretation of the raw data collected in the fieldwork of this study. The different research cycles within this study can be read in detail in this chapter. It is in this chapter that a summary of the results, as well as a model of the research findings as derived by the researcher, can be found.

Chapter 5 highlights the findings in the empirical study. In this chapter, the results from the fieldwork together with its correlation with the literature review is presented. It is in this chapter that recommendations are presented.

CHAPTER 2
Literature review

2.1 Introduction

Since my first concerns were about the changes in SA curricula and how the subsequent curriculum was supposed to represent an improvement on the preceding curriculum in terms of the quality of the education it espouses, it might be the impetus for the way in which I could improve the quality of my own professional education practice. The SA curriculum in general and its old-new comparison seems to be the appropriate focal point in the introduction of this literature review. The purpose is to establish how the intended curriculum might have an impact on the quality of my professional practice as the implemented curriculum in action.

2.2 Curriculum

The curriculum is central to the quality of education that is delivered in education. The word curriculum has its origins from the Latin, meaning the pathway which a race should follow (Barrow & Milburn, 1990). However, immediately when one wants to find a simple definition of a curriculum, one finds that there is a variety of views and perspectives. In fact, Carl (2012) says that *"…'curriculum' is more complex than trying to put it in a box and capture one final definition and then claiming: This is what we understand by the concept 'curriculum'".* (Carl, 2012, p 29).

Despite this diffusion, the definition of Marks and colleagues (1978) still provides a valuable contribution to the understanding of the concept of a curriculum, although it is not all-encompassing:

> "A curriculum is a sum total of the means by which a student is guided to attaining the intellectual and moral discipline requisite to the role of an intelligent citizen in a free society. It is not merely a course of study, nor is it a listing of goals or objectives, rather, it encompasses all the learning experiences that students have under direction of the school" (Marks et al., 1978, p 475).

The above statement by Marks et al. (1978) emphasizes that curriculum entails moral discipline. According to Mchunu and Msibi (2013) curriculum implementation and development should be interactive, constantly changing, collaborative and intellectually engaging. Tyler (2013) stated that curriculum is therefore a process to change the behavioural patterns of people, using their thoughts, feelings and actions in the process. This requires teachers to

engage learners not only on an increasingly higher level of cognitive function, but in an overall sense on an increasingly higher quality level of life, holistically. Curriculum is therefore a course of actions and experiences enabling a child to grow into a successful adult within adult society (Chaudhary & Kalia, 2015).

A fairly common traditional view of the curriculum was that it is a document that could be accepted without hesitation, like an instructional manual to operate a machine, because it was assumed to have been compiled by experts in the field (Mchunu & Msibi, 2013). However, the implementation of a curriculum cannot merely be seen as such an instructional manual to be used step-by-step to produce a predetermined end product. The way to ensure an interpretation of the curriculum that maintains its integrity during its implementation, lies in the transparency of its design. Curriculum design is a substantially complex and holistically integrated process. It is, therefore, unfortunate that when decisions for curriculum policies and its curriculum design is made, *"…they're often disconnected from the research-based evidence and the real-world experiences of educators, students and families"* (Hammond, 2015, para. 18). If the policymakers were part of the teaching population, it might result in a much better and more appropriately designed curriculum to achieve the educational outcomes of the community it is purposed to serve.

2.3 Curriculum design and development

Curriculum design is pivotal to education because it eventually determines the source of the quality and success thereof. Curriculum design is concerned with issues surrounding the setting of curriculum proposals within the framework of what these are and how they should be implemented to advance the understanding and success of its implementation (Barrow & Milburn, 1990). Following Tyler's rationale for curriculum, the goals of society and the study of the learner's nature, form the platform for the objectives chosen for the curriculum, as the school should prepare learners to deal with problems in their daily lives (Tyler, 2013).

Curriculum design went through development from rigidly linear to dynamically interactive, moving from the objective model to the process model and then to the interactive model, as will be discussed in later paragraphs. According to Scales (2013), there are two views of curriculum development. The first is the product view, which focuses on what learners should know, whereas the second is the process view, which focuses on how learners learn (Scales, 2013). The product view has to do with communicating outcomes with a means-to-end approach (O'Neill, 2010), falling within the objective model (Chaudhary & Kalia, 2015). This is where Tyler's model (Tyler, 2013) plays a role, as it starts with objectives, selecting and

organising learning experience and then ends with evaluation (Chaudhary & Kalia, 2015). This is said to be the foundation of the Outcomes Based curriculum within the technical scientific approaches of curriculum design (O'Neill, 2010). The product approach is more subject centred and based on themes, broad fields and conceptual clusters (O'Neill, 2010). Tyler's model (Tyler, 2013), as a scientific approach, led to the development of Bloom's taxonomy (Scales, 2013). According to O'Loughlin and Thompson (2015), Bloom's taxonomy is used widely in educational research to assess the cognitive level of assignments and examinations within a course. Bloom's taxonomy has been in use in education since the 1950s in teacher training and professional preparation, helping one to classify different domains of human learning (Wilson, 2016).

On the other hand, Wheeler's model, which still falls within the product view, seems to be an improvement on Tyler's model (Chaudhary & Kalia, 2015). Figure 2.1 shows the Wheeler model, which is a cyclical model in comparison with the linear model of Tyler (2013).

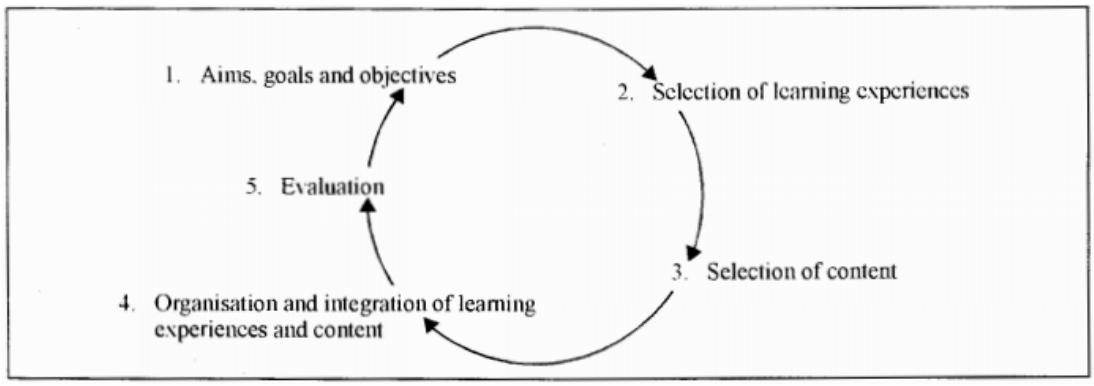


Figure 2.1: Wheeler's model of curriculum design.
(Ndlovu, 1997, p 55)

The second view of curriculum development is the process view. The process model is classified within the non-technical approach, where learners act as participants and learning is holistic (O'Neill, 2010). The construction and understanding of knowledge enjoy priority above only receiving knowledge (Scales, 2013). The process approach embraces uncertainty (O'Neill, 2010), which can be helpful within the context of the uncertainty that the 21st century holds. The experiential model of curriculum approach is a process approach where the focus is on learning from real-life experience and solving problems to improve daily life (O'Neill, 2010). This follows Kerr's model (Figure 2.2) where the objectives are divided into groups of the affective, psychomotor and cognitive (Chaudhary & Kalia, 2015). Within Kerr's model (Figure 2.2), Tyler's and Wheeler's ideas are included, only with school experiences as an

addition to Kerr's model. Knowledge shapes the outcomes, instead of the other way around (Chaudhary & Kalia 2015, p 59). The process view is therefore more learner centred and focused on a problem-based and integrated curriculum, as advocated in professional programmes (O'Neill, 2010).

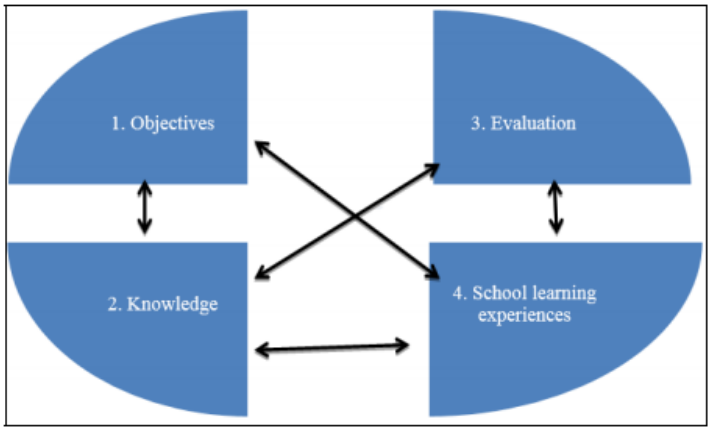


Figure 2.2: Kerr's model of curriculum design.
(Chaudhary & Kalia 2015, p 59)

There appears to be very little difference between curriculum design and curriculum development. Table 2.1 represents a global review of curriculum development phases with their corresponding action (Carl, 2012). Due to the increasing dynamic interactions between these two components, tinkering with one component, for the purpose of curriculum development, must have a bearing on all the other components.

Table 2.1: Curriculum development phases.

Phase	Actions
1. Initiation	An introductory investigation is launched.
2. Planning	Situation analysis, goal formulation, determining of criteria for the selection and classification of the content and planning of experimental design.
3. Development	Selection and classification of learning content and refinement of goals. Supply of didactic guidelines. Production of teaching materials, development of teaching materials and development of evaluation mechanisms.
4. Testing	Submission to experts for evaluation, teacher preparation for instructional task, instruction, formative evaluation and review.
5. Implementation	Planning of learning contents, dissemination, teacher orientation and instruction.
6. Summative evaluation	Final evaluation of programme.

(Carl, 2012, p 41)

Curriculum development models often ignore human aspects such as feelings, attitudes and values (O'Neill, 2010). It is known that all the education systems worldwide are constantly being reformed, using international comparative studies to help criticise each country's education system to eventually design the best possible curriculum for their country within a continuing evolving society in a global world (Cao et al., 2016). There is no doubt that SA, as would all other countries, need to ensure a curriculum design and development that can accommodate the constant and rapidly increasing changes globally on all levels and in all domains of life. This requires an extraordinary unique curriculum that cannot depend on knowledge and skills as its foundation.

2.4 The South African curriculum design and development

It was to be expected that the new political dispensation in 1994 in South Africa would include a new education dispensation with a new curriculum. It is said that South Africa has had three different schools of thought within the transformation of its curriculum (Steyn, 1998). Firstly, there was Christian National Education with its focus on the distinctive cultural groups within South Africa; secondly there was liberal education that focused on equality of opportunities; and Liberation Socialism was the third school of thought, with its focus on the reconstruction of society (Steyn, 1998). It was therefore a challenge to find a curriculum that would accommodate all South Africans. South Africa has had 160 new policy texts written and implemented in the past sixteen years (Kanjee et al., 2013). The authors questioned whether the amount of policies militates against the capacity for implementing them and whether the efforts for change are focusing on constructing policies rather than being active in implementing change (Kanjee et al., 2013).

2.5 The OBE curriculum in South Africa

A new Outcomes Based Education (OBE) curriculum, also known as Curriculum 2005 (C2005), was designed and introduced in South Africa in 1997. There are several variations of OBE from which the South African one was sourced. The South African version was based on an Australian curriculum derived from mixed origins and was very complex (Chrisite, 1997). The reality is that the curriculum has only been adjusted, as we still follow the philosophy of the OBE system. In consultation with Spady (1994) who's concept of OBE was much more foundational and simplistic, the C2005 was created (Chisholm, 2003). Naidoo (2011) explains that the SA curriculum *"…is founded on a very simple, practical, logical notion that every one of us uses everyday in our lives. An outcomes-based approach means knowing what you want to achieve – your outcome – and then taking the steps to achieve it"* (Naidoo, 2011, para 1).

It has been claimed that the South African education authorities had “completely missed the boat” with the version of OBE that they have finally compiled, urging for South Africans to stop referring to what they have adopted as OBE because it has “never existed” (Barbeau, 2008). In addition, OBE - as hastily implemented as it was compiled - became inadvertently subject to several subsequent curriculum changes. The curriculum compilers are correct in their defence that the changes in the South African curriculum was not a full-on curriculum change, but more of an adjustment of C2005 because it is maintained that we are still operating from the philosophy of OBE and that our curriculum is rather a progressive one. (Mchunu & Msibi, 2013). Although the fact that “only adjustments” was made, which might be admittedly true in a technical sense, the experiences of teachers and learners were to the contrary. Various authors predicted failure of the SA curriculum, for example Baxen and Soudien (1997), Jansen (1998), Jansen and Christie, (1998) and Naidoo (2011), among others.

It is beneficial to study the key publication of Spady (1994) to understand what the most encompassing reason might be for OBE’s failed implementation in South Africa, taking cognisance of some of the key aspects of “real” OBE. According to Spady (1994) the OBE paradigm is a shift in focus that makes “*really accomplishing results”* more important than simply providing services so that all learners should emerge from the system genuinely successful learners. Spady states the following two key purposes underlying the ‘success for all students’ philosophy:

- “Ensuring that all students are equipped with the knowledge, competence, and qualities needed to be successful after they exit the education system.
- Structuring and operating schools so that those outcomes can be achieved and maximised for all students.” (Spady, 1994, p 9)

Note that Spady (1994) deviates from the normal curriculum mantra of knowledge, skills, and values to knowledge, *competence*, and *qualities*. These competences and qualities refer to human qualities that need to be attained as outcomes, and which are, according to Barnett (2007, p 102) “*durable in their nature*” as opposed to finite, fallible, and frail knowledge and skills. “*They [durable qualities] constitute the pedagogical being of the student. They should be the focus of our ‘teaching’…”* (Barnett, 2007, p 102).

Spady and Marshall (1991, p 66), and Spady (1994, pp 11–20) provided the following four principles on which OBE is based:

- Clarity of the focus
- Expanded opportunity and support for learning success

- High expectations for all to succeed
- Design down from one ultimate, culminating outcome

Maree and Fraser (2008) were of the opinion that *"Educators should apply these principles consistently, systematically, creatively and simultaneously when constructing teaching and learning environments…"* (Maree & Fraser, 2008, p 25). Since learning is what qualifies education to be education and since learning always implies change within educational context, it always means enhancement. This was reflected in Spady's definition of an outcome: *"Outcomes are high quality, culminating demonstrations of significant learning in a real-life context"* (Spady, 1994, p 6). When Maree and Fraser (2004) indicated that demonstrating outcomes *"must be contextualised and cumulatively contribute towards the fulfilment of real-life roles"* (Maree & Fraser, 2004, p 26), it becomes important to realise that the outcomes within OBE context should be immersed in and derived from real-life. Spady (1994) has identified ten such real-life roles and calls them fundamental life performance roles. Figure 2.3 indicates these fundamental life performance roles and illustrates the relationship between these performance roles (Spady, 1994), which are divided into two sections: above the dotted line represents the roles that involve interactions with other people (interpersonal) and underneath the dotted line represents roles that involve the individual (intrapersonal).

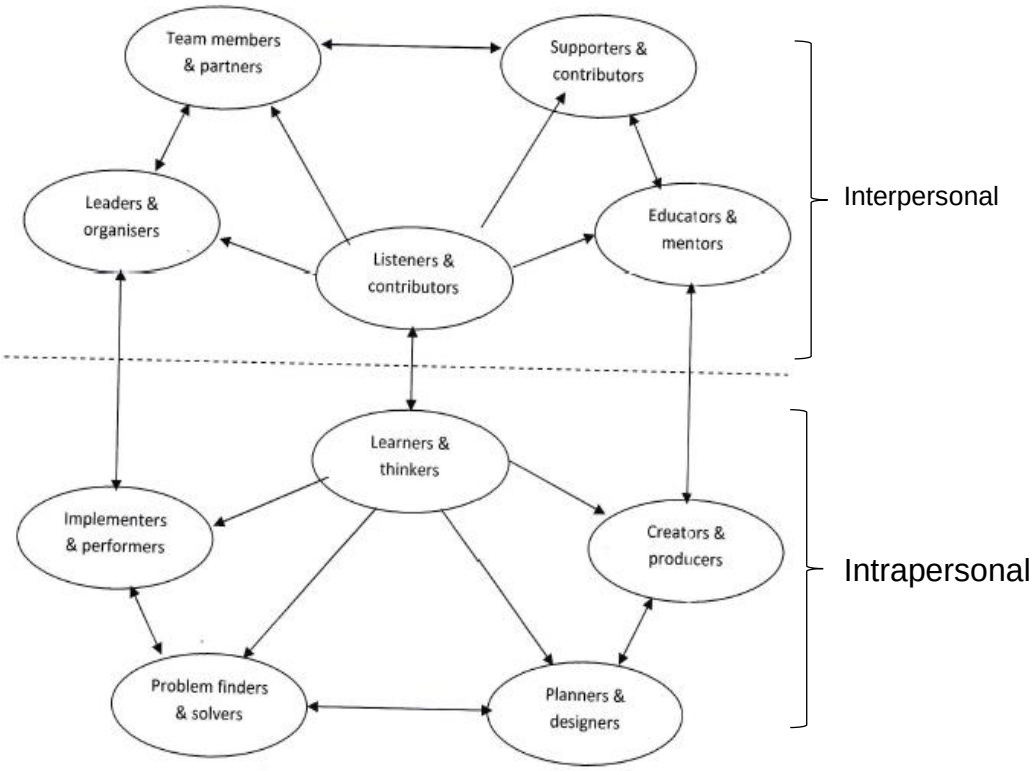


Figure 2.3: Performance roles in setting outcomes.
(Spady, 1994, p 69)

These life performance roles were translated into a set of three outcomes customised to the South African context, as indicated below (Department of Education, 2002a, p 1-2):

a. Critical (Cross-field) outcomes are outcomes to be achieved by all learners irrespective of learning area;
   - Identify and solve problems and make decisions using critical and creative thinking;
   - Work effectively with others as members of a team, group, organisation and community;
   - Organise and manage themselves and their activities responsibly and effectively;
   - Collect, analyse, organise and critically evaluate information;
   - Communicate effectively using visual, symbolic and/or language skills in various modes;
   - Use science and technology effectively and critically, showing responsibility towards the environment and the health of others; and
   - Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.
b. Developmental outcomes are outcomes of a broader developmental nature that all learners need to achieve irrespective of learning area:
   - Reflect on and explore a variety of strategies to learn more effectively;
   - Participate as responsible citizens in the life of local, national, and global communities;
   - Be culturally and aesthetically sensitive across a range of social contexts;
   - Explore education and career opportunities; and
   - Develop entrepreneurial opportunities.
c. Learning outcomes are the lowest level of outcomes relevant to each subject or learning area immersed in and derived from the Critical and Developmental outcomes.

Since the performance roles are essential roles every human being needs to fulfil to live a quality life, Maree and Fraser (2004) are of the opinion that:

> "Learners must be exposed to challenges on a higher level that will raise the standard of the expected level of performance for successful learning. This means that learners should be continually challenged beyond their current ability" (Maree & Fraser, 2004, p 26).

The above views of Maree and Fraser (2004) are in line with the theory of OBE, which is:

> "Working to continuously improve student learning before graduation. Outcome-based systems define student achievement as the highest level of performance a student may reach at any given time. Ultimate school achievement is directly reflected in what

> students can do successfully before or after their formal instructional experiences ended" (Spady, 1994, p 7).

Thus, the purpose of OBE may be fundamentally transformational, especially in terms of personal development of the highest order (Turak, 2014). Referring to Barnett's (2007, p 102) previous quotation, it is significant that he deliberately inserted 'teaching' in inverted commas: he may indicate that it is not the most appropriate concept to be used in that context. Spady (1994) has the following explanation in terms of OBE: *"Curriculum, instructional strategies, assessments and performance standards are developed and implemented to facilitate key outcomes"* (Spady, 1994, p 6). Therefore, OBE may have brought the concept of facilitating learning formally into the educational framework: *"Sound outcome-based models incorporate several elements that work together to change how schools operate and facilitate learning success for students"* (Spady, 1994, p 8).

However, what facilitating learning entails remain in dispute to this day. The confusion about what facilitating learning is has caused it to be understood as anything from direct, gross intervention through to the least possible intervention in the learning process of the learner. However, understanding what it is not, might bring us closer to understand what it is**:** *"Facilitation is not teaching, not telling, not lecturing, not preaching and not directing. Facilitation is providing the resources and structures for participants to explore, learn and develop"* (Rooth, 2000, p 35).

What is clear, though, is stated aptly by Spady (1994) when he referred to the learners' daily life challenges: *Schools are expected to fulfil their obligation of equipping all students with the competence and qualities needed to face the challenge beyond the schoolhouse door"* (Spady, 1994, p 9). Facilitating learning, therefore, must portray a radically different kind of educational intervention to achieve this aim as significant as the paradigm shift that OBE constitutes, especially if such a high standard of learning outcome quality is to be achieved. Spady and Marshall (1991) refer to the significant outcome of transformational OBE: *"'Outcomes of Significance' require substance of significance, applied through processes of significance, in settings of significance"* (Spady & Marshall, 1991, p 5). In an article written by the Independent Projects Trust (2011), Jansen claims that C2005 had to be reconstructed to take the available resources of specific schools and classrooms into account, as many schools still battles with outdated textbooks and communities with a lack of appreciation for education. The statement in C2005 that all learners can learn everything is a major concern as it does not take the local realities within schools into account. Although there was support for C2005,

it could not succeed in view of these realities and the inadequacy of resources provided (Horn, 2010).

The C2005, which was South Africa's own version of Outcomes Based Education, was based on two philosophies in order to promote quality education to all learners, focusing on social reform (Horn, 2010). These philosophies were based on the behaviourist and humanist psychologies, where the focus is not on the mastery of content but on shaping the learners' attitudes and values (Horn, 2010) instead of focusing on skills, as the original OBE curriculum intended. As in the case of C2005, schools became social engineers - with behaviourism playing a role towards social reconstruction (Horn, 2010). Alternatively, schools should take the responsibility of inculcating universal morals such as respect, honesty, mercy and justice, and not move beyond these morals as it did (Horn, 2010).

The question remains: Why did OBE fail? Not only in South Africa, but in so many places all over the world? Most likely for the same reason that educational reform in general has achieved its purpose as were expected. Although OBE was focused on learners taking responsibility for their own learning within groups, promoting democracy and critical thinking, it also overestimated the ability of learners to take responsibility for their own learning. The fact that learners are immature beings in need of adult guidance seems to be ignored, escalating the situation by untrained teachers in the field of adult guidance (Horn, 2010). OBE's failure seems unavoidable when the system, that so fundamentally transformational, is misunderstood for what it really is. If the implementation of OBE is represented simply by a curriculum to be adopted without the transformation of the context within which the system is meant to operate, and without the corresponding personal transformational educational intervention, it is deemed to fail.

Prior to OBE, the education system was prescriptive and oriented towards rote learning, leaving teachers unprepared for a constructivist teaching approach as required for the implementation of OBE (OECD, 2008). Another concern was that only one teacher per school was trained to teach OBE, in the hope that this training would then be dispersed to the rest of the teachers within the school. This did not happen in practice, causing more confusion on what teachers should implement within their classrooms (Mchunu & Msibi, 2013). Teaching in the OBE system led to criticism that the language used was too complex and placed a huge burden on teachers' administration, with a lack of adequate release time and appropriate class sizes (Independent Projects Trust, 2011).

It is therefore emphasised that teachers need to structure and guide learners very carefully within the self-construction of knowledge, and its absence is a very serious problem for the implementation of such a curriculum. Due to the limited teacher involvement with the structuring of the OBE curriculum and the amount of vast changes at once, together with a very complex and confusing innovation of language within the OBE, the curriculum was harshly critisized (Mchunu & Msibi, 2013).

Unfortunately, it seems as though we lacked the patience to tolerate the unavoidable change implementation dip when everything seems to fail with OBE. This made us remain with crisis managed, ad hoc inadequate results, with one of the most likely reasons expressed by Daniel and colleagues (2003) that we have an *"…inadequate recognition of curriculum as the core business of education departments"* (Daniel et al., 2003, p 278), which is perpetuated even in the most recent CAPS and its associated pacers and curriculum trackers.

2.6 The Revised National Curriculum Statement

The major modification that took place between the initial OBE curriculum, C2005 (also known under the label of National Curriculum Statement) and the eventual Revised National Curriculum Statement (RNCS) was an increasing removal of the complex language, in an attempt to simplify it (Mchunu & Msibi, 2013). Structural changes were also included, e.g., Grades were categorised into phases (Grades 1,2 and 3: Foundation Phase; Grades 4, 5 and 6: Intermediate Phase; Grades 7, 8 and 9: Senior Phase; Grades 10, 11 and 12: Further Education and Training Phase) and groups of subjects were categorised in Learning Areas, in an attempt to disolve the barriers between subjects. The changes also entailed a gradual importation of learning support materials, staffing and resourcing of functions and structures within education and changes in teacher orientation and training (Mchunu & Msibi, 2013). After the criticism of factors that inhibit participation within schools in C2005, the RNCS made room for inclusivity of all abilities by specifying only the minimal requirements learners need to attain (Department of Education, 2002a). The learning outcomes, which stayed the same for each Grade per phase, have now been paired with assessment standards that change per Grade (Department of Education, 2002a) as can be seen in Figure 2.4. This assists with the determination of the level of achievement for specific learning outcomes (Department of Education, 2002a).

Figure 2.4: Overview of the RNCS curriculum design.
(Department of Education, 2002a, p 93)

What is most interesting within the RNCS, of which quite a number of versions exists, is that its earlier versions indicates that the *"…RNCS builds its Learning Outcomes for the General Education and Training Band for Grades R-9 (for schools) on the critical and developmental outcomes that were inspired by the Constitution and developed in a democratic process"* (Department of Education, 2002a, p 1), with the critical and developmental outcomes remaining unchanged.

The critical outcomes within the RNCS (Department of Education, 2002a, p 1) envisage a learner who is able to:

1. identify and solve problems and make decisions using critical and creative thinking;
2. work effectively with others as members of a team, group, organisation and community;
3. organise and manage themselves and their activities responsibly and effectively;
4. collect, analyse, organise and critically evaluate information;
5. communicate effectively using visual, symbolic and/or language skills in various modes;
6. use science and technology effectively and critically, showing responsibility towards the environment and the health of others; and
7. demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

The developmental outcomes within the RNCS (Department of Education, 2002a, p 1-2) envisage a learner who is able to:

1. reflect on and explore a variety of strategies to learn more effectively;
2. participate as responsible citizens in the life of local, national, and global communities;
3. be culturally and aesthetically sensitive across a range of social contexts;
4. explore education and career opportunities; and
5. develop entrepreneurial opportunities.

Within the RNCS, one can find a clear description of the kind of teacher that is envisaged. The National Curriculum Statement envisions teachers who are qualified, competent, dedicated and caring and who will be able to fulfil the various roles outlined in the Norms and Standards for Educators written in the Government Gazette No 20844 (Department of Education, 2000). These see teachers as mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors and learning area/phase specialists (Department of Education, 2002a). What is significant in this regard, is that it included the seven roles of an educator of which 'teacher' is not one, but the role of the teacher as a mediator of learning is specified. What is most significant about the kind of teacher that is envisaged is that, besides the variety of life performance roles that the teacher needs to fulfil, 'teaching' as a role is nowhere to be found.

Just as a specific kind of teacher is envisaged in the RNCS, so is a certain kind of learner envisioned. It is stated in the RNCS that the promotion of values is very important (Department of Education, 2002a). In the earliest version, which was apparently sponsored by South African Institute of Distance Education (SAIDE) the following appears as an introduction under the heading of the learner that is envisaged:

> The one thing that transcends language, outward expressions of culture, physical appearance, age, sex or beliefs, are the values that give meaning to our solitary spiritual journeys and even our intellectual and imaginative excursions. The Manifesto on Values, Education and Democracy, August 2001 (pp. 9-10) states the following about education and values:
>
> Values and morality give meaning to our individual and social relationships. They are the common currencies that help make life more meaningful than might otherwise have been. An education system does not exist to simply serve a market, important as that may be for economic growth and material prosperity. Its primary purpose must be to enrich the individual, and by extension, the broader society. The kind of learner that is envisaged is one who will accordingly be imbued with the values and act in the interests of a society based on respect for democracy, equality, human dignity, and social justice (Department of Education, 2002b, p12 -13).

Only after the introduction within the later RNCS version the following appears (Department of Education, 2002a, p 3):

> The kind of learner envisaged is one who will be inspired by these values, and who will act in the interests of a society based on respect for democracy, equality, human dignity, life and social justice. The curriculum seeks to create a lifelong learner who is

> confident and independent, literate, numerate and multi-skilled, compassionate, with a respect for the environment and the ability to participate in society as a critical and active citizen.

Learning areas have now become integrated, just as the original OBE system required but never applied within the South African context (Department of Education, 2002a). The eight learning areas were reduced to only six, and the time allocation for English and mathematics was increased (Daniel et al., 2003). The RNCS focused more on the implementation of teaching, learning and assessment (DBE, 2003). Action was taken to provide a guide for teachers to develop a learning programme to assist with the absence of required content within the OBE curriculum (Department of Education, 2003). This was the construction of an NCS that had a clear structure and was conceptually coherent, promoted the values of equity and led to development of critical and creative, problem-solving learners (Mchunu & Msibi, 2013).

According to the RNCS for mathematics (Department of Education, 2002a), the following knowledge prescriptions, which is also referred to as the learning outcomes, needs to be obtained by the learner:

1. Numbers, Operations and Relationships: The learner is able to recognise, describe and represent numbers and their relationships and can count, estimate, calculate and check with competence and confidence in solving problems.
2. Patterns, Functions and Algebra: The learner is able to recognise, describe and represent patterns and relationships, and solves problems using algebraic language and skills.
3. Space and Shape: The learner is able to describe and represent characteristics and relationships between 2-D shapes and 3-D objects in a variety of orientations and positions.
4. Measurement: The learner is able to use appropriate measuring units, instruments and formulae in a variety of contexts.
5. Data Handling: The learner is able to collect, summarise, display and critically analyse data in order to draw conclusions and make predictions, and to interpret and determine chance variation (Department of Education, 2002a, p 4),

For each of the above mathematics learning outcomes/knowledge prescriptions, as it is known in the RNCS, there are applicable assessment standards for each specific grade in the specific phase. The following images has been extracted and copied from the RNCS for mathematics Intermediate phase (Grade 4-6), to illustrate how the Assessment Standards for the first learning outcome were set out for Grade 4 (Figure 2.5) as well as Grade 5 and 6 (Figure 2.6).

Grade 4

Learning Outcome 1

NUMBERS, OPERATIONS AND RELATIONSHIPS

The learner will be able to recognise, describe and represent numbers and their relationships, and to count, estimate, calculate and check with competence and confidence in solving problems.

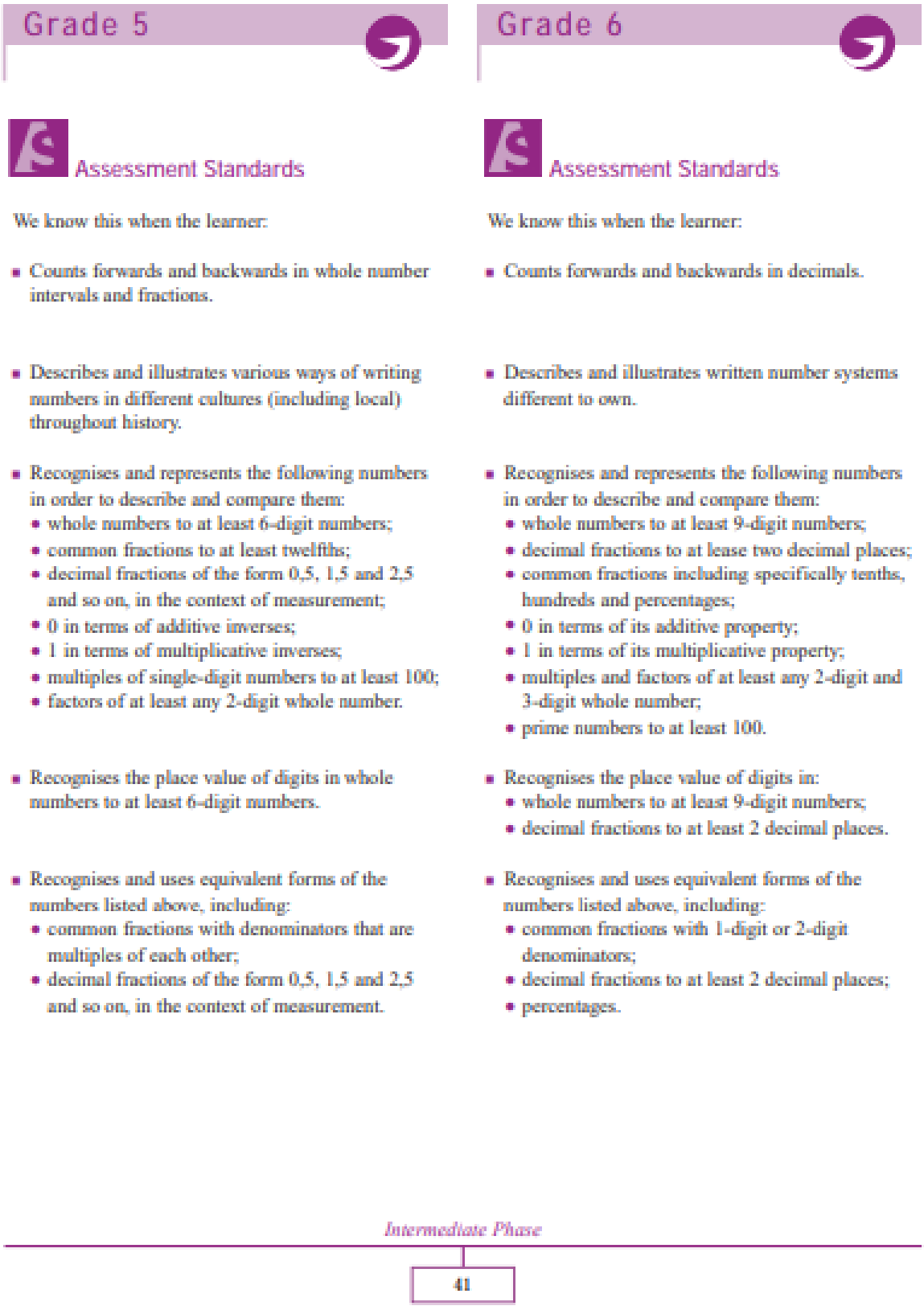
Assessment Standards

We know this when the learner:

- Counts forwards and backwards in a variety of intervals (including 2s, 3s, 5s, 10s, 25s, 50s and 100s) between 0 and at least 10 000.
- Describes and illustrates various ways of counting in different cultures (including local) throughout history.
- Recognises and represents the following numbers in order to describe and compare them:
  - whole numbers to at least 4-digit numbers;
  - common fractions with different denominators including halves, thirds, quarters, fifths, sixths, sevenths and eighths;
  - common fractions in diagrammatic form;
  - decimal fractions of the form 0,5; 1,5 and 2,5 and so on, in the context of measurement;
  - odd and even numbers to at least 1 000;
  - multiples of single-digit numbers to at least 100.
- Recognises the place value of digits in whole numbers to at least 4-digit numbers.
- Recognises and uses equivalent forms of the numbers listed above, including:
  - common fractions with denominators that are multiples of each other;
  - decimal fractions of the form 0,5, 1,5 and 2,5 and so on, in the context of measurement.

Figure 2.5: Assessment standards and learning outcome 1 for Grade 4.

(Department of Education, 2002a, p 40-41)



Grade 5

Assessment Standards

We know this when the learner:

- Counts forwards and backwards in whole number intervals and fractions.
- Describes and illustrates various ways of writing numbers in different cultures (including local) throughout history.
- Recognises and represents the following numbers in order to describe and compare them:
  - whole numbers to at least 6-digit numbers;
  - common fractions to at least twelfths;
  - decimal fractions of the form 0,5, 1,5 and 2,5 and so on, in the context of measurement;
  - 0 in terms of additive inverses;
  - 1 in terms of multiplicative inverses;
  - multiples of single-digit numbers to at least 100;
  - factors of at least any 2-digit whole number.
- Recognises the place value of digits in whole numbers to at least 6-digit numbers.
- Recognises and uses equivalent forms of the numbers listed above, including:
  - common fractions with denominators that are multiples of each other;
  - decimal fractions of the form 0,5, 1,5 and 2,5 and so on, in the context of measurement.

Grade 6

Assessment Standards

We know this when the learner:

- Counts forwards and backwards in decimals.
- Describes and illustrates written number systems different to own.
- Recognises and represents the following numbers in order to describe and compare them:
  - whole numbers to at least 9-digit numbers;
  - decimal fractions to at lease two decimal places;
  - common fractions including specifically tenths, hundreds and percentages;
  - 0 in terms of its additive property;
  - 1 in terms of its multiplicative property;
  - multiples and factors of at least any 2-digit and 3-digit whole number;
  - prime numbers to at least 100.
- Recognises the place value of digits in:
  - whole numbers to at least 9-digit numbers;
  - decimal fractions to at least 2 decimal places.
- Recognises and uses equivalent forms of the numbers listed above, including:
  - common fractions with 1-digit or 2-digit denominators;
  - decimal fractions to at least 2 decimal places;
  - percentages.

Figure 2.6: Assessment standards for learning outcome 1 for Grade 5 and 6.

(Department of Education, 2002a, p 40-41)

Together with the knowledge prescriptions and assessment standards mentioned earlier, the following skills should also be obtained by the mathematics learner: representation and interpretation, estimation, calculation, reasoning, communication, problem posing, problem solving, investigation, describing and analysing (Department of Education, 2002a, p 4).

Whereas learning outcomes represented the knowledge, and the assessment standards represented the skills to be acquired, the pace, sequence or scope of teaching and learning were not specified (OECD, 2008). However, the RNCS did provide templates with policy guidelines within which mathematics teachers were supposed to construct their own learning programmes, but these learning programmes still had to be constructed by the teachers themselves (Department of Education, 2002a). In the foreword of the Teacher's Guide for the Development of Learning Programmes document of the RNCS in 2003, Mseleku states that teachers will develop as curriculum leaders (Department of Education, 2003). He also stated his misplaced conviction that mathematics teachers had now gained enough experience, skills, knowledge and techniques from C2005 (OBE) to be able to excel in the Revised National Curriculum (Department of Education, 2003). Mathematics teachers were therefore responsible for developing their own learning programmes (OECD, 2008).

To have been provided with such a document with 120 pages for mathematics Grades 4-6 as the new curriculum, would have had even the best teachers become utterly despondent because of the inadequate way in which our OBE was constructed and hastily implemented. Over the years, changes had been made attempting to salvage whatever may be possible that finally brought the Curriculum and Assessment Policy Statements (CAPS) documents to become known as the new South African curriculum.

2.7 The Curriculum and Assessment Policy Statement for mathematics

Even after the revised version of the National Curriculum Statement (NCS) were implemented, there was still a great deal of criticism, arising especially from the link between teacher profesionalism and curriculum that had yet again been ignored (Mchunu & Msibi, 2013). Thereafter, the Minister of Education called for the end of the NCS label and introduced the CAPS curriculum, stating that it was still not a complete new curriculum. Clearly, therefore, the Minister of Education wanted to steer away from the criticism of OBE and the RNCS by introducing a modified version of the curriculum with a new name. CAPS revealed itself to be a repackaged curriculum that moved back to the traditional approaches of the education system prior to OBE, and was not as progressive as it was thought to be (Mchunu & Msibi, 2013).

The following paragraphs intend to compare the major components as they were identified in the RNCS and to make a comparison with the CAPS in terms of how these components have now been accounted for, or not, and how it may have supported teacher professionalism. Firstly, the Critical and the Development outcomes appear in the CAPS curriculum among a number of General Aims of the South African curriculum; thus these outcomes have been effectively replaced by aims. In my view, although these aims are extensive and have elements of values incorporated, they do not portray the importace of values as the RNCS used to. The emphasis on values regarding the learner that is envisaged in the RNCS, has been replaced completely with only the following as one of five elaborated general aims: *"The National Curriculum Statement Grades R-12 aims to produce learners that are able to:"* (DBE, 2011b) after which the critical and developmental outcomes, as it was written in the RNCS, is included. However a very small but significant change to the second aim/previous outcome was made: *"Work effectively with others as members of a team, group, organisation and community"* has been replaced with *"work effectively as individuals and with others as members of a team".* It may not be viewed as much but the ommision of the individual and its personal development of the highest order serves in a certain sense as a prerequisite for working effectively in a team, for the simple reason that *intrapersonal* development is fundamental to integrated holistic human development as an ontological imperative (Heidegger, 1962; Barnett, 2007). In addition to the kind of learner that is envisaged, the kind of teacher that is envisaded was also omitted.

A second comparison between the RNCS and the CAPS involves the definition of mathematics. For example, the CAPS definition (Department of Education, 2011b, p 8) states that:

> Mathematics is a language that makes use of symbols and notations to describe numerical, geometric and graphical relationships. It is a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. It helps to develop mental processes that enhance logical and critical thinking, accuracy and problem-solving that will contribute in decision-making.

The definition of mathematics in the RNCS (Department of Education, 2002a, p 7), is that it is:

> …a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. Through this process new mathematical ideas and insights are generated. Mathematics uses its own specialised language that involves symbols and notations for describing numerical, geometric and graphical relations. Mathematical concepts build on one another, thereby creating a coherent structure.

> Mathematics is a product of investigation by different cultures; it is a purposeful activity in the context of social, political and economic goals and constraints. It is not value-free or culturally-neutral.

Although the CAPS definition is more technically sound, elements of a kind of dehumanisation within it are evident, although not perhaps intentional.

Thirdly, the CAPS curriculum was intended to lessen the administration required of teachers and to ensure consistency in the quality of teaching, as it gives a more detailed guide to what and how the teachers should teach and assess (Maskew Miller Longman, 2013). Within the CAPS curriculum, it has been stipulated what the teacher should do every term in every grade (Mchunu & Msibi, 2013). This teacher accountability and control decreases the confusion as to what needs to be done (Mchunu & Msibi, 2013). In an article written by SAinfo (2015) it is claimed that CAPS successfully provide guidelines to what should be taught, with the aim of closing the gap that exists between poor and well-resourced schools. The time allocation for mathematics has increased from four and a half hours to six hours per week from the RNCS to CAPS (DBE, 2011b). However, the CAPS document does not have a certain type of teacher envisaged as does the RNCS, which could question the professionalism of the teacher required to implement the CAPS curriculum.

Besides the general aims in CAPS, specific aims (A) have replaced RNCS's purpose for learners, remaining unchanged, except for the development of awareness of historical cultural and social practices of mathematics (DBE, 2002a), which was left out in CAPS. However, CAPS provided specific skills (B) that was absent in the RNCS (DBE, 2011b, p 8-9):

A. Specific Aims

The teaching and learning of mathematics aim to develop:

- a critical awareness of how mathematical relationships are used in social, environmental, cultural and economic relations;
- confidence and competence to deal with any mathematical situation without being hindered by a fear of Mathematics
- a spirit of curiosity and a love for Mathematics
- an appreciation for the beauty and elegance of Mathematics
- recognition that Mathematics is a creative part of human activity
- deep conceptual understanding in order to make sense of Mathematics
- Acquisition of specific knowledge and skills necessary for:
  * the application of Mathematics to physical, social and mathematical problems

* the study of related subject matter (e.g. other subjects)
* further study in Mathematics.

B. Specific Skills

To develop essential mathematical skills the learner should

- develop the correct use of the language of Mathematics
- develop number vocabulary, number concept and calculation and application skills
- learn to listen, communicate, think, reason logically and apply the mathematical knowledge gained
- learn to investigate, analyse, represent and interpret information
- learn to pose and solve problems
- build an awareness of the important role that Mathematics plays in real life situations including the personal development of the learner.

Lastly, the five Learning Outcomes of the RNCS has become five content areas in the CAPS (DBE 2011b, p 11–14):

1. Numbers, operations and relationships
2. Patterns, functions and algebra
3. Space and shape (geometry)
4. Measurement
5. Data handling

The above paragraphs quite obviously indicate the content-based nature of CAPS, where each content area is divided into topics. Table 2.2 indicates that each content area contains a General Content focus as well as an Intermediate Phase specific content focus. The content for each topic for each of the Grades 4-6 is specified in Table 2.3.

The Clarification of content for each content area and each topic, specifying the concepts and skills to be acquired as well as some clarification notes or teaching guidelines for each of Grades 4-6 is shown in Table 2.4.

In addition to all these tables, mathematics time allocations for each topic per term for Grade 6 is provided in Table 2.5 and gives a complete summary of the year, which was not present in the RNCS, making the CAPS document more user friendly.

Table 2.2: CAPS content knowledge.

MATHEMATICS CONTENT KNOWLEDGE		
Content area	**General content focus**	**Intermediate Phase specific content focus**
Numbers, Operations and Relationships	Development of number sense that includes: • the meaning of different kinds of numbers • relationship between different kinds of numbers • the relative size of different numbers • representation of numbers in various ways • the effect of operating with numbers • the ability to estimate and check solutions.	• The range of numbers developed by the end of the Intermediate Phase is extended to at least 9-digit whole numbers, decimal fractions to at least 2 decimal places, common fractions and fractions written in percentage form. • In this phase, the learner is expected to move from counting reliably to calculating fluently in all four operations. The learner should be encouraged to memorise with understanding ,multiply fluently, and sharpen mental calculation skills. • Attention needs to be focused on understanding the concept of place value so that the learner develops a sense of large numbers and decimal fractions. • The learner should recognize and describe properties of numbers and operations, including identity properties, factors, multiples, and commutative, associative and distributive properties.
Patterns, Functions and Algebra	Algebra is the language for investigating and communicating most of Mathematics and can be extended to the study of functions and other relationships between variables. A central part of this content area is for the learner to achieve efficient manipulative skills in the use of algebra. It also focuses on the: • description of patterns and relationships through the use of symbolic expressions, graphs and tables • identification and analysis of regularities and change in patterns, and relationships that enable learners to make predictions and solve problems.	• Numeric and geometric patterns are extended with a special focus on the relationships: - between terms in a sequence - between the number of the term (its place in the sequence) and the term itself. • The study of numeric and geometric patterns develops the concepts of variables, relationships and functions. The understanding of these relationships will enable learners to describe the rules generating the patterns. • This phase has a particular focus on the use of different, yet equivalent, representations to describe problems or relationships by means of flow diagrams, tables, number sentences or verbally.
Space and Shape (Geometry)	The study of Space and Shape improves understanding and appreciation of the pattern, precision, achievement and beauty in natural and cultural forms. It focuses on the properties, relationships, orientations, positions and transformations of two-dimensional shapes and three-dimensional objects.	• The learner's experience of space and shape in this phase moves from recognition and simple description to classification and more detailed description of characteristics and properties of two-dimensional shapes and three-dimensional objects. • Learners should be given opportunities to: - draw two-dimensional shapes and make models of three-dimensional objects - describe location, transformations and symmetry.

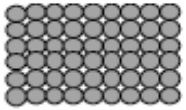
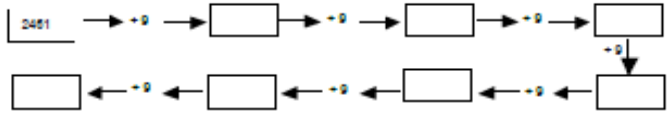
(DBE, 2011b, p 10 - 11)

Table 2.3: Specification of content (Phase overview)

SPECIFICATION OF CONTENT (PHASE OVERVIEW) NUMBERS, OPERATIONS AND RELATIONSHIPS			
• The main progression in Numbers, Operations and Relationships happens in three ways: - the number range increases - different kinds of numbers are introduced - the calculation techniques change. • The number range for doing calculations is different from the number range for ordering numbers and for finding multiples and factors. • As the number range for doing calculations increases up to Grade 6, learners should develop more efficient techniques for calculations, including using columns and learning how to use the calculator. These techniques however should only be introduced and encouraged once learners have an adequate sense of place value and understanding of the properties of numbers and operations. • Contextual problems should consider the number range for the grade as well as the calculation competencies of learners. • Contexts for solving problems should build awareness of other subject and content areas, as well as social, economic and environmental issues.			
TOPICS	**GRADE 4**	**GRADE 5**	**GRADE 6**
1.1 **Whole numbers**	**Mental calculations involving**: • Addition and subtraction of: - units - multiples of 10 - multiples of 100 - multiples of 1 000 • Multiplication of whole numbers to at least 10 x 10 • Multiplication facts of: - units by multiples of 10 - Units by multiples of 100	**Mental calculations involving**: • Addition and subtraction of: - units - multiples of 10 - multiples of 100 - multiples of 1 000 • Multiplication of whole numbers to at least 10 x 10 • Multiplication facts of: - units by multiples of 10 - units by multiples of 100 - units by multiples of 1 000 - units by multiples of 10 000	**Mental calculations involving**: • Addition and subtraction of: - units - multiples of 10 - multiples of 100 - multiples of 1 000 • Multiplication of whole numbers to at least 12 x 12 • Multiplication facts of: - units and tens by multiples of 10 - units and tens by multiples of 100 - units and tens by multiples of 1 000 - units and tens by multiples of 10 000

(DBE, 2011b, p 13)

Table 2.4: Clarification content for Grade 6.

CONTENT AREA	TOPICS	CONCEPTS AND SKILLS	SOME CLARIFICATION NOTES OR TEACHING GUIDELINES	DURATION (in hours)
NUMBERS, OPERATIONS AND RELATIONSHIPS	**1.1 Whole numbers** Counting, ordering, representing and place value of digits	**Number range for counting, ordering and representing, and place value of digits** • Order, compare and represent numbers up to at least 9-digit numbers • Represent prime numbers to at least 100 • Recognize the place value of digits in whole numbers to at least 9-digit numbers • Round off to the nearest 5, 10, 100 and 1 000	Although counting in whole numbers is not specified in Grade 6, learners should be proficient in the Grade 5 level of counting. In Term 1, learners should revise and consolidate work done in Grade 5 **Counting** Counting should not only be thought of as verbal counting. Learners should count using apparatus such as • counters • counting beads • number grids • structured, semi-structured and empty number lines • pictures of objects, especially pictures of large numbers of objects that are presented in a grouped or structured way. An example of a picture of objects suitable for counting is provided at the end of the Grade 5 section of Numbers, Operations and Relationships. • arrays or diagrams of arrays e.g.  • other diagrams for counting e.g.  Counting should not always start with the first multiple. Nor should it always start on any other multiple e.g. counting in 25s can start from 27 or 113 , counting in 9's can start from 2 641 or from 38 **Place value**(number range 0 to 999999) Learners should be able to break up numbers into hundreds, tens and units using • the number names (number words) • place value or flash cards • expanded notation Recommended apparatus: place value, flash cards, Dienes blocks	**2 hours**

(DBE, 2011b, p 215)

Table 2.5: Mathematics time allocations per topic.

TIME ALLOCATION PER TOPIC: GRADE 6							
Term 1		**Term 2**		**Term 3**		**Term 4**	
Topic	**Time**	**Topic**	**Time**	**Topic**	**Time**	**Topic**	**Time**
Mental Mathematics (10 minutes daily)	**8 hours**	Mental Mathematics (10 minutes daily)	**7 hours**	Mental Mathematics (10 minutes daily)	**8 hours**	Mental Mathematics (10 minutes daily)	**7hours**
Whole numbers: counting, ordering, comparing, representing and place value (6-digit numbers)	**2 hours**	Whole numbers: counting, ordering, comparing, representing and place value (9-digit numbers)	**1 hour**	Mass	**5 hours**	Whole numbers: Counting, ordering, comparing, representing and place value (9-digit numbers)	**1 hour**
Number sentences	**3 hours**	Whole numbers: multiplication (4-digit by 2- digit)	**5 hours**	Whole numbers: counting, ordering, comparing, representing and place value (9-digit numbers)	**1 hour**	Whole numbers: Multiplication (4-digit by 3-digit)	**5 hours**
Whole numbers: addition and subtraction (5-digit numbers)	**7 hours**	Properties of 3-D objects	**5 hours**	Whole numbers: addition and subtraction (6-digit numbers)	**8 hours**	Common fractions	**5 hours**
Common fractions	**10 hours**	Geometric patterns	**6 hours**	Viewing objects	**3 hours**	Properties of 3-D objects	**5 hours**
Time	**4 hours**	Symmetry	**2 hours**	Properties of 2-D shapes	**4 hours**	Area, perimeter & volume	**7 hours**
Properties of 2-D shapes	**8 hours**	Whole numbers: division (4-digit by 2-digit)	**8 hours**	Transformations	**3 hours**	History	**1 hour**
Data handling	**10 hours**	Decimal fractions	**10 hours**	Temperature	**1 hour**	Whole numbers: Division (4-digit by 3-digit)	**7 hours**
Numeric patterns	**4 hours**	Capacity/volume	**5 hours**	Percentages	**5 hours**	Number sentences	**3 hours**
				Data handling	**9 hours**	Transformations	**3 hours**
				Numeric patterns	**5 hours**	Position and movement	**2 hours**
				Length	**5 hours**	Probability	**2 hours**
Revision	**4 hours**	Revision	**5 hours**	Revision	**3 hours**	Revision	**6 hours**
		Assessment (all subjects)	**6 hours**			Assessment (all subjects)	**6 hours**
TOTAL: 60 HOURS		**TOTAL: 60 HOURS**		**TOTAL: 60 HOURS**		**TOTAL: 60 HOURS**	

(DBE, 2011b, p 212)

According to Louw and colleagues (2013) the same inadequate teacher training was given with the introduction of CAPS into the South African education system. There was an enormous gap between the "what" should be known and the "why and how" it should be taught. This gave the impression of a curriculum that has reverted to be a full-blown content curriculum, which questioned the value of such a curriculum in the 21st century to the fore. Louw et al. (2013) further revealed that adequate assessment training and departmental support were not given to support the implementation of CAPS, nor were there adequate teacher and learning support materials and resources and overcrowded classes added to the problems.

Focusing on the content in the CAPS may be very beneficial and the indications of teaching time required may be very useful. However, the pacers and curriculum trackers require that, at any particular day, every learner in every school, in every grade in South Africa has to be on the same page in the curriculum. This is expected, despite the curriculum documents stating that a slight deviation was allowed and despite teaching guidelines being available. In practice, and to my view, with such a tight and voluminous curriculum, my focus as a teacher (as is the focus of most teachers I encounter) is to use whatever is provided and adhere to all requirements without exception; this approach may be the safest way to attempt to cover the curriculum. Muller (2016) states that the strict adherence to the fast-paced content packed curriculum, leaves a backlog in learners, leaving no time for teachers to address these backlogs. This contradicts the National Policy Pertaining to the Promotion Requirements, which emphasizes learning to be tailored to address learner barriers and backlogs (Muller, 2016) by professionally interpreting the curriculum. The overwhelmingly prescriptive and regimented curriculum also allows little space for professionalism, which most probably is why so many teachers have failed their learners.

2.8 Importance of mathematics education

Mathematics is thought to be related to things in everyday life, providing us with basic life skills and processes to become productive citizens in a society (Ajagbe et al., 2012). The advancement of the human environment in early days lead to unforseen contingencies, which caused new problems and created an urgency to formulate new and alternative methods to find solutions for these unpredictable problems, which ultimately lead to the existence of mathematics as becoming the answer to these problems (Ajagbe et al., 2012). According to Charles and Lester (1984), mathematics is now an essential part of almost any profession.

The traditional teaching of mathematics is based on learning theory with facts and concepts, with the understanding of mathematics being only the absorption of content by means of teacher explanations and textbooks (Ajagbe et al., 2012). However, it seems that the traditional way of teaching in the 21st century is longer sufficient: *"The content of mathematics curriculum must focus on ways to equip students with an ability to learn things that no one yet knows; such focus implies a different role for mathematics teachers"* (Ajagbe et al., 2012, p 477). According to Arends and colleagues (2017), the practices that teachers use within their classrooms plays a critical role in learners' understanding of, and performance in, mathematics. In the following paragraphs, the use of problem-based learning and use of technology in mathematics in primary education will be discussed.

2.8.1 Problem based learning in mathematics education

A lot of attention has been given to problem based learning in mathematics education as it is said to encompass skills and functions needed for daily life and assists in adapting to changes not only in people's careers, but also in their personal lives (Ajagbe, 2012). According to Ajagbe et al., (2012, p 477) the main purpose in mathematics teaching and learning should be to: *"…develop the ability to solve a wide variety of complex mathematics problems."* as problem solving is important to develop mathematical and analytical knowledge. In a study by Misfeldt and Zacho (2015), teachers were inclined to use scenario design to introduce technology within their primary teaching. The scenario teaching seems to reconcile the use of technology and the teaching plan. However, it seems that the problems / scenarios teachers use within the classroom are not equally complex as the problems that students encounter in their daily lives (Ajagbe et al., 2012). *"Real-life problems are messier and more complicated, with a number of viable routes providing alternative solutions"* (Ajagbe et al., 2012, p 476). Problem solving should not be the recall of well-learned procedures or facts (Charles & Lester, 1984). However, problem solving in mathematics education should be a process in which learners find the solution useful in their daily lives, by means of developing skills to be able to manage situations that may be challenging and unpredictable (Ajagbe et al., 2012).

2.8.2 Use of Technology in mathematics education

Different countries try to approach mathematics to adapt to the world of work in the 21st century. According to Niess (2005) the use of technology within the teaching of mathematics is important to enable and enhance communication, research, decision making, problem solving and the understanding as well as appreciation for mathematics in students. Digital education also allows teaching to transform from traditional approach to one that is more based on problem-solving (Attard, 2017). For example, Jurak (2004) studied the impact of computers as a facilitator of problem solving in mathematics and found that its use can bridge

the gap between abstract mathematics and real-life problem solving. However, Attard (2017) was of the opinion that technology should not be the only resource used by the teacher and that a balance was very important.

In Denmark, the use of technology within the teaching of mathematics have become an increasing obligation, together with an increased pressure to enhance creativity, innovation and collaboration (Misfeldt & Zacho, 2015). Although the use of computer algebra, spreadsheets and dynamic geometry within the teaching of mathematics is becoming very popular, it may become problematic in the organisation of schools, non-proficiency of teachers, unavailable technological resources and resistance to change (Misfeldt & Zacho, 2015). For digital teaching to be successful, the school's infrastructure should be in place. Barriers such as outdated technology, the cost of technology in the school, the lack of a network infrastructure and limited time paired with an unstable connection can hamper the successful use of digital learning (Delorme, 2016). Therefore, there is a lot of controversial research on the application of using technology within the teaching of mathematics.

In the current study, although I take note of the above benefits, the research premises of my study does not have this digital infratructure. My study focuses on the pedagogy of facilitating learning, which will not be affected by the inclusion or exclusion of digital teaching, thus the consideration of digital use is irrelevant in this study.

2.9 Primary school mathematics in South Africa

Though South Africa has made progress in attempting to secure access to all learners in primary schools, the quality of teaching received has not yet improved (Arends et al., 2017). Therefore, a lot of focus has been placed, recently, on the quality improvement in education and the influence of the teacher's practices on learner performances (Arends et al., 2017). It has also been stated by Dunne and Long (2014) that the teacher's view and approach of teaching mathematics often are reflected, and it is recommended that teachers should engage with different views and approaches, by means of professional development, in order to improve their understanding and reflect on their own teaching and learning.

In South Africa, it seems that teachers with a higher level of pedagogical knowledge are more likely to teach in wealthier schools (Arends et al., 2017), which results in a major gap in the quality of education between wealthier schools and the less wealthy governmental schools. It is unlikely to describe the impact of teacher practices on mathematics teaching in South Africa, without taking the dual system of fee-paying schools versus no-fee paying schools into

account (Arends et al., 2017). Diverse teaching methods and financial constraints in South Africa complicates, and limits, education quality and consistent implementation of the curriculum within mathematics. Thus, teachers need to improve their understanding of mathematics pedagogy and engage in different approaches, as emphasized by Dunne and Long (2014).

There appear to be different approaches within the teaching of mathematics (Dunne & Long, 2014). CAPS seem to follow a topic approach, as it includes week-by-week and hourly prescriptions (Long & Dunne, 2014), which ensures that the curriculum will be covered in a progressive manner. However, the curriculum designers might assume that the topic-based curriculum does not need advanced mathematical knowledge (Long & Dunne, 2014). A crucial aspect, as Muller (2016) states, is that primary school teachers are being trained as generalists in the field of mathematics teaching, but the mathematics specialists are being appointed in high schools, despite the backlog already starting at primary level. We therefore need to address the differences in training teachers for primary versus secondary schools. We need to train primary teachers to become specialists.

Another approach to teaching mathematics in South Africa, as it was identified in the C2005, is the process approach that focuses on problem solving and the thought process of learners, enhancing learners' discovery of new learning (Long & Dunne, 2014). However, the teacher also needs advanced mathematical understanding and requires an extensive and higher degree of planning (Long & Dunne, 2014). A third approach is the conceptual field approach, where a single concept may be applied to more than one situation and may be applied in conjunction with other concepts, highlighting that related concepts do not develop in isolation (Long & Dunne, 2014). For the conceptual field approach, teachers also need to become specialists.

However, Long and Dunne (2014) argues that, no matter the approach of teaching, the extended subject knowledge of the teacher, supported by the theory of conceptual fields, is what is essential in the teaching of mathematics in South Africa.

2.10 Beyond content in the curriculum for mathematics

When the progression in the curriculum development over the years in South Africa is analysed in terms of the general aims, it could be described as comprehensive in depth, scope and quality and is not only comparable to the best in the world, but may even be surpassing it in some instances and to a certain extent. Interestingly, it is the very earliest general aim of

the 2005/OBE Curriculum within the RNCS of 1997 - about the learner that is envisaged - that is immediately captivating in its inspiration and so encompassing that there is little in all the other general aims and principals of the subsequent mathematics curricula that are not explicitly or implicitly incorporated in that one statement. Most outstanding, about the learner that is envisioned, is not only the presence of values but placing it at the centre of what education is all about. However, in the consecutive curriculum changes, the mention of values diminished to one or two inconspicuous appearances.

Besides the increasing ignorance regarding values in the kind of learner that is envisaged, the values of the teacher that is envisaged could also not earn its own identification. This recognisable tendency of increasing value ignorance has far reaching consequences for education, as stated by Claxton (2012 p 1):

> We live in a morally bashful age. Perish the thought that anyone might try to impose their values on anyone else. Trying to 'adopt the moral high ground' sounds, to modern ears, arrogant or hubristic. You risk becoming a figure of fun, like a Speakers' Corner tub-thumper. Education colludes with this squeamishness by pretending that the only serious questions it faces are technical ones, such as how are we going to raise standards? Or what are the most appropriate methods for testing students, and when, and how much? And should we have an 'English Baccalaureate', or a six-term year? But this coyness is both weaselly and pusillanimous. Education is essentially a moral enterprise. Whether overtly or covertly, every aspect of a school system is riddled with value judgements about what is worth knowing, and what kinds of young people we are trying to turn out.

One example of ignoring the aim of attaining values, is the way in which it has become easy to manipulate the mathematics pass rate by encouraging learners to take easier subjects, as this may increase the pass rate (Spaull, 2013). It is estimated that the amount of South African learners choosing mathematics as a subject dropped from 56% to 48% between 2008 and 2011. Instead, learners are taking Mathematics Literacy as it is a much less demanding subject (Spaull, 2013). This means that fewer learners are choosing subjects that will address any of South Africa's critical skills shortages (BusinessTech, 2015b). This once again emphasises that the focus is on quantity and not quality education within South Africa. In addition to this, almost 50% of learners drop out of school before matriculating, with only 40% passing and 12% qualifying for university, even though the passing requirements are already substandard (Spaull, 2013).

The Democratic Alliance noted that 28% of learners who wrote matric in 2014 failed any form of numeracy assessment (this included both mathematics and Mathematics Literacy) and 70% of all the matric learners achieved under 50% for these numeracy assessments (BusinessTech, 2015b): this statistic paints a very pessimistic picture of South African education. After the first OBE matriculants wrote their first test at tertiary level, it was very clear that students did not have the conceptual understanding of the fundamental concepts that are to be expected from a first-year student (Louw et al., 2013). Yet the response to these results does not seem to be the focus of teaching practices in a regimented presribed curriculum. This speaks of a persistent reflection on failing to address the real issue of today's education, which is stated to be the lack of teacher professionalism (Mchunu & Msibi, 2013).

The Department of Education tried to respond to the criticism to some extent. One of the major complaints from teachers in coping with a work overload and oversized classrooms, only resulted in compensated by means of a new salary scale. The Department of education also introduced and implemented an Integrated Quality Management System (IQMS) to regulate professional development opportunities (OECD, 2008). The concept behind the IQMS system was that the performance of teachers would be evaluated and improved by guidance from the teachers' superiors within the school, holding teachers accountable for the performance of learners, especially considering the low performance results of matriculants (Mosogo & Pilane, 2014). According to Mosogo and Pilane (2014), the implementation of the IQMS was distorted, with teacher development still not enjoying the priority that it should have. It is generally thought that when a country lowers its expectations of learners and inhibits the professionalism of teachers, it could change schools into factories (Mchunu & Msibi, 2013). In these factories, a curriculum is used as a manual by the workers (the teachers) to produce a certain product (the learners), which is currently one of the big issues that needs to be addressed in South Africa's education system (Mchunu & Msibi, 2013).

With the world constantly changing, South Africa realised that it needs to produce effective, adaptive and creative people and that having a national education and training system, which responds to these rapid changes and encourages life-long learning, is a matter of high necessity (SAQA, 2014). This realisation by the government gave rise to the shift from education for employment to education for employability, which aimed at providing learners with the ability to adapt to different careers (SAQA, 2014). Higgs's (2008) view on education is that it is not a social science but rather a human science. Higgs reported the following: *"The dominant discourse in education has been concerned with social and cultural values and not primarily with human values."* (Higgs 2008, p. 452). He also states that education should be *"…an open critical educational philosophy focusing on individual commonly human values*

such as dignity, freedom and self-determination." (Higgs 2008, p 451). The statements of Higgs (2008) complement my study of focusing on human values, and not only on knowledge and skills.

It is, however, not easy to improve human qualities within South African schools if there are still immoral behaviours – even from those in charge of the management of education who needs to make the moral decisions about what is valuable. Louw et al. (2013) mentioned that Grade 12 results have been skewed to create a false impression of successful growth. Sadly, incidents of corruption and fraud on the part of those who govern our education system, continuously rise to the surface: the fraudulent awarding of tenders and the textbook crisis in Limpopo province are only a few examples (Louw et al., 2013). To counteract these unacceptable trends, South Africa has introduced a National Development Plan (NDP) which aims to potentially eliminate poverty and reduce inequality by 2030, by improving the quality of public services (South African Government, 2016). The proposal is called Vision 2030, and states that the NDP wants to develop a united society led by humanity and integrity (Partners For Possibility, 2016). The focus of this proposal is on the development of active citizenship, leadership and effective government. Apart from the efforts made by the DBE, there are a couple of non-governmental and community-based projects that provide a variety of developmental programmes for teachers (SACE, 2011).

The Partners For Possibility programme was launched in 2010 in Cape Town and is only one example of many, of a business leader, Louise van Rhyn who partnered with a school principal in an attempt to improve the school's education outcome and to strive towards quality education for all children by 2025 (Partners For Possibility, 2016). A cycle for developments was initiated where principals and business leaders work together for this united society, and working towards quality education for all by the year 2025 (Partners For Possibility, 2016). The development cycle (Figure 2.7) has its roots in the *Action Plan to 2014: Towards the Realisation of Schooling 2025* (DBE 2011a, p 1). Within this document, plans were made to strengthen relationships between schools and society.

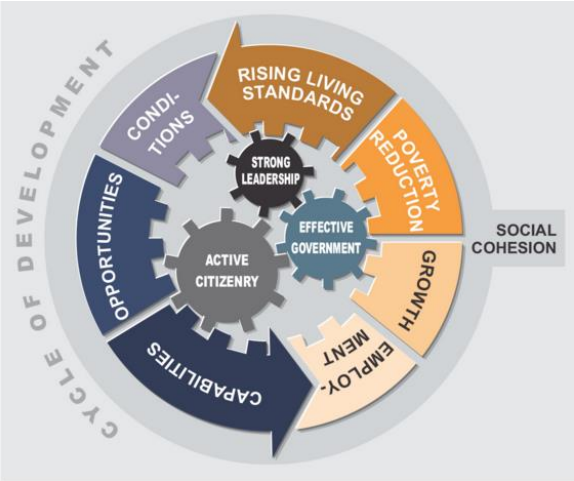


Figure 2.7: Development cycle of learners.
(Partners For Possibility 2016, para. 4)

The Action Plan to 2014 revealed that the skills shortage in South Africa is due to the low number of learners that qualify for Bachelor's studies (DBE, 2011a). For example, in SA, there is a great shortage of learners with a pass in mathematics, which creates big obstacles when it comes to the solving of shortcomings in medicine, engineering and financial analysis (DBE, 2011a). This Action Plan to 2014 also revealed that only a third of teachers had recently received formal in-service training, with access to relevant training courses being inadequate (DBE, 2011a). The 2014 Action Plan has now been replaced by the Action Plan to 2019, Towards the Realisation of Schooling 2030, shifting the focus to the preparation of youth for the world of work and life after school (DBE, 2015).

2.11 How do other countries cope with curriculum challenges?

Due to the major change in way of life within society, many countries are adapting their curricula to cater for a society that now requires more creativity, communication, application and cooperation (Cao et al., 2016). In 2015, the top five countries in mathematics and science were Asian countries and at the bottom were the more Western-oriented countries such as South Africa and Ghana (Coughlan, 2015). The following paragraphs will reveal what some of these top countries, such as China and Singapore in particular, have incorporated in their education system, to make it such a success.

2.11.1 China

The approach to mathematics teaching in China requires teachers to act as guides and organisers, with the learners being at the centre of the activities (Cao et al., 2016). An article published by the British Broadcasting Corporation (BBC) claims that Asian classrooms are focused and coherent, as the teacher expects each learner to succeed: this attracts very

talented teachers, and increases the quality of their teaching (Coughlan, 2015). Another educational goal is student participation: this has been proved to improve achievement, with many studies indicating that participation in Eastern schools is based on the behavioural level and not the cognitive level (Cao et al., 2016). China has gone so far as to include learner participation as one of their goals, as active participation means that higher-level thinking is taking place (Cao et al., 2016).

Furthermore, in China, the Dao Jiang Ping (DJP) model is being followed in teaching mathematics (Cao et al., 2016). It is argued that learners should explain concepts and solutions in front of the classroom, enhancing higher-order thinking and helping learners to understand concepts better (Cao et al., 2016). This falls into the category of "knowing what to do when you don't know what to do". The DJP model stands for three characters: Dao, refers to self-study, before the teacher teaches a concept; Jiang, refers to student teach, where students act as the teacher in front of the class; and Ping, refers to comments from peers. Thus, the model improves the learners' learning abilities by using a self-study, teaching and peer comment approach, with the teacher only guiding the process (Cao et al., 2016). In this model, where passive participation of learners and rote learning of controlling teachers no longer is an option (Cao et al., 2016), a more transcending paradigm of learning is produced. The teachers are all adequately trained to use the DJP model (Cao et al., 2016), which is another necessary advantage.

On the other hand, Singapore works with fewer topics within their curriculum, but they deal with these topics in depth, where learners not only learn how to do mathematics but also understand how mathematics works (Keierleber, 2015).

2.11.2 The Singapore mathematics curriculum

According to Speiser (2015), Singapore is the world's number one country when it comes to mathematics and science. Singapore also has 15-year-olds who are best at solving unstructured problems within contexts that they are not familiar with (Keierleber, 2015). The Ministry of Education of Singapore (2013) claims that mathematics is the most important and fundamental element of all education systems for countries that want to prepare their learners for the 21st century.

The important skills needed in the 21st century, according to the Ministry of Education Singapore (2013), should include measuring, calculating and statistical analysis by means of creative, critical, abstract and logical thinking. Singapore's curriculum focuses on hands-on group activities, moving towards visual presentations and then to abstract equations

(Keierleber, 2015). Instead of revisiting existing knowledge, the Singapore curriculum focuses only on building the next skill (Keierleber, 2015). It is said by the Ministry of Education of Singapore (2013) that different pathways to mathematical concepts must be catered for within the curriculum as not all learners are on the same level, taking the new generation of learners into consideration.

Singapore has also shifted its focus from knowledge, to the skills and competencies needed for the 21st century, giving more importance to the process of learning than to what is taught and learnt (Ministry of Education Singapore, 2013). Thus, the Singapore mathematics curriculum is focused on problem solving (Keierleber, 2015). Singapore also emphasises the importance of curriculum implementation and encourages teachers to believe in the value of the curriculum changes, which are essential to ensure the quality of a curriculum (Ministry of Education Singapore, 2013). Moreover, the Ministry of Education of Singapore believes that the mastery of mathematics, supporting learners in their lives, is the overarching goal of education, with learners who have higher ability being allowed to pursue mathematics at the highest possible level. Thus, mathematics should enable learners to understand mathematical concepts and skills, to develop positive attitudes towards mathematics and to develop cognitive and metacognitive skills by solving problems (Ministry of Education Singapore, 2013).

Keierleber (2015) argues that the approach to mathematics should not be whether learners are born with the ability to do mathematics, but rather that it is the invested effort that makes them more competent in mathematics. Singapore's mathematics curriculum has a very relevant mathematical framework which sets the direction for teaching, learning and assessment regarding problem solving on all mathematical levels; these levels also reflect the competencies necessary for the 21st century (Ministry of Education Singapore, 2013). In Singapore's education framework (Figure 2.8), application and modelling connect mathematics, which learners have learnt with their experiences in real life, to enhance their understanding of these mathematical concepts (Ministry of Education Singapore, 2013).

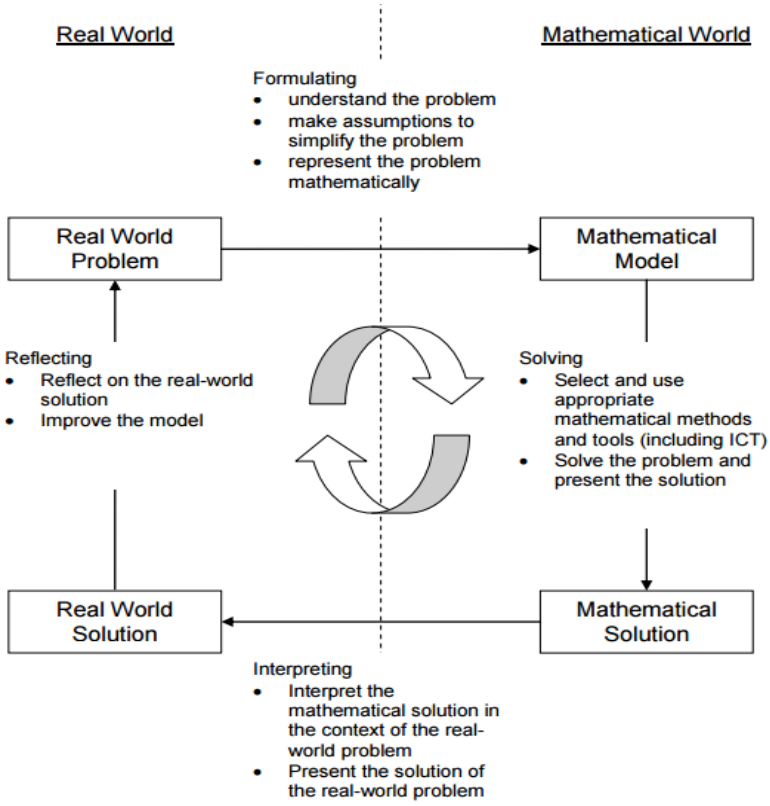


Figure 2.8: Education framework of Singapore.

(Ministry of Education Singapore 2013, p 14)

It is argued that learners learn to make connections, apply appropriate mathematical skills and concepts and reflect on the solutions to real-life problems (Figure 2.9) to make informed decisions (Ministry of Education Singapore, 2013). Mathematical modelling can therefore be defined as a cognitively demanding activity that formalises an image of the real world, interpreting mathematical results within this real-world image (Blum, 2012).

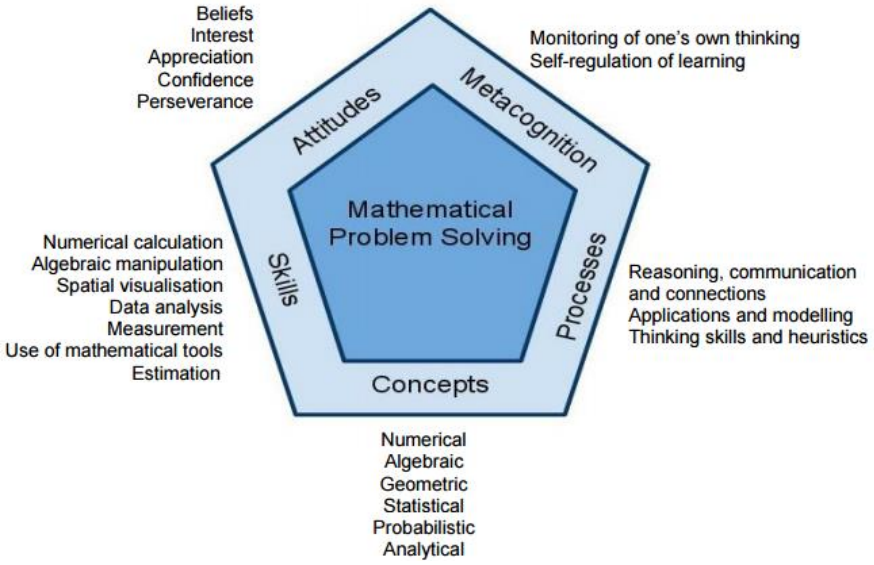


Figure 2.9: Illustration of mathematics and problem solving.
(Ministry of Education Singapore, 2013, p 16)

There appears to be three teaching principles: *"teaching is for learning, learning is for understanding ... ultimately for problem solving."* (Ministry of Education Singapore, 2013, p 21). Teachers should therefore build on the knowledge of learners, and teaching should emphasise 21st century competencies by connecting learning to real-life situations. According to the Singapore mathematics syllabus, there are three phases of learning which can be described as readiness and prior knowledge, engagement in real life activities and mastery of learning, where consolidation takes place (Ministry of Education Singapore, 2013).

2.12 What is pivotal to mathematics education in the 21st century?

What is becoming increasingly evident is that human dispositions and qualities are the keys to 21st century education. In fact, Barnett (2007) states that *"…dispositions and qualities are durable in their nature. They constitute the student's pedagogical being. It is they that have to be the focus of 'teaching'"* (Barnett, 2007, p 101). According to Facer (2011), the accumulation of certificates and examinations are no longer adequate for the preparation of our students for the future; learning should rather focus on students' response to future environmental challenges. In agreement with the views of Barnett (2007) and Facer (2011), human dispositions and qualities should also be the focus of education in SA, because:

> Through their disposition and their qualities, students have the capacities to acquire both knowledge and skills … Without dispositions and qualities, nothing else of any substance is possible: Learning is not possible, the acquisition of skills is not possible, and nor is any independence of action or thought possible (Barnett, 2007, p 101).

Education seems to be about finding oneself, instead of finding things (Purpel & McLauren, 2004). It has also been stated that the activation and development of every person, by following the holistic approach, should be the primary purpose of education (Slabbert et al., 2009). Taking these views into consideration, it is clear why Slabbert and colleagues (2009) highlighted that ethical practice in the sense of using a person's potential, together with a code of values that portray the acquired character, would always be required to maximise human potential. These values are human virtues one acquires to become and be fully human, that defines human excellence, which has to be acquired through real life experiences, as it cannot be taught or learned (Slabbert et al., 2009).

The above values can be referred to as fundamental human virtues. They are derived from Aristotle's virtues and Heidegger's (1962) authenticity. Slabbert et al. (2009) have identified a number of fundamental human virtues (see Table 2.6) as they pertain to education as reminder that they are ethical competences of moral excellence. There are two types of fundamental human virtues. The first is intrapersonal which can only authentically be required individually by working alone through meta-learning (Mohanan, 2005). The second is Interpersonal human virtues, which indicated that they are authentically required through working in small groups through cooperative learning (Jacobs et al., 2002).

> A virtue is an ethical competence of moral excellence. What is vital, though, is the way in which they are attained. According to Hursthouse (2013) the key to attaining virtues and exhibiting *phronesis* (practical wisdom) to achieve *eudaimonia* (human flourishing or prosperity) is that *"…it characteristically comes only with experience of life"* (Hursthouse, 2013, para 8). That is why learning through being challenged by demanding authentic real-life experiences are vital to an education that is worth its name. In fact, Facer (2011) suggests that educators should support learners to understand, know and become themselves. According to Davis and Gardner (2012), learners should experience the meaning of caring for something bigger than themselves when the teacher is set on nurturing the ethical minds of the learners by setting a trusting tone for social interactions. Teachers should challenge learners to *be* the future that they want instead of accepting the future they are given (Facer, 2011).

Table 2.6: Fundamental human virtues.

Intrapersonal	**Interpersonal**
Self-confidence (I can)	**Humanisation** (How I see you)
Motivation (I want)	**Communication** (How I interact with you)
Initiative (I start)	**Dealing with feelings** (How I react to you)
Effort (I work hard)	**Justice and forgiveness** (How I want you to react to me)
Perseverance (I finish)	**Love** (How do I care for you)
Common sense (I decide)	**Leadership** (How I lead you to utilise your maximum potential)
Responsibility (I do the right thing and accept the consequences)	
Independence (I do it myself)	
Curiosity	
Joy (I am joyous)	
Love	

(Slabbert, et al., 2009, CD-ROM, p 90-92, 107-109)

Davis and Gardner (2012) argue that there are five "minds" that need to be developed for learners to be good workers and citizens within the ever-changing society of the 21st century. According to Davis and Gardner (2012), a good worker is an experienced engager and deliverer of quality work, done in an ethical manner. The first of the five minds that Davis and Gardner (2012) identified is the disciplined mind, which is the different ways of thinking with which people approach their work (Gardner, 2008). The second mind is the synthesising mind, where one needs to think about one's thinking by judging information to make it meaningful to oneself (Davis & Gardner, 2012). The third mind is the creating mind, which is where one uses existing knowledge to produce new knowledge by thinking out of the box (Davis & Gardner, 2012). The fourth mind is the respectful mind (Davis & Gardner, 2012), since emotional and interpersonal intelligence is needed to respond to the motivations of others with tolerance. The respectful mind is said to be easy to explain, but very complex and difficult to achieve (Gardner, 2008). The fifth mind (i.e., the mind of the future) is the ethical mind, which one would need to consider one's rights and responsibilities as a worker and citizen (Davis and Gardner, 2012). The above moral character described by Davis and Gardner, is said to activate the creative wisdom needed in the power and freedom of choice. *"Having the moral authority of creative wisdom in making choices, provides the challenge and opportunity to maximise human potential…to create a safe, sustainable and prosperous future for all"* (Slabbert et al., 2009, p 93). The above five minds of the future therefore go hand in hand with the fundamental human virtues (Table 2.6) in the pursuit of finding oneself.

I therefore conclude this section with the following quotation by Magrini (2011, p 1):

> Due to the depersonalization and alienation occurring in contemporary education … education has lost sight of and is moving further away from what it means to be truly human. That is, both students and educators are estranged from their authentic phenomenological sense of self-hood … For the sake of education's potential reform, once made philosophically aware of this condition, educators should seek a return for appropriation to this forgotten understanding of what it means to be human and which is, in the first instance, always and already a primordial way of Being-in-the-world in which life unfolds as an original 'educative' process.

Together with the above, the skills from the Partnership for 21st Century Learning framework, as mentioned earlier in chapter 1, will also need to be taken into consideration when one is working with the learner holistically.

2.13 Theoretical framework for the study

What has become increasingly evident in the realm of educational transformation is that large scale curriculum research and development did not necessarily bring improvements. According to Kemmis et al. (2019, p 181) *"…it would require teacher research – local research by researchers into their own practices – to achieve lasting improvements in the quality of education."* The preceding quotation from Magrini (2011) reflects the essence of what education means and this is articulated in terms of our educational task in the following way: ***"****Our educational responsibility is, in principal, not an epistemological task of the acquisition of knowledge and skills, but it is, primarily, an ontological challenge of the transformation of the human being - nothing less"* (Barnett, 2004, p 256). Barnett (2004, p 252, 260) explains further: *"This kind of education: calls for a transformatory curriculum and pedagogy which are themselves understood to be practiced as endeavours of high risk; high risk not just for the participants but also for the academic staff in their educational roles …"*. For that, the actual learning processes themselves will also need to be high-risk and transformatory in character.

The theoretical framework for my research study is primarily based on the paradigm of constructivism, which is aptly defined as follows (Heylighen, 1997, p 2):

> According to constructivist epistemology, knowledge is not passively received either through the senses or by way of communication, but it is actively constructed by the individual through interactions with the environment. Knowledge can therefore not be transferred or transmitted through teaching and instruction. When learners are in interaction with their environment attempting to make sense of the world, they are

constructing knowledge through their experiences which constitutes the construction of meaning.

A theory is about the construction of knowledge within the social world (Cohen et al., 2011). When a theory is visually represented, the word "model" is used interchangeably with the word "theory" as they both are explanatory with a conceptual framework (Cohen et al., 2011). Kolb's (1984) Experiential Learning Theory (ELT) postulates that learning takes place in a cycle (Figure 2.10) that consists essentially of four phases, namely concrete experience, reflective observation, abstract conceptualisation and active experimentation.

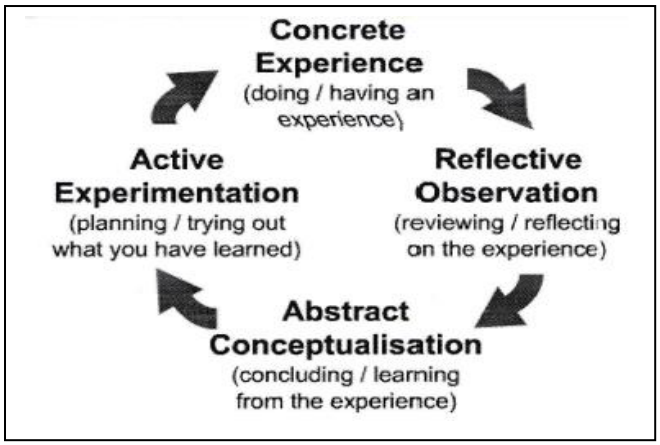


Figure 2.10: Kolb's experiential learning cycle.
(Mcleod, 2013, para. 2)

The ELT is the most closely associated with constructivism, and I regard constructivism within the context of Kolb's ELT as the theoretical framework for my study. Constructivism is discussed later in chapter 3. Kolb identified the following characteristics of experiential learning (Kolb, 1984, p 79):

* Learning is best conceived as a process, not in terms of outcomes.
* Learning is a continuous process grounded in experience.
* The process of learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world – learning is by nature full of tension.
* Learning involves transactions between the person and the environment.
* Learning is a holistic process of adaptation to the world.
* Learning is the process of creating knowledge – the result of transactions featuring personal and social knowledge.

My theoretical framework is therefore a constructivist experiential learning one. Knowledge can be identified as the grasping and transforming of an experience, which involves the

experiencing, reflecting, thinking and acting in any learning experience (Kolb & Kolb, 2011). There are four learning styles connected to Kolb's framework (Mcleod, 2013). Within these four learning styles, there are different factors influencing the choice of learning style, with educational experience being one of them (Mcleod, 2013).

The learning style that was most used in my study is converging, as it allows learners to solve problems by using their learning to find practical solutions. Converging is known as the doing and thinking learning style, enabling technological and specialist abilities as well as experimenting with new ideas (Mcleod, 2013). In my view, these are all abilities that South Africans are lacking. Another important learning style of Kolb's ELT is the assimilating learning style, which is important for science and information careers, as it requires more abstract learning by means of watching and thinking (Mcleod, 2013). Both the converging and assimilating learning styles were therefore used in my study, following the same reflecting framework, not only for the students within each learning task, but also for me, as the researcher and professional developer in this study.

It is claimed by Berthelsen et al. (2012) that teachers promoting strong acts of constructivism within the classroom, assist learners in a deep-holistic approach to learning. These teachers use real-life problems, allowing learners to think in a higher order in collaboration with other students and the teacher (Berthelsen et al., 2012). The Business Directory (2013) states that learning is the permanent change in behaviour due to experience. In the process of effective learning (Figure 2.11) as described by Kolb and Fry (1974) , the learner first experiences the learning, which is followed by an observation and reflection of this learning experience, leading to concluding the learning experience and then using it to test future learning experiences (Mcleod, 2013).

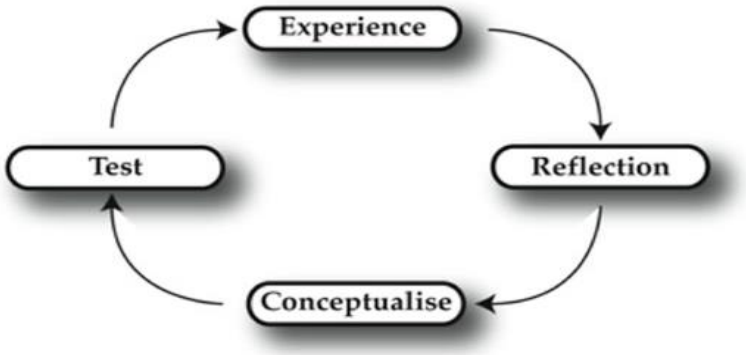


Figure 2.11: Effective learning.

(Mcleod 2013, para. 2)

2.13.1 Authentic learning

The above cycle of effective learning (Figure 2.11) goes hand in hand with the cycle of authentic learning as described by Slabbert et al. (2009), who indicated that immersion, reflection, construction and exploration are all characteristics of authentic learning, including holism, which is not present in Figure 2.12.

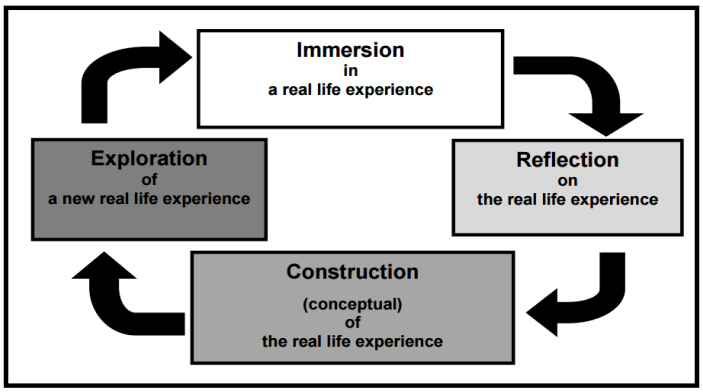


Figure 2.12: Authentic learning cycle.
(Slabbert et al., 2009, p 73)

Holistic learning refers to the interconnectedness of reality and experience (Mahmoudi, 2012). It has been argued that learning is a holistic process, meaning that it takes the thinking, feeling, perceiving and behaving of a person into account when it comes to learning (Kolb & Kolb, 2011). Slabbert and colleaghues (2009) also states that fragmentation of education into different parts has led to confusion in terms of the meaning of holism, which they think is essential to being human. The concept of being holistically human, means that there is an inseperable interrelatedness of the physical, mental, emotional and spiritual levels of being, ways of knowing, and levels of potential or inteligences (Slabbert et al., 2009). This means that the real-life experiences of a learner, together with all other relationships while engaging in the world, should be taken into consideration in education.

Slabbert and colleagues (2009) have divided domains of intelligence into four fundamental constituents: mental intelligence, emotional intelligence, spiritual intelligence and physical intelligence. These four domains of intelligence can also be linked to the Native American Medicine Wheel that refers to the integration of human potential as spiritual, mental, emotional and physical regions (Scheele & Warm, 2009). Humans can either become products of their environment or produce their environment by means of free will and their own creativity (Cohen et al., 2011). Slabbert et al. (2009) emphasise that: *“It is our spiritual intelligence that*

makes human beings the most powerful beings on earth" (Slabbert et al., 2009, p 82). It is therefore our spiritual inteligence that is the significance of authentic learning.

According to Lombardi (2007) researchers that have investigated the term 'learning', have identified 10 design elements for authentic learning experiences. They include the following (Lombardi, 2007, p 3):

1. The learning task should be designed to imitate the professional practice and its real-life problems as closely as possible, so that they can work actively with abstract facts and concepts in their world of work in the 21st century.
2. The authentic learning activities should be open to multiple interpretations for learners to be able to identify the subtasks to be completed by themselves.
3. The authentic tasks should be complex enough for learners to take time to solve the real-life problem at hand, and not just to arrive at the solution in an hour.
4. Learners should not be given resources, but they should be allowed to examine the task from practical and theoretical perspectives. Students should therefore be able to distinguish between relevant and irrelevant information to find the solution to the problem presented.
5. The task should incorporate the collaboration of learners in solving problems and not only solving them individually.
6. The authentic tasks should make room for learners to reflect on their learning by evaluating their choices both individually and as a team (room for metacognition).
7. Authentic activities have consequences that should extend to more disciplines or fields of specialisation, enabling learners to think in interdisciplinary terms. This will allow learners to adapt to a variety of roles.
8. Assessment of the authentic task should not be summative but rather woven through the task in such a way that it reflects the real-world evaluation process.
9. The conclusion of the authentic activity should not be a preparation for the something else, but should rather peak in the creation of a whole product.
10. Authentic learning activities should allow a variety of interpretations where there is not a single correct solution, but rather, competing solutions as applicable.

Figure 2.13 illustrates the process and factors involved in authentic learning, bringing the effective learning cycle (Figure 2.11) together with the design elements as stated by Lombardi (2007). Therefore, the model of authentic learning (Figure 2.13) formed the foundation of the fieldwork in my study. Authentic learning also formed part of the focus of my study, as authentic

learning goes hand in hand with facilitating learning, where considering the learner, in his totality, is central in the learning process.

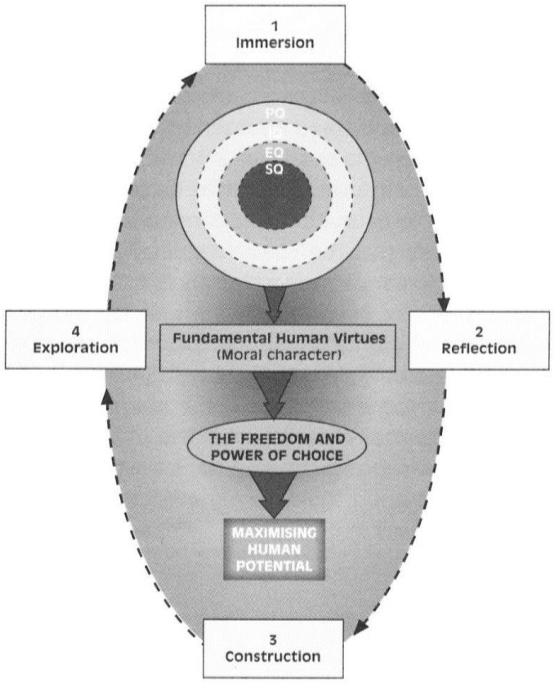


Figure 2.13: Authentic learning.
(Slabbert et al., 2009, p 94)

2.13.2 Facilitating learning

Facilitating learning occurs when there is a shift from teaching to learning to what is in the learner's mind (Mohanan, 2005). According to Slabbert et al. (2009) facilitating learning can be defined as the deliberate intervention of a facilitator of learning, who challenges learners to maximise their human potential by means of authentic lifelong learning. Facilitating learning in my study should not be confused, and does not refer to, the general perception in the literature, which could mean anything from the lowest level of learning (through imitation), right through to highly sophisticated independent research. In my study, the term facilitating learning is used as a concept of the professional practice of facilitating learning, as it is written by Slabbert et al. (2009), with its three purposes and six functions (within the three purposes), to ensure the highest possible quality of learning (refer to Table 2.7 as well as Figure 2.14).

Table 2.7: Facilitating learning.

FACILITATING LEARNING		
What is the major purpose?	**What are the required relationships to be established?**	**What is the function of facilitating learning?**
INITIATING LEARNING	Relationship of searching for meaning	Learning task design (LTD)
		Learning task presentation (LTP)
LEARNING	Relationship of constructing meaning	Authentic learning (AL)
MAINTAINING LEARNING	Relationship of enhancing meaning	Learning task execution (LTE): * Meta-learning (ML) * Co-operative learning (CL)
		Learning task feedback (LTF)
		Learning task consolidation (LTC)

(Slabbert et al., 2009, p 102)

The first purpose of facilitating learning, namely the initiating learning purpose, is getting learners involved in the challenge by creating a need to learn and to search for meaning (Slabbert et al., 2009). Within this purpose, the learning task is designed, and learners are urged to solve the problem presented in the learning task. The Learning Task Design (LTD) and the Learning Task Presentation (LTP) are the first two functions of facilitating learning (Slabbert et al., 2009).

The second purpose of facilitating learning is to get the learner engaged in the learning process by constructing meaning, which is the purpose of learning (Slabbert et al., 2009). Within this purpose, the learning is based on authentic learning, where a relationship of what needs to be learnt is established, to make a construction of their experience (Slabbert et al., 2009). The third function of facilitation of learning is therefore the authentic learning (AL).
The third purpose of facilitating learning is to maintain learning through ensuring that learners reach the highest possible quality of learning by means of staying engaged until this is reached (Slabbert et al., 2009). Within the third purpose of facilitating learning, maintaining learning is said to be unpredictable: *"…it cannot be planned or designed because it depends solely on*

the response from learners at any given time – because they are in complete control of their own learning" (Slabbert et al., 2009, p 108). There are three functions within the purpose of maintaining learning, which makes this the 4th, 5th and 6th function of facilitating learning (Table 2.7). These are the learning task execution (LTE) by means of meta-learning (ML) and co-operative learning (CL), learning task feedback (LTF) and learning task consolidation (LTC), which will each be described in the paragraph below.

When describing the functions of LTE, two types of relationships (that enhance learning within the purpose of maintaining learning) can be identified, namely meta-learning (ML) and co-operative learning (CL) (Slabbert et al., 2009). Meta-learning is where learners enhance their learning, by continually sharing the meaning they constructed through their real-life experience (Slabbert et al., 2009). Meta-learning can also be described as learning how to learn effectively (Flavell, 2004). It is here where learners think about their thinking and then co-operatively learn by sharing their constructed meaning with others (Slabbert et al., 2009). The drive for a learner to co-operate arises in the evolution of humans to maximise and exploit their potential (Armstrong, 1991). The relationship between meta-learning and co-operative learning results in an effective, active, interdependent life-long learner who will obtain the fundamental intra- and interpersonal virtues required to enhance continually an active community of truth and to function fully as a human being (Slabbert et al., 2009).

The second function within the purpose of maintaining learning, is LTF (Table 2.7), which is the feedback the facilitator of learning gives to the learners during the learning task execution (Slabbert et al., 2009). In other words, the facilitator of learning is not 'doing' the meta-learning and co-operative learning, the learners are. In fact, it should be clear that the learners' learning is primary in facilitating learning and the facilitator only facilitates their learning during their execution of their meta-learning and co-operative learning process. It is thought that feedback becomes crucial in maintaining the growth, flow and improvement of a learner as a human being (Slabbert et al., 2009). Since the LTF cannot be designed or planned, it should be anticipated by means of acute observations (Slabbert et al., 2009).

It has to be emphasised that facilitating learning is a holistic integrating practice and not a preceding selection of a teaching strategy, method or technique: it is the learners' learning responses that determine a most appropriate facilitator action to have learners (re) engage with the learning task at hand and their learning. It may be, however, besides the foundational actions in the facilitating learning context, that the facilitator may have decided that anyone of the existing teaching strategies, methods or techniques may be the most appropriate for the particular facilitating learning intervention. However, the existing teaching mode would not be

simply utilised, it would be adapted to function optimally within the context of the most appropriate facilitating learning intervention. All existing teaching strategies, methods and techniques are, therefore, at the disposal of the facilitator of learning to use, but only if the established LTF interventions have not succeeded in (re) engaging the learners with the learning task.

The third, and last function of maintaining learning within the facilitating learning, is the learning task consolidation (LTC) (Table 2.7). Here, the learners consolidate what they have learnt thus far during the contact session after that specific learning session (Slabbert et al., 2009). Figure 2.14 below illustrates the model for facilitating learning to provide a better visual understanding of how the different parts of facilitating learning (as described on the previous pages) fit together.

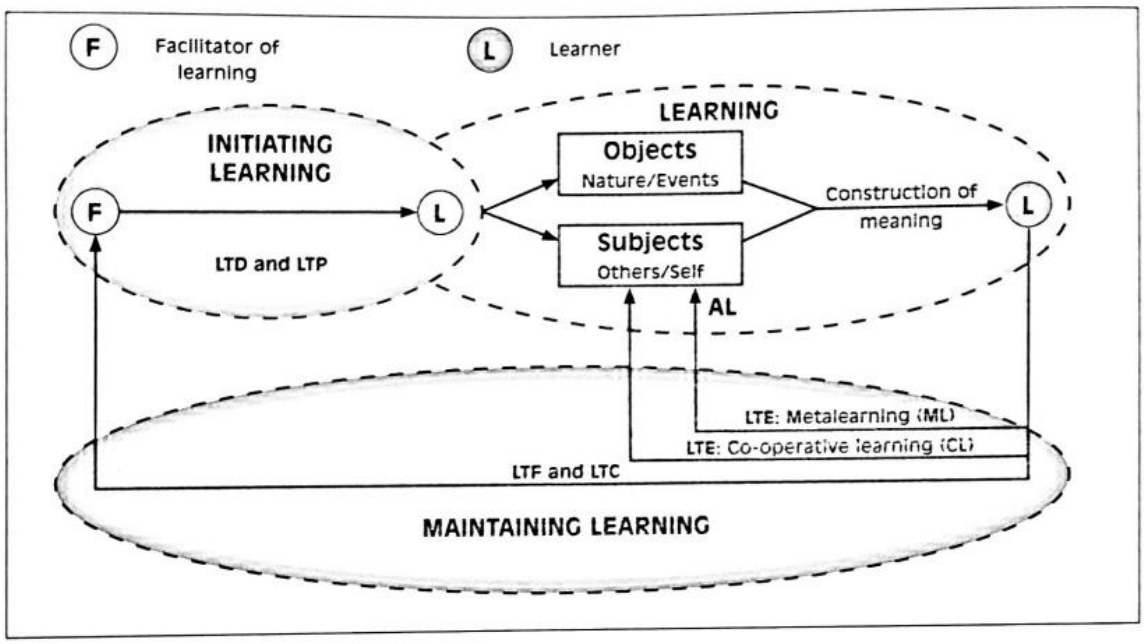


Figure 2.14: Model for facilitating learning.
(Slabbert et al., 2009, p 118).

Whereas Table 2.7 depicts the relationships and functions of authentic learning, Table 2.8 represents the professional practice of facilitating lifelong authentic learning.

Table 2.8: The professional practice of facilitating lifelong authentic learning.

WHAT IS THE FACILITATING LEARNING PURPOSE?	WHAT IS THE FACILITATING LEARNING FUNCTION?	WHAT ARE THE MAJOR CHARACTERISTICS, ACTIONS, OPTIONS, REQUIREMENTS, STRUCTURES?
INITIATING LEARNING	**Learning Task Design (LTD)**	Transforming the curriculum into learning tasks. A learning task is a demanding real-life challenge which the learners have to actually experience personally in the form an existing real-life problem to be solved or a serious desire to improve the quality of life for which there is currently no known resolution - at least for the learners. The challenge has to demand immediate resolution by the learners themselves even if it is a required proactive action now to prevent disaster later. Finding the resolution to the challenge should be possible only through the acquisition of the knowledge, skills and values indicated in the curriculum by the learners themselves. Resolving the challenge has to be an actual experience by the learners of their own personal development and the subsequent improvement of the quality of their lives.
	Learning Task Presentation (LTP)	Presenting the learning task orally in the form of a monologue and accompanying support only to indicate clearly what the real-life challenge is the learners need to resolve, the importance and urgency of resolving it immediately within implicated parameters and that action is required immediately. Its purpose is to immerse the learners into actually experiencing of the real-life challenge in its holistic uncompromising complexity within the shortest possible time but without allowing any interaction from their side at this point in time. Only the essence of the oral presentation is also provided to the learners in written form for referencing purposes. NB: No information/knowledge/skills are provided to students from this point forward in whatever way or format Everything the student needs to eventually resolve the challenge have to be found/acquired/constructed by the student self.
LEARNING	**Authentic Learning (AL)**	Facilitating authentic learning through the immersion of the learners in the challenging real life experience; demanding their reflection on the real life experience to establish what the actual real life challenge is and what would be necessary to resolve it; ensuring that learners purposefully probe all appropriate existing curricular avenues that might contribute to the resolution of the real life experience and subsequently constructing the best possible quality real life experience resolution; finally eliciting the exploration of executing the proposed resolution to the challenging real life experience.
	Learning Task Execution (LTE):	Ensuring that the learners execute the learning task themselves by resolving the demanding real-life challenge through authentic learning, meta-learning and cooperative learning to acquire fundamental (essential) human virtues (an ethical competence of moral excellence).

MAINTAINING LEARNING	(a) Meta-learning (ML)	Ensuring that learners resolve the real life challenge – personally and individually on their own - by taking full control of and responsibility for their own learning, through planning, executing, monitoring and assessing their own learning to submit the following highest possible quality end products: (a) the resolved challenge (Why: values) (b) how it was resolved (How: skills) (c) the content learned (What: knowledge) The learner, subsequently, becomes an active, effective, independent, lifelong learner, who continually increases the quality of his or her own learning, maximising his or her own potential and personal development through acquiring fundamental (essential) intrapersonal human virtues (qualities): will; motivation; courage; effort; common sense; perseverance; resilience; responsibility; integrity; independence; joy; love. .
	(b) Co-operative Learning (CL)	Ensuring that the learners help one another to learn in small groups with the sole purpose of enhancing the quality of their own learning and that of others through the following demanding requirements: base groups of four learners; heterogeneous groups – academically and socially; positive interdependence; individual accountability; promotive interaction; and assessment of cooperation. Besides the achievements of the individual learner during meta-learning learners also become interdependent through acquiring fundamental (essential) interpersonal human virtues (qualities): humanisation; communication; dealing with feelings; justice and forgiveness; love; leadership.
	Learning Task Feedback (LTF)	This is the epitome of facilitating learning through the intervention of the facilitator of learning during AL, ML and CL with the sole purpose of improving the quality of the learners' learning – by compelling the fundamental human virtues to come forth. This is achieved through the appropriate execution of a hierarchical order of actions executing the next one only if and when the current one does not result in the learner's (re)engagement with LTE: emotional encouragement and support (non-verbal, then verbal); asking for clarification from learners (What are you doing? Why are you doing it?) in order to elicit meta-learning for personal growth of the highest order through: requesting them to answer their own questions; demanding reflection by asking content void but quality enhancing questions (Where/how could you find what you need? How would you convince me that what you are doing is the best? What else is possible? How would you ensure that you have explored all avenues/resources/possibilities? etc.); requiring resourcefulness; demanding resilience; advising auto-education; providing edutainment. Using any other existing educational technique,
	Learning Task Consolidation (LTC)	Ensuring that learners ascertain the rate of their learning progress, assess the quality of their learning and determine what exactly is to be done to sustain the focus on resolving the real-life challenge in the next learning period, thus significantly bridge the time gap between this learning period and the next.

(Summarised from Slabbert et al., 2009, 102-119; CD-ROM The essential tools for facilitating learning, p 1-127)

2.14 Recapitulation of comments

My investigation into the transformatory curriculum and pedagogy, which is required for the achievement of essential human qualities, has directed me to the professional education practice of facilitating learning as set out by Slabbert et al. (2009). It is also encapsulated in a transformatory aim of education: The aim of education is to empower learners to maximise (completely develop and utilise) their human potential (human qualities and dispositions which are manifested in fundamental human virtues) by facilitating lifelong authentic learning (resolving real-life challenges) in order to create a safe, sustainable and prosperous future for all (Slabbert et al., 2009).

According to Herrington and colleagues (2014), authentic learning can be described as a pedagogical approach linking learning tasks with real-life situations, in which learners will need to solve problems in the classroom that they would normally encounter in their daily lives. This chapter contributes to the choices explained in the following chapter.

CHAPTER 3
Research design

3.1 Introduction

The previous chapters set the foundation from which I could design my research. The point of departure of the design of my research is, however, my research questions and my subsidiary research questions, for which the answers could be obtained through different ways. In this chapter I will describe the approach I followed to answer the following question:

> "What educational quality improvements are envisaged in the CAPS curriculum for Grade 6 mathematics, in comparison with its predecessor, namely the RNCS?"

An investigative comparison between the respective curricula could be achieved by a document analysis and/or a literature review on the two curricula, but the way in which teachers have experienced the two curricula might also provide a valuable insight to an answer to this question. The teachers' experiences could be revealed through appropriate interviews conducted with them.

The first subsidiary question, "What are the challenging demands of 21st century education in general and in Grade 6 mathematics education in particular?", is a critical question in today's education, for which we need answers in terms of, among others, the fourth industrial revolution. This revolution determines how we will live in the near future, with increasing unbridled freedom and a matching level of moral standard as an ethical imperative. It would therefore be valuable to hear from today's employers how ethical imperatives are required. Finally, my personal quest, which had to be answered, is the third subsidiary question: "How can I improve the quality of my Grade 6 mathematics professional classroom practice to meet the demands of 21st century education?" The answer to this question requires a theoretical framework identified in my literature review. The kind of educational intervention required is Kolb's Experiential Learning Theory (ELT), with a constructivist paradigm (Kolb, 1984). Since this intervention requires a mode of enquiry, identified as action research, the framework for my entire research design is clarified in the paragraphs that follow through the reasoning behind each choice that was made to conduct my study in an appropriate manner.

3.2 Research premises: delineating paradigmatic assumptions and perspectives

Research can be described as the search for truth (Cohen et al., 2011). Research is therefore the different ways in which to know or understand a phenomenon (Mertens, 2015). Cohen et al. (2011) argue that ontological assumptions lead to epistemological assumptions, as assumptions about the nature of reality lead to ways of enquiring about the nature of reality. This in turn then leads to research methodology and therefore to considerations about the data collection (Cohen et al., 2011). Within the social world, concepts can be approached by means of the assumptions that underpin them. Burell and Morgan (1979) identified four assumptions namely 'ontological assumptions', 'epistemological assumptions' and 'assumptions about human nature'. These three assumptions directly influence the 'research methodological assumption', which in turn becomes the fourth assumption (Cohen et al., 2011). The four assumptions relevant to my study, is discussed in detail in the following paragraphs.

3.2.1 Ontological assumptions

Ontology deals with what there is to know, focusing on the nature of the world (Willig, 2013). According to Cohen et al. (2011) ontological assumptions have to do with the social phenomenon itself. Ontology is the study of the nature of reality (Mertens, 2015). According to Cohen et al. (2011), the means people use to understand the nature of reality is based on experience, research and reasoning. Ontology includes the realist position, positing that the world consists of cause-effect relationships (Willig, 2013). Ontology can also be described as a relativist position, that is not as fixed and structured as the realist position (Willig, 2013). The third category of ontology can be described as the contextualist position, where participants in the study construct a shared understanding by means of facilitating learning within supportive contexts (Schraw, 2013). Within the contextualist position of ontology, the researcher is interested in the process that participants went through to construct their knowledge, as well as the authentic application in the context that the knowledge is learnt (Schraw, 2013). The type of knowledge is not important within the contextualist position (Schraw, 2013). The ontological position in my study is therefore a contextualist position, as I used facilitating learning while I focused on the process of learning and not the type of knowledge thought necessary to obtain.

3.2.2 Epistemological assumptions

The epistemological assumption is the study of knowledge and how we come to know (Steup, 2005). Epistemological assumptions can be described as assumptions about how knowledge is communicated to other human beings (Cohen et al., 2011). Berthelsen et al. (2012) claimed that

teachers have revolutionised the way they think about knowing, knowledge and the nature of how they teach in response to the complexity of our world. The authors also claimed that the personal epistemology of teachers influenced their level of critical thinking, with a sophisticated epistemology producing a higher level of thinking (Berthelsen et al., 2012). These teachers are more likely to solve problems because of their awareness that knowledge is both interrelated and uncertain. Shraw (2013) claimed that these teachers favour learner-centred instructional practices that focus on critical thinking. People are therefore dependent on their experience when it comes to everyday life problems (Cohen et al., 2011).

Learner-centred social constructivist theories seem to become the most effective strategies in the 21st century as they enable facilitating learning in teaching and learning situations (Berthelsen et al., 2012). According to Ultanir (2012), a teacher should only act as a guide and co-explorer for learners, encouraging them to seek and challenge ideas. This also maintains an authentic learning perspective in that epistemological competence is achieved when learners are confronted with real-life challenges that need to be resolved (Slabbert et al., 2009). Learners should therefore be active and engage in the meaning-making process, as suggested by Ultanir (2012).

Further, it is thought that there are three types of reasoning within research, namely deductive reasoning, inductive reasoning and inductive-deductive reasoning (Ary, Jacobs, Sorensen & Walker 2014, p 4). Deductive reasoning is an approach to gain knowledge by reasoning logically and thinking from the general to the specific, while during inductive reasoning, the researcher makes conclusions from observations and not only from absolute truths passed on by authorities (Ary et al., 2014). Inductive-deductive reasoning is where the researcher is constantly moving back and forth from the observation to the hypothesis and the specific to the more general, and then from the hypothesis to its implications (Cohen et al., 2011). My study used inductive-deductive reasoning, as it was necessary that I moved between the different fieldnotes (to reflect and learn from them before the improved task could take place) and conducted interviews during the analysis of the data to improve the accuracy of the analysis.

3.2.3 Assumptions about human nature

According to Cohen et al. (2011), assumptions about human nature focus on the relationship between humans and their environment, with one being that of humans responding to their environment and therefore becoming products of it. The second relationship can be described as

the humans producing their environment by means of their own free will and creativity (Cohen et al., 2011). In the ELT, the process of learning from experience is said to be applicable in the everyday life of the learners involved (Kolb & Kolb, 2011). This study therefore followed a humanistic paradigm, where learners used their free will to produce their own environment while they were interacting with that environment.

3.2.4 Methodological preferences

One learns from the writings of McNiff and Whitehead (2006) that the methodology of a study refers to *"…a theory of how we do things"* (McNiff & Whitehead, 2006, p 23). It does not refer to the method of a study, which has to do with the techniques used to do research. Maree (2007) states that there are two approaches within one's methodology, one being an idiographic approach and the other a nomothetic approach. According to Cohen et al. (2011), the nomothetic approach is focused on formulating general laws, predominantly following quantitative research. The idiographic approach, on the other hand, focuses on the individual, explaining and understanding an individual case in which individuals create, modify and interpret the world that they are in (Cohen et al., 2011). Tus, this study followed an idiographic approach as it was intended, not to discover a general law, but to focus on individuals and their behaviour within the world of learning mathematics.

3.3 Delineating a mode of enquiry

3.3.1 Research design

A research methodology is the approach used in the investigation of a research topic (Willig, 2013). The qualitative research methodology is focused on the understanding of the phenomenon at hand, in contrast with the numerical analysis of data associated with quantitative research (Ary et al., 2014). Qualitative research can produce explanations or descriptions of a phenomenon by means of interpretation and identify patterns that recur in the experiences of a group of people (Willig, 2013) and is concerned with the bigger picture and not with single variables (Ary et al., 2014). Therefore, this study followed a qualitative research design as it is more descriptive in nature.

A paradigm can be described as a world view (Mertens, 2015). The philosophical world view, or paradigm, of this study is one of social constructivism, which is linked to qualitative research as individuals seek to understand their world of work and the world they live in (Creswell, 2009). Within this paradigm, questions become broad for individuals to construct their own meaning,

which forms by means of interactions with others, with the focus on the process of learning (Creswell, 2009). The focus here is on knowing as a process, instead of knowledge as a product (Ultanir, 2012). Even though my study is based on the philosophy of socio-constructivism, it is also interpretive, as the researcher must interpret all the observations and interviews conducted (Creswell, 2009) while focusing on the differences of people in a natural phenomenon and determining the individual's social behaviour (Cohen et al., 2011). In my study, participants were observed within their natural environment, with the researcher being the one who collected all the data.

The approach of my study is therefore an interpretive qualitative study within the socio-constructivism paradigm, followed by participatory action research as the strategy of inquiry (Creswell, 2009), as I am a teacher who aimed to improve my practice. According to Stringer (2014), action research uses investigation to find solutions to problems experienced in specific situations in ways that can improve the efficiency of the researchers in their context, such as teachers and other professionals in the social context. Action research is described in more detail in the following paragraphs.

3.3.2 Action research

Action research is thought to be qualitative in nature, as it engages the dynamics in a social context (Stringer, 2014). Action research aims to improve learning by improving actions and practices (McNiff, 2016). Even though action research was not originally accepted as a research method for creating knowledge and theories, it soon started to enjoy popularity when applied to professional learning (McNiff, 2013). Herrington, Oliver and Reeves (2014) stated that action research relates learning to future use. Together with this, Graue and Trainor (2013) indicated that action research aims to produce a change in the context of real life. What should be understood is that the need for certainty should be ignored and it should be accepted that in real life, things are unpredictable and transformational (McNiff, 2013). McNiff (2013) claims action research to be a process that will help others to challenge themselves, realising their humanity as part of this process. Stringer (2014) suggested that service professionals should replace their mechanical and technical visions with facilitating learning and creative investigations. This supports my action research study, where I am the researcher actively involved in facilitating learning in my classroom.

With facilitating learning, one could focus on the individual in totality. According to McNiff (2016) a researcher in action research puts himself in the position of an insider. Within action research, the action is regarded as the improvement of learning within the development of behaviours and critical thinking (McNiff, 2016), where the action is in the interest of the researcher as well as others. Action research has to do with a researcher's encouragement for others and a researcher's own ability to think and act critically (McNiff, 2016). According to McNiff (2016), action research identifies value-based reasons for actions to be carried out. Action research was chosen for my study, as I developed from thinking and acting as an insider to learning through facilitating learning. I also played an active role in improving the learning of not only the students, but also my own.

There are different variations of action research, such as participatory research, action learning, collaborative enquiry, contextual action research and emancipatory research. The combination of collaborative research and changing practice leads to participatory action research, as it fuses the two types of research which can be done separately as well (Bergold & Thomas, 2012). One can refer to participatory action research as a process where both the researcher and the participants are equally involved, with the researcher viewing the participants as experts while aiming for social change (Comeau et al., 2010). Participatory action research is said to permit the researcher to act as a participant, a facilitator of learning and a learner in the study (MacDonald, 2012). Participants are therefore active in the search for information to guide and improve their future actions (MacDonald, 2012). Being involved in participatory action research means that one can involve oneself and impact the improvement of quality of life of others in the community (Comeau et al., 2010). These improvements might also include the development of critical consciousness and transformation in social structures, allowing the expression of the participants' full human potential (MacDonald, 2012).

It is stated by MacDonald (2012) that participatory action research seeks to address the issues that threaten human values, as it is value oriented. Participatory action research plays a vital role in the research of teachers and teaching within the world of education (MacDonald, 2012). The aim of this type of research is to improve teaching practice instead of only producing knowledge (MacDonald, 2012). Educational action research therefore presents teachers, learners and parents with the opportunity to accept responsibility together for the improvement in education, the curriculum and professional development (MacDonald, 2012). I aimed to accurately apply

facilitating learning and therefore followed the qualitative research methodology embedded in participatory action research.

As discussed earlier, the experiential model is the theoretical framework used in this study, with the converging learning style and the assimilating learning style of this theory to be followed. These learning styles are important for careers in science and information, as they require more abstract learning by means of watching, doing and thinking and allows learners to solve problems by using their learning to find practical solutions (Mcleod, 2013). Both the converging and the assimilating learning styles were used, with the same reflecting framework for the learners within each learning task, and for myself, as professional developer in this study. I therefore used the experiential model, as it focuses on learning from real-life experiences by means of solving problems with authentic assessment taking place (O'Neill, 2010). With the experiential model, the fieldwork can be evaluated, as it fits the cycles of action research. Action research has flexible procedures that are cyclic, solution oriented, systematic and participatory to provide improvements in practice (Stringer, 2014). This study is cyclic, as O'Brien (2001) suggests that action research is cyclic, and consists of four stages, namely planning, acting, observing and reflecting (Figure 3.1).

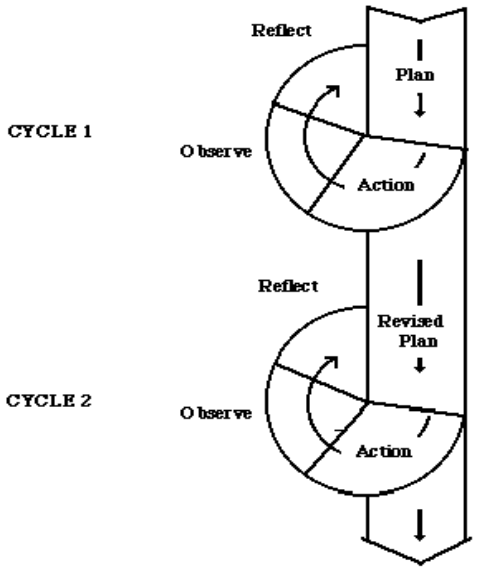


Figure 3.1: Model of reflective cycles by Kemmis and McTaggart
(O'Brien, 2001, p 1)

The cyclic model was developed by Kemmis and McTaggart (1988) to demonstrate the reflective cycles. After reflection on the first cycle, the next cycle follows with the same four steps until the researcher is satisfied with the results. The reflective cycles served as foundation for facilitating learning of this study, and each reflective cycle is discussed in Table 3.1 according to the reflective steps mentioned in Slabbert et al. (2009).

Table 3.1: Action research steps for each reflective cycle.

Action research steps for each reflective cycle	
1. Plan	This is the 'who, what, where, when and why' of the action research to be done. This is done before any contact with participants are made, as it is the aspect the researcher wants to improve on in her practice.
2. Act	This is the execution of the plan mentioned in step 1. This is where the researcher starts to interact with the participants in the study.
3. Observe	This is the collection of data while the plan is being executed. This includes the recording of actions to be able to classify the data collected during the action step
4. Reflect	Reflection on data collected takes place in this step, where the researcher comes to conclusions on the specific cycle in order to start a similar plan of action with the aim of improving it.
5. Review	A revised plan of action based on the reflection of the previous cycle to start the next reflective cycle.

(Slabbert et al., 2009, p 143)

3.3.3 Model of reflective cycles for this study

I constructed a reflective model that is designed to be particularly applicable for this study, based on the model of Kemmis and McTaggart (1988): each reflective cycle included planning, acting, observing and reflecting. A revised plan followed in the next cycle, after reflecting on the current cycle (Dick, 2000).

Within the reflective cycle model of my study, three main reflective cycles can be identified: The first cycle contained my first exposure to facilitating learning practice in mathematics by means of a learning task. The learning task, designed by me with the focus on facilitating learning, aimed to improve my professional practice. Three different learning tasks were conducted to conclude my improvements in professional development by means of facilitating learning. After cycle one was planned, acted out and observed, it was reflected on to improve and start a reviewed plan for cycle two, as can be seen in Figure 3.2.

The second cycle (Figure 3.2) therefore represented the second or reviewed learning task. After all the observations of improvements have been noted and lacking aspects were identified in the second task, the third cycle was introduced with the third learning task in mind (Figure 3.2), to increase validity of this study. After completion of the three cycles, I could reflect on the entire reflective cycle and make conclusions.

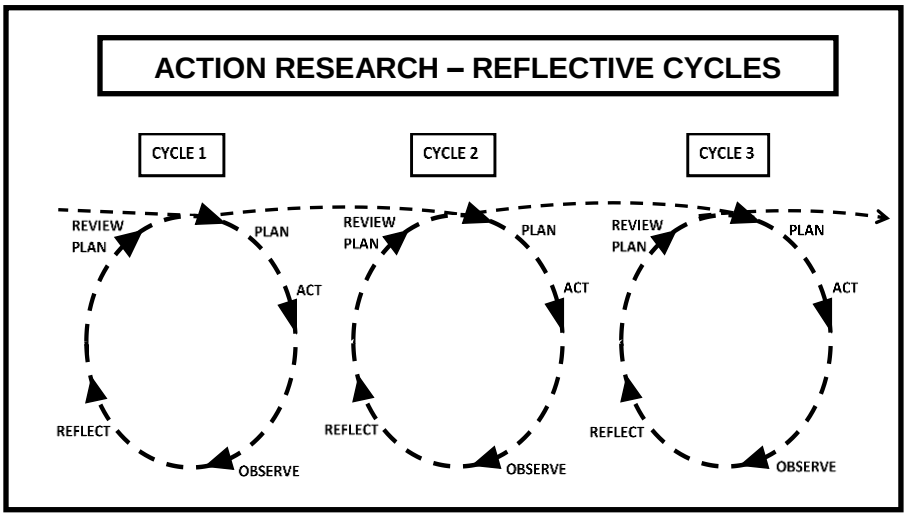


Figure 3.2: Model of reflective cycles used in my study.
(Adapted from O'Brien 2001, p 1)

3.4 Research method

As we have discussed the research methodology earlier in this chapter, one will find the different methods and techniques used to collect the data for this qualitative participatory action research study in the following paragraphs.

3.4.1 Research site

The site used for all the field work of this study, was completed in my classroom, at an anonymous private school in Midrand. This site was chosen as it was convenient me. For a full-time teacher with extra-murals, it was important to manage time effectively. It was therefore practical to use the school the researcher is working at, as the research site. This school is a diverse parallel-medium school with Christian values.

3.4.2 Population and sampling

A sample is the participants chosen from the population that the researcher is collecting data from (Mertens, 2015). There are different types of sampling in qualitative research. One sampling strategy is called criterion sampling, where the researcher searches for participants that match the criteria for the study (Maree, 2007). Another sampling strategy is the snowball sampling strategy, where already active participants are used to refer others in their social network with similar criteria to contribute to the study (Maree, 2007). Convenient sampling depends on the accessibility of the sample, geographical proximity, the time available for the fieldwork and the willingness of the volunteer (Farrokhi & Mahmoudi-Hamidabad, 2012).

Another sampling strategy is stratified purposive sampling, where participants are selected by means of matching the criteria that are relevant to the research question (Maree, 2007). Stratified purposive sampling also depends on the researcher's available time and resources. For my qualitative study, I used stratified purposive sampling, as the focus of this study was Grade 6 mathematics, which served as the criterion that is relevant to this study, when the teachers, learners and employers were chosen. This sample was also dependent on the available time and resources of the researcher, as participants were limited to those being taught mathematics me (at the research site mentioned in the above paragraph). The observations before the conduction of the learning tasks, during and after – for one Grade 6 mathematics class consisting of nine learners - were formally recorded. The learning tasks were also conducted with another Grade 6 mathematics class consisting of twelve learners, however they were not formally observed or recorded at any time. This second class was used only for crystallisation purposes and were therefore only interviewed after the learning tasks, using only the responses from the interviews of this second class in the collection of my data.

Of the two classes, six learners of the observed class and five learners of the non-recorded class were interviewed after cycle three to strengthen the reliability of this study. All the observations and interviews were conducted after school in the third term in the mathematics class. Interviews were conducted with two senior mathematics teachers, the Head of Department (HOD) of mathematics, one teacher with the same teaching experience as the researcher (me) as well as two employers in the field of mathematics.

3.4.3 Data collection

Within action research, the knowledge that people construct is relative, temporary and dependent on observations (Ultanir, 2012). I used multiple data collection methods, and the nature of the design was emergent as changes took place as the fieldwork were completed (Creswell, 2009). According to Hart (2001), searching the literature is essential in every research project. In my study, public documents were looked over for analysis, with all other relevant literature discussed in chapter 2. Other forms of data collected in my study included observations, field notes and the writing of a reflective journal as well as semi-structured interviews that were conducted. All these methods correlate with qualitative data collection (Creswell, 2009).

3.4.3.1 Observations, field notes and reflective journal

Observations in the social sciences can be based on participant observations and in-depth interviews (Marvasti, 2013). According to Maree (2007) there are four types of observations within qualitative research, namely (1) the complete observer type, (2) an observer as participant type (where the researcher remains uninvolved), (3) the participant as observer type (where the researcher becomes part of the research and participates in the situation being observed) and (4) the complete participant observation type (where the researcher is so completely immersed in the observation that learners are not even aware that they are part of the observations).

In my study, I (the researcher) am part of the research process as well as the participants, as I am interested in my own actions and reflections together with the behaviours of the participants as a result of my actions. I therefore used the ‘participant as observer’ type of observation. According to Maree (2007) the ‘participant as observer’ type of observation is used in action research and this study is based on participatory action research. Observations were taken on three learning tasks, which followed Kolb's ELT (Kolb, 1984).

The learning tasks were audio-visually recorded for observation purposes. Observations were made for reflection purposes, as reflection-driven practices within teaching have been reported to show more teacher growth than a non-reflective driven practice (Shraw, 2013). I used a reflective journal to write reflections and wrote field notes after each task that might be useful for the analysis of the data collected in my study.

3.4.3.2 Semi-structured interviews

Punch (2009) states that there are three types of interviews, namely structured interviews (tightly organised; no attempt to probe further), unstructured interviews (no pre-planned questions) and semi-structured interviews (open-ended; could lead to follow-up questions) (Punch, 2009). The interviews that were conducted in my study were semi-structured, as each interview was an in-depth interview that were only conducted once, and lasted approximately 30 minutes (Jamshed, 2014). I conducted these interviews to allow for open-endedness and a narrative flow of data, but also to allow for probing, where data needed to be enriched (Maree, 2007). These interviews were recorded, as suggested by Jamshed (2014), to ensure that I did not miss any important information. All interviews were transcribed so that each one could be analysed.

Interviews with the four teachers (as mentioned in section 3.4.2) were conducted face-to-face before facilitating learning to assist me in finding the answers to my subsidiary questions. All the interviews with the learners were conducted face-to-face, after facilitating learning, as all the questions I needed to ask, could be answered in the interviews held after facilitating learning.

Furthermore, to increase the efficiency of my attempt at improving my education practice, I deemed it profitable to conduct interviews with businessmen who provide employment for which mathematics is a prerequisite. The purpose was to obtain an indication of the contextual importance of mathematics particularly in the workplace, or the lack thereof, in order to know how to prepare our learners for the future of work. The first interview was conducted with a CEO at a pharmacy link store, who is responsible for the employment of all the staff and management of these staff members (varying from the financial clerks to the pharmacists and floor staff). The second interview was conducted by means of an electronic interview, as I was unable to interview the participant concerned face-to-face. This participant is a director in a town development business, responsible for building a town of estates with enclosed roads, businesses, restaurants, churches, two private schools, a medical centre, retirement village and other properties (which includes the employment and management of engineers, building contractors, provision of electricity, etc.). The interviews with the two above mentioned employers were also conducted to assist me in answering my second research question, which dealt with the challenging demands of 21st century education, in general, and in mathematics.

3.5 Recording data

According to Maree (2007) there are three ways of recording data. The first refers to anecdotal records based on short descriptions with no self-reflective notes. The second is the structured observation record, where categories are made by the researcher before the observations start. The last type of data recording is the running records, where the researcher focuses not only on the actions but also on the context; these are more detailed observations. In my study, I used running records, where the context was just as important as the action. After several observations (including the use of an observation schedule for each reflective cycle), I analysed and reflected on the data to improve my practice and actions accordingly. These changes were again analysed and reflected upon, by me, to achieve further improvements in the classroom.

3.5.1 Transcriptions of interviews

According to Roulston (2013), research interviews can be described as socially constructionist, where the “how accounts” can be co-constructed by the interviewer, with the interviewee being the focus of the analysis. When doing qualitative research, it is important to set verbal research into a written form by means of what is called transcription (Kowal & O’Connell, 2013). The mode of transcription for my study was literary transcription, as Kowal and O'Connell (2013) suggested that literary transcription still accommodates any deviations in pronunciation in a meaningful manner. When the transcript of an interview is interpreted, it is suggested that the researcher should refer to the audio or video recordings of the interview for verification, as there should be a correlation between the recording and the transcriptions (Kowal & O’Connell 2013). This served as motivation to make voice recordings in my study.

3.6 Data analysis and interpretation strategies

When analysing data, interpretation should be based on the researcher’s openness to the data, instead of on the application of concepts from the literature (Roulston, 2013). It has been suggested that observations can best be demonstrated when they are written, whether they are transformed from audible or visual data (Marvasti 2013). The constructionistic researcher is thought to use own observations to find out how participants make sense of their social worlds by choosing the focus of what is important (Marvasti, 2013). Analysis within this study should therefore be a reflective activity completed throughout the study, not just at the end of the study to inform the data collection.

The researcher considered the use of a Computer-Assisted Qualitative Software Program (Cone) to analyse the data, as programs such as ATLAS.ti can be very useful. However, interpretations in the findings provided by ATLAS.ti analysis still had to be made by the researcher. I therefore decided to rather do the analysis manually, in order to get more immersed in the data and to make more accurate conclusions. Doing the analysis manually allowed me to see how the model of the data analysis developed, as the findings started to unfold with me being part of this process. This also allowed me to focus more on the data and the findings instead of on the wonderful, yet irrelevant, features that the ATLAS.ti program can offer. Furthermore, I followed the recommendation of Saldana (2010) to do the coding manually on hard-copy printouts.

3.6.1 Coding data

It is important that the researcher reorganise the data by means of coding and categorising (Roulston, 2013). Reorganising the data includes reading, reflecting, writing, rereading and making connections between ideas, to collapse categories into main ideas (Roulston, 2013). I therefore needed to reread and recode the data as the analysis proceeded to increase the reliability and validity of the analysis. As Schreier (2013) suggested that the defining of a category can be very abstract, it seemed helpful to include examples taken from the materials, such as the interview transcriptions.

Coding can be described as a construct generated by the researcher to translate data for pattern detecting, categorising and capturing the essence of the data (Saldana, 2016). Identifying patterns makes findings more trustworthy, as patterns *"…demonstrate habits, salience and importance in people's daily lives"* (Saldana, 2016, p 6). My study relied on the writings of Saldana to analyse the transcriptions of this study.

Coding is a cyclic process, where the first cycle of coding is not the best attempt, and I therefore needed to code and recode the same data to verify my findings during the analysis process. In my study, initial coding was used as the first cycle, as initial coding is the breakdown of qualitative data into discrete parts *"…to remain open to all possible theoretical directions indicated by your readings of data"* (Saldana 2010, p 81). After initial (open) coding was completed, the next step of the coding process in my study was to move to the second cycle of coding by means of axial coding. Saldana's second cycle of coding can be referred to as the main phase. The second cycle, known as axial coding, refers to exploration of how the categories and subcategories are related to each other (Saldana, 2010). During the axial coding cycle, I codified the data by using the

codes identified in the first cycle to divide, group, regroup and relink the different codes to consolidate the meaning of the codes (Saldana, 2016). Codes may also be subsumed within one of the categories if necessary, and the categories may overlap, as Saldana (2016) suggested that categories are not discretely bound all the time.

The final step in data analysis is selective coding, where the different categories are reduced to create main themes in the data collected (Male, Needham & Palaiologou, 2016), following a streamlined code-to-theory model, as suggested by Saldana (2016). In this model, categories can contain a collection of codes from which a subcategory can be identified. After this process, themes can be established from the categories, which then lead to the theory of the data. In this study, the themes established referred to the meaning of the data and not to a new theory, as it would in the case of a study following grounded theory.

I therefore categorised the open codes, by first writing the amount of times that the same phrase repeated, next to the category. The most recurrent codes were listed first. The codes were then grouped into similar groups, which lead to different subcategories that were divided into themes in my study. This model can be visualised by referring to the code-to-theory model presented by Figure 3.3.

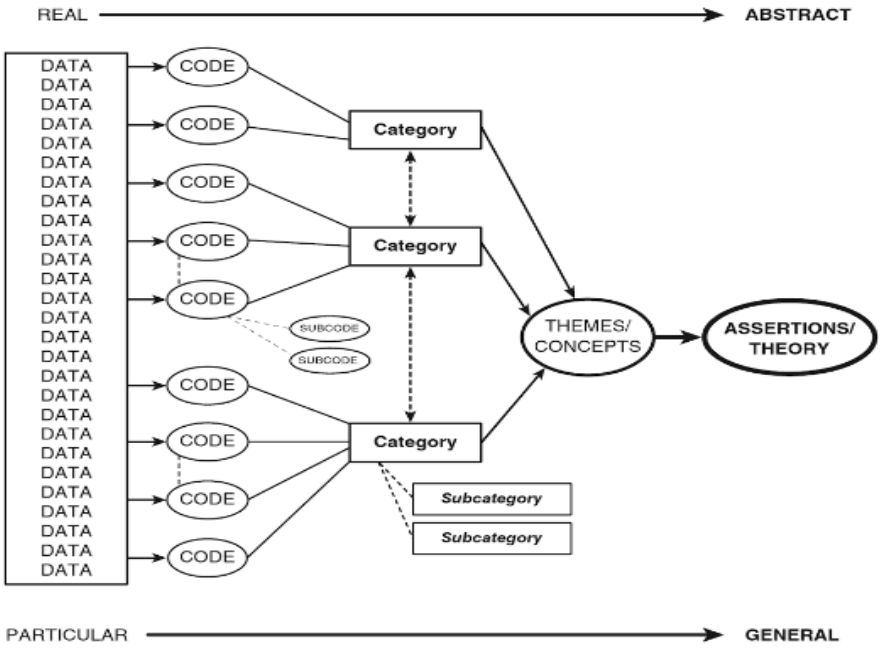


Figure 3.3: Code-to-theory model
(Saldana, 2016, p 14)

The code-to-theory model in Figure 3.3 allows the researcher to keep focus on the purpose of the study during the process of coding by keeping and consulting a printed paper of the research problem, research question, theoretical framework and goals of the study (Saldana, 2010). This step assisted me when decisions needed to be made on what to code in the data. As the codes in the transcriptions were used to make assertions, it would be good practice for me to pre-code the data in the transcriptions by means of underlining and highlighting the transcripts, as the phrases highlighted can be put to good use later in the study, when I wanted to support the assertions made after the process of coding (Saldana, 2010).

3.7 Data verification

The validity of action research lies in the researcher's intention to teach according to the values that have been identified and targeted in the study (McNiff, 2016). Crystallisation is where there are multiple forms of analysis and representations of data combined into one text, highlighting the vulnerability and position of the researcher (Ellingson. 2014). By following crystallisation, this study was validated by a validation group, also called my critical colleagues, consisting of people whose opinions are valuable to me (McNiff, 2016). This included the supervisor of this study, together with another postgraduate student.

The credibility of a study is shown by the depth of understanding achieved by the individual who reads the study (James, 2010). To make the study credible, I needed to systematise the data in a logical sense. The reliability of the study refers to the correlation between the data, the findings and to the research practices applied to the collection and analysis of the data (James, 2010). A study is also said to be reliable when it can be implemented in other contexts. My study can be implemented in different South African contexts where one would like to use facilitating learning as a teaching method.

3.7.1 Crystallisation

Crystallisation can be referred to as an influenced approach of triangulation. In this study, I needed to analyse the collection of observations taken, interviews from the point of view of the learners on the same phenomenon, as well as the views of different mathematics educators and employers. As my study is a constructivist study, it benefited from the more flexible crystallisation approach, as suggested by Ellingson (2014). Constructivism is a theory of learning and knowledge, where researchers observe the reality being formed daily (Ultanir 2012). It is thought

that knowledge within constructivism can be described as a reflection of a representation (Ultanir, 2012), which is in line with crystallisation, as mentioned earlier.

3.7.2 Researcher bias – eliminated

By means of crystallisation, one can further eliminate researcher bias as there is a correlation between the different sets of data collected.

3.8 Possible contributions of this study

According to McNiff (2016) the significance of an action research study is in the improvement of the researcher's education and that of others within the researcher's context. The possible contribution of this study is to identify whether facilitating learning of authentic real-life challenges as a teaching strategy can be successful in mathematics at Grade 6 level in South Africa. If successful, learners will be able to creatively utilise their mathematical literacy to contribute to the quality of their own lives and those of the community, including people of different ages. More importantly, learners will acquire the scientifically based, essentially human virtues that may endure and improve throughout their lives when they enter the world of work. This may enable learners to create a safe, sustainable and prosperous future for all. My study may add value to the evaluation of the current CAPS curriculum that is currently applied in South African education and may therefore be used to support other research conducted on the South African education system.

3.9 The role of the researcher

I (the researcher) was an active participant and observer within this study, as I was part of the action research cycles. I prepared, constructed, conducted and analysed the interviews of this study. I also constructed the learning tasks within its three cycles, applying Kolb's theory for each cycle.

Furthermore, my role was to evaluate the quality of the current curriculum and to make the necessary the necessary improvements to my professional education practice to transcend the compliance requirements. I therefore aimed to construct a comprehensive literature study to form a bigger picture of educational changes within South Africa and the leading world countries. This may assist me in understanding potential shortcomings of my own educational practice in the teaching of mathematics. I needed to crystallise all the data collected, to reach an unbiased

conclusion. Then, I had to compile all the information into a sensible research report. As this is a study in action research, my aim was to improve my own learning and so to improve my own practice and action, increasing the value of my role in this study.

3.10 Ethical considerations

To guard against atrocities, ethical guidelines should be adhered to when conducting a study (Mertens, 2015). In this study, all the ethical considerations stipulated by the Gauteng Department of Education (GDE) have been strictly adhered to. A GDE research request form was completed with all the details of the research study to be conducted, to apply for permission to conduct this study within a school (GDE, 2012). Information such as details of additional persons involved in the study was given, together with the purpose of the study and the value of this study to the research within education (GDE, 2012).

In accordance with the GDE research request form, the following was also included to obtain ethical approval for this study (GDE, 2012, pp 3–4):

* The proposed research method, together with a copy of the interview schedule;
* The type, name and number of institutes involved;
* The district and number of learners involved in this study;
* The number of educators involved, together with the average time spent with each person involved in this study;
* The school term in which the research will be conducted, together with the time of day in which the research would take place;
* A declaration of the researcher and the supervisor, in which both parties agree to abide by the conditions prescribed by the GDE.

To get permission for this research, the GDE required permission to be applied for, two months before research will be conducted, as no research may be started prior to the granting of permission. The Research Coordination entity has 30 days to collect information and input from the Department before granting approval for the research to be conducted. Research is only allowed to be conducted between February and the end of the third school term (GDE, 2012). The application is then scrutinised, ensuring alignment of the topic with the goals of the GDE, and then approved by the GDE (GDE, 2012).

This study was approved by the GDE for research to be conducted in the third school term, between September and October 2015, with the learning tasks taking place after school hours.

An interview schedule was attached, as well as the different declaration forms for permission to be granted by the principal of the school, parents of the learners, interviewees and the videographer who took an audio-visual recording of one of the learning tasks. Within this declaration, it was specified that the anonymity of all participants would enjoy priority and that participants were free to withdraw from the study at any given time, as participation in the study is stipulated by the GDE to be voluntary (GDE, 2012). This ethical permission and declaration letter also stipulated the aim of the study as well as the assurance of consonant of the individual's dignity, explaining that all audio-visual recordings taken during the learning tasks would be destroyed after the research has been conducted - to ensure the anonymity of the participants (GDE, 2012). No medical testing of any learners had been conducted during the study, as this was prohibited by the GDE (2012). All the participants involved have completed and signed the declarations/permission forms requested by me.

3.11 Delimiters of this study

There are certain delimiters that set the boundaries of this research, which can be described by using the framework in Table 3.2 (Maree & van der Westhuizen, 2009). Table 3.2 served as a checklist for possible shortcomings in this study, in order to measure the validity of my study.

Table 3.2: Delimiters of this study.

DELIMITERS OF THIS STUDY	
POTENTIALLY LIMITING ISSUE	**DELIMITER**
Naturalistic enquiry	Only a limited number of Grade 6 learners in mathematics from an anonymous private school were used for observation. Only mathematics teachers from this school participated.
Inductive analysis	Only one person (the researcher) performed the data collection, analysis and interpretation.
Holistic perspective	The "Hawthorne effect" was considered for this study, as human subjects were used. This might have influenced the class environment and dynamics, which is the reason why a second group was observed without audiovisual recording.
Qualitative data	Detailed descriptions in line with qualitative data collection techniques were given; however, only one individual (the researcher) performed this task.
Personal contact and insight	The findings were critiqued, taking personal bias and the "Hawthorne effect" into consideration.
Dynamic systems	There were no changes in the classes investigated due to participants leaving the course or newcomers arriving.
Unique case orientation and context sensitivity	The context was focused on self-directed learning. Influences or differences in the environment that could affect the behaviour of participants might not be known.
Empathetic neutrality	Observations might have been strange to the audio-visually recorded learners but not to the second group of learners observed without audiovisual recordings, which did not influence their behaviour.
Design flexibility	The flexibility of this study might have been influenced by the structural research requirements.

(Maree & Van der Westhuizen 2009, pp 38–39)

3.12 Possible limitations and challenges of this study

Time was one of the biggest challenges and limitations, as only a certain amount of time was available to cover a concept. Facilitating learning usually takes more time, as learners need to engage in higher levels of thinking as they get challenged within the learning tasks. As authentic learning is not only a cognitive endeavour but is effectively transforms the learner in an observable way, changing the behaviour of the learner, facilitating learning of authentic learning may take more time. However, because facilitating learning targets the acquisition of human virtues, it will increasingly compensate for learner self-regulation of learning.

The diversity of the class posed another challenge to this study. The process of finding the knowledge, and not the knowledge itself, is important, and this can be very challenging, as learners needed to make their own way with only guidance from the facilitator of learning. Each individual think differently and might interpret facilitating learning in a very different way. This is where the facilitator of learning becomes challenged, as learners needed to be guided back on the path of success without learners being taught by means of instructing.

Facilitating learning can become particularly challenging due to a learner's lack of pre-knowledge. This meant that the facilitator of learning was challenged with creative thinking to guide the learners in solving the learning tasks. Facilitating learning requires a high-level of professionalism, as each learner had to be encouraged to think at a higher level than usual. This was the first time that learners were exposed to facilitating learning, thus, taking learners out of their comfort zone. Learners had to challenge themselves to willingly engage in thinking critically and not rely on the teacher for answers. They needed to take responsibility for their own learning and challenge themselves to reach something that felt impossible to them as they attain human virtues. I predicted that this could be a chaotic learning experience during the first task, but that it would improve with every session. There was no set recipe for what was going to happen in the classroom with this type of transcending teaching approach, but this is what sets the learning curve for this study.

Another challenge was the role I had to fulfil in this study: I had to be very careful not to force the goals of this study onto the learners, as facilitating learning can be very frustrating, and special care had to be taken at every step to ensure reliability. I needed to ensure that the learners fulfil the requirements of the current curriculum without sacrificing their achievements. This was a daunting but challenging task. As an OBE and RNCS product of the schooling system myself, this study made me aware of my own lack of pedagogical knowledge in facilitating learning and what it is that we want to convey to the learners. I had to develop and grow through this process by not just regurgitating knowledge. I needed to get my bearings quickly and efficiently when applying facilitating learning.

3.13 Recapitulation of comments

In chapter 3, one can now clearly see the steps that the researcher took throughout the study, from compiling the literature review and the research design, to the techniques used to collect and analyse the data collected from the fieldwork completed. In chapter 4, the empirical research was conducted according to the design set out in chapter 3.

CHAPTER 4
Empirical research

4.1 Introduction

This chapter contains the fieldwork conducted for this study. As indicated in chapter 3, the empirical research was essentially a participatory action research study, in an attempt to improve my mathematics education practice with my Grade 6 mathematics learners within three consecutive reflective action research cycles.

Besides the action research cycles, the following associated research components are represented in this chapter:

1. Interviews with mathematics teachers.
2. Point of departure – reflective notes on my profession before facilitating learning of authentic mathematics.
3. Participatory action research cycles.
4. Interviews with learners after the participatory action research cycles.
5. Interviews with employers in the context of mathematics.

Before the first reflective cycle were conducted, interviews with mathematics teachers in the field of mathematics were conducted, to reflect on what they experience in their teaching.

4.2 Interviews with mathematics teachers

The interviews conducted with mathematics teachers of different experience levels before facilitating learning, provided rich data to how mathematics education is viewed through implementers of the curriculum. The information below represents the most prominent results from the initial coding, as it was identified in the interviews.

4.2.1 Results from interviews with mathematics teachers

Many teachers believed that mathematics was a practical subject used to enhance everyday life. Participant four responded that learners should do things practically in mathematics and that application was therefore more important: *"…children have to learn to think in a different way, and to use the skills and methods and knowledge that we teach them to apply it in everyday life"* (Initial coding: Mathematics teachers, p. 2). Participant two was of the belief that mathematics played a

central role in our modern culture: "*In our daily life, mathematics is the basics of what we need to survive"* (Initial coding: Mathematics teachers, p. 1). Regarding how the role of mathematics determine our education, participant three indicated that mathematics education should be adapted to make provision for deficiencies in the world outside of school: *"…needs must first be identified in the outside world, where there are certain short comings. Then the education should adapt accordingly and provision must be made in your syllabus for these short comings, to address these short comings"* (Initial coding: Mathematics teachers, p. 3). Participant one thought that mathematics is woven into everything we do and every problem we have to solve, without realising it and that learners "…*work out a problem by using their maths skills without knowing it, but they work it out and they do solve a problem"* (Initial coding: Mathematics teachers, p. 3).

If the above teachers were granted the opportunity to construct the best possible mathematics curriculum, they passionately responded that mathematics should be related to their world outside of school. According to participant three "*We need to give them the tools needed so that they can be independent and know what to do"* (Initial coding: Mathematics teachers, p. 4). One day, learners will be working with their own budgets, and they should therefore be able to understand and solve certain problems. Participant three was also of the opinion that teachers need to be innovative: "*You just need to make sure that your curriculum has all the things needed, be innovative and adapt your curriculum to what is needed in the world outside"* (Initial coding: Mathematics teachers, p. 5). Participant two felt that knowledge, skills and values of the community needed to be incorporated: "*It also depends on the community and what the needs are"* (Initial coding: Mathematics teachers, p. 4).

The steps that the interviewed teachers seemed to follow, when compiling their best possible curriculum, ranged from setting learning goals to incorporating knowledge and problem solving. According to participant one, setting learning goals for oneself, could assist one in placing next steps into action: *"Remember that learning goals/outcomes do not place limits on what you can teach in a course; instead, goals provide a map that tells students where the course is going"* (Initial coding: Mathematics teachers, p. 5). The participant also believed that learning could be defined as something that you have encountered, which you have not encountered before: "*When you found something that you haven't realised before, actually knowing something that you haven't done before or you know concept of how to get to a certain problem or problem solving"* (Initial coding: Mathematics teachers, p. 5). Participant two responded that one should focus on skills and knowledge to empower learners to be able to survive in their surroundings: *"It can go*

wider with the values that the learner needs to have to be part of the community in order to have the same values as that community" (Initial coding: Mathematics teachers, p. 6). According to participant four, the teacher should present the work in real life situations and see how they cope with it by presenting problems to be solved: *"I think that's another thing, our kids are not willing, or we don't give the kids enough opportunity, to grapple with something, i.e.., to sit and struggle until you figure it out"* (Initial coding: Mathematics teachers, p. 6).

The RNCS certainly had its advantages. According to Participant three, there was an integration of many subjects, allowing information to be utilised on different levels. It taught learners to solve problems with creative and critical thinking. Learners had to work things out themselves and be helpful towards others. This helped learners *"To act as a responsible person one day and it teaches you entrepreneurial skills, which is very important"* (Initial coding: Mathematics teachers, p. 9). Participant four is of the opinion that the curriculum served as a good guideline, but limit teachers, which could be either good or a bad, as teachers can incorporate what is needed: *"It does incorporate everything you need"* (Initial coding: Mathematics teachers, p. 9).

As with anything, the RNCS also had its shortcomings. According to participant two, the implementation was problematic, as it was curriculum overload, with no clear benchmark: *"These range from curriculum overload to confusion about the curriculum and disparities in learner performance as measured against both international and local benchmarks"* (Initial coding: Mathematics teachers, p. 9); "*The admin around the curriculum was horrendous. Nobody really knew what to do"* (Initial coding: Mathematics teachers, p. 9). This participant also felt that values and skills were left unattended to: "*The focus was on knowledge at the expense of skills, values and attitudes"* (Initial coding: Mathematics teachers, p. 9). It seems that the administration was indeed horrendous when participant three added that programs were available to get teachers updated with the RNCS changes, but never addressed the concerns and there was no space for adapting the RNCS: *"I think the department tried to host these trainings and it did help to a certain extent, but I still feel that there weren't enough training"* (Initial coding: Mathematics teachers, p. 9).

The CAPS curriculum had its advantages too. Participant two agreed with Participant one's view that CAPS had a standard which one could follow, and suggested that CAPS was more user friendly and involved less paper work: "*Concepts, content and skills are set out and structured with explicit instructions on how to reach the goal"* (Initial coding: Mathematics teachers, p. 10).

According to both Participant two and three, CAPS followed a more critical approach, where learners were more involved in their own learning: "The *learner's involvement in their own learning is more"* (Initial coding: Mathematics teachers, p. 10). Moreover, critical thinking and problem solving of learners seemed to be promoted: *"They can help themselves in situations. Their self-confidence and sense of responsibility are improved"* (Initial coding: Mathematics teachers, p. 10).

When it comes to the shortcomings of the CAPS curriculum, it ranged from work overload to availability of resources. Participant three, together with Participant one, raised the concern that a lot of work needed to be covered, making the mastering of skills very difficult. Participant one's opinion was that: *"There is not really time to do a recap on the work that they didn't get*" (Initial coding: Mathematics teachers, p. 8), while Participant three's contribution to the above statement was that: *"There is a lot of work that needs to be done, which can put extra pressure on the teacher and the learner, as some learners can fall behind and struggle to keep up, as there isn't always time to catch up on the concepts missed"* (Initial coding: Mathematics teachers, p. 11). Participant two emphasised his worry that not all teachers had the same resources, leaving it to the teacher to make the work practical and applicable for the learners in that community: *"The curriculum itself is not the problem, it includes all the aspects needed, but it is the implementation of it"* (Initial coding: Mathematics teachers, p. 11). The shortage of resources, together with a lack of teacher training, as stressed by Participant three, could result in a disastrous classroom situation.

In order to improve on the CAPS curriculum, Participant three suggested that teachers should help learners to understand mathematical concepts and that class discussions should be held: *"Learners should be able to reflect on the mathematical problems and decide on strategies to solve these problems"* (Initial coding: Mathematics teachers, p. 12). Learners should be granted the opportunity to get to solutions by themselves, with the teacher only giving support: *"They can then discuss it in their groups and there where they are struggling with a solution, the teacher can always provide support"* (Initial coding: Mathematics teachers, p. 12). Here one can read that the teacher acts as facilitator of learning, by only providing learners with support and allowing learners to grapple. Participant four supported this view, and responded that learners should have time to grapple with ideas and learn the skill to decipher information to overcome information overload: *"When you go to varsity, that's what they expect of you, you're not just regurgitating information and you just throw it back to the lecturer"* (Initial coding: Mathematics teachers, p. 12).

When reading the above paragraphs, I could learn from the responses from teachers that problem solving should enjoy preference in the classroom, allowing learners to grapple and persevere, while the teacher only guides learners. This view can be closely linked to the application of facilitating learning. I would therefore like to improve my own professional teaching and application of the curriculum by means of facilitating learning together with the embedding of fundamental human virtues, as it falls in line with the CAPS curriculum. Table 4.1 below represents the axial coding of the different categories and sub-categories that one could summarise from the interviews.

Table 4.1: Axial coding from interviews with mathematics teachers.

Axial coding from interviews with mathematics teachers	
Main Category	**Sub-category**
Nature and structure of mathematics	Importance of mathematics is that it is practical / about application / apply to world of work.
	Mathematics is important for everyday life / survival.
	Mathematics enhances science / technological advancements.
	Mathematics requires us to think/understand.
	Mathematics involves calculation skills / reasoning / working out.
	Mathematics is about problem solving.
How mathematics determines education	Mathematics is present in society / daily life.
	Mathematics enables learners to reason / solve problems / think.
	Mathematics should be applied/adapted/keep up with trends.
Requirements for best mathematics curriculum	Curriculum has to make sense/ learners understand why their doing it.
	Important that the teacher knows what's going on / what to do.
	Mathematics should be about living/applying/everyday life.
	Curriculum must help with problem solving.
	One should teach learners to enjoy / love mathematics.
Steps for best mathematics curriculum	Must contain the figuring out by learner / self-study / content not seen before.
	Curriculum should feature problem solving / real-life / thinking.
	Teachers must hint / guide / give no answer / allow learners to think for themselves.
	Learners must practise / try until they get it right / grapple struggle / be challenged.
	Teachers must make the time to allow the above.
	It is very important that the teacher has goals / know where they're going / what they're working towards.
	Must contain values.
Advantages of RNCS	It encouraged discovery / self- help / life-long learning.
	Incorporated democratic citizenship / values.
	Layout was systematised / greater clarity on what taught and assessed.
	RNCS allowed overlapping / incorporation of different subjects.
Disadvantages of RNCS	Excessive admin / work overload / time consumption.
	Problematic implementation / nobody knew what or how.
	Lacks creativity and adaptation.
	Inadequate training not / addressing of problems.
	Too knowledge-based at the expense of skills and values.

Advantages of CAPS	Allowed the setting of a standard / expectations to be known / user friendliness / due dates.
	Leads learners to solve problems.
	Learner involvement is active / learners are made responsible.
	Less admin for teachers.
Disadvantages of CAPS	Learners' paces differ / needs to be made more open.
	Time lacks for recap / consolidation.
	Importance of different communities / resources not accommodated.
	Problematic implementation / teacher training.
	Teachers need to have a set of skills / the right people picked to do the job.
	Not accommodating Multi-level teaching / providing guidelines for multi-level teaching.
Improvements from RNCS to CAPS	Learners understand what and why they are doing it.
	Curriculum has more critical and creative thinking / problem solving present.
	Progression is present in curriculum
Advice for classroom practices	Important that problem solving / doing work themselves is incorporated.
	Learners should think /put in effort / ask / grapple / struggle with work
	Flexibility should depend on different schools / resources.
	Better planning of time is needed.
	Should allow more class discussions / different methods / strategies to be given.
	Teachers should only provide support.

(Derived from interviews)

4.3 Point of departure for action research

The point of departure for my action research cycles first started with a reflection of my professional practice, before I endeavoured in my quest in facilitating learning of authentic learning as described in chapter 3.

During my teaching, prior to the action research cycles, I felt compelled to jump to the explanations and examples as soon as possible, thinking that I was equipping learners with the necessary tools with every example and explanation given, before they had to rush to the next class. I would hurry through the content they needed to know, explaining the work in detail, giving examples, drawing on the board, ensuring that learners knew the content before they started with their activities. Thereafter, learners would open their workbooks to start writing the date and the heading of their activity. If learners did not understand, I hurriedly repeated the work again, giving them answers to their questions. After the lesson, learners would hurriedly clear their tables and rush to the next class. Though the CAPS curriculum was very clear, it demanded a strenuous amount of activities, which meant that I had to rush through concepts within the given time set out in the CAPS curriculum document. This placed pressure on me, increasing the frustrations of failing learners who showed no interest in the work. This was very frustrating to me, as the "good teacher" that I thought I was. It still seemed that learners had no respect for me, no matter how much effort I had put in and supported them.

I noticed that I had to re-explain the work all the time. Learners were absent-minded, asking the same questions repeatedly. Some learners had a careless attitude towards their academics, referring to incomplete work. It was as if responsibility for their learning was not taken. "*I noticed that the learners still waited for me to give them the answers and didn't try too hard to figure it out themselves*" (Reflective journal, p 1), as they knew that the answers would be given to them, irrespective of their lack of efforts.

I was grappling with the thought that teaching meant explaining and demonstrating examples to learners, showing them how to do what they needed to. I believed that learners were learning when they could perform calculations correctly, regurgitating what I have taught them. It was when I read the article by Claxton (2012) stating that education is a *"moral enterprise"* and that we constantly follow *"value judgements about what is worth knowing, and what kinds of young people we are trying to turn out"* (Claxton, 2012, pp 1-2), that I understood the criticality of the focus on the learner in totality, moving away from teaching to facilitating learning. It is therefore not only

the transfer of the curriculum that takes place within a classroom; it also includes the controlling of their interactions. We are trying to prepare learners for their futures, expecting of them to follow value judgements of what is important to know, but we cannot do that if learners cannot take responsibility for their actions and if they are not able to analyse a situation without regurgitation. *"A change is needed to get learners to take more responsibility for their learning and to embed the crucial human virtues so desperately needed in society and the world of work within the 21st century"* (Reflective journal, p 1).

In the beginning of the year a learner questioned why they should learn mathematics: *"I immediately referred to everyday situations, for example calculating the time it takes them to get ready in the mornings, implying that calculating the amount of time you have left is part of everyday life, which is part of mathematics. I realised that mathematics should be made as authentic and practical as possible*" (Reflective journal, p 2). This reflection led me to realise the importance of conducting the research cycles of authentic learning by means of facilitating learning.

For the following action research cycles, I decided to focus on the acquisition of human virtues to solve authentic problems by means of facilitating learning in order to gain 21st century skills. I started putting certain strict rules in place, such as standing quietly in two proper lines before entering the classroom, standing on attention with shirts neatly tucked in before greeting, and ensuring that your table is shifted on the exact location provided, before leaving the classroom. These rules were not put into place to dictate learners, but to rather support the human virtues such as respect and responsibility throughout the study. I knew that I would experience moments of grappling, just as my students would, as I knew that I was opening myself up to the real meaning of what it is to learn, just as I would be doing with my learners.

4.4 My action research cycles

4.4.1 Introduction

Within the following paragraphs of the study, the empirical research of each research cycle is represented and analysed. For each research cycle - according to the facilitating learning model presented in chapter 2 (Figure 2.14) – the following structure was followed -

1. The Plan represented the first function of facilitating learning by means of the LTD.
2. The Act step represented the function of the LTP, which can be identified within the LTD.
3. The Observe step represented the three functions of maintaining learning by means of

facilitating learning (LTE, LTF and LTC).

4. The reflect step represented the authentic learning that took place by means of reflection.
5. The Review step represented the aspects the researcher formulates that needs to be changed in order to build an improvement on the next research cycle.

All three of the authentic learning tasks were aligned with the CAPS curriculum and focussed on measuring. The same learning task design format in all the research cycles can be observed. One should also take note that facilitating learning is the focus and that it is more than three tasks, as the journey began with embedment of human virtues from the beginning of the study, between the three learning tasks and after the three learning tasks have been conducted. The learning tasks were more complicated than it seemed, as the planner needed to take the holistic human elements (the physical-, emotional-, mental- and spiritual intelligence) into consideration while still following the CAPS curriculum document, in creating a task of a real-life situation where facilitating learning could be applied.

Table 4.2 represents the relationship between human virtues (interpersonal and intrapersonal), the needed 21st century skills and the five minds of the future and how they were applied in the study within each of the learning tasks.

Table 4.2: Human virtues, 21st century skills and minds of the future

The relationship between human virtues, 21st century skills and minds of the future				
Human virtues		**21st century skills**	**Minds of the future**	**Introduced in which task?**
Intrapersonal	Self-Motivation	Critical thinking	Disciplined mind	Learning task 1
	Perseverance			
	Responsibility			
	Self-motivation	Critical thinking	Disciplined mind	Learning task 2
	Perseverance	Creative thinking	Synthesising mind	
	Responsibility		Creating mind	
	Effort			
	Initiative			
	Independence			
	Self-motivation	Critical thinking	Disciplined mind	Learning task 3
	Perseverance	Creative thinking	Synthesising mind	
	Responsibility		Creating mind	
	Effort			
	Initiative			
	Independence			
	Self confidence			
	Common sense			
Interpersonal	Humanisation	Communication	Respectful mind	Learning task 1
	Communication	Collaboration	Ethical mind	
	Dealing with feelings			
	Humanisation	Communication	Respectful mind	Learning task 2
	Communication	Collaboration	Ethical mind	
	Dealing with feelings			
	Humanisation	Communication	Respectful mind	Learning task 3
	Communication	Collaboration	Ethical mind	
	Dealing with feelings			
	Leadership			

(Derived from Chapter 2)

4.4.2 Cycle 1: Learning task 1

The first research cycle refers to the first learning task of the participatory action research cycles that I conducted, using facilitating learning as my pedagogical approach. When the athletics and the sport season started, learners became infatuated in playing with different sport balls (hockey ball versus tennis ball) at the same time. When throwing the balls to each other, the learners asked me why the tennis ball and the hockey ball did not reach the other person at the same time. At first, I replied that each person throws it differently, but they then started questioning my comment, as they let the same person throw the two balls at the same time. This soon became a guessing game between the learners as they started to play with the balls, so they decided that the person who could guess the outcome correctly for the most times, was the winner. Clearly, they were curious about this phenomenon and I had no distinct answer for them. Learners also questioned me on how the sprint winners could be announced if the difference between the winner and the second place was so close. These inquiries reminded me that learners were acquainted with the progression of time, up to the last second, but they were not familiar with smaller time intervals such as a tenth of a second. Playing with balls and seeking answers to questions directed me to my first learning task.

4.4.2.1 Plan: Learning Task Design

For the first learning task, I expected learners to learn about smaller time intervals, using stop watches to calculate the average time fallen for each of the different balls (as mentioned in Table 4.3).The learners could repeat the experiment until they were satisfied with their results. This task was chosen specifically as learners needed to focus on variables; they needed to be honest in their calculations and they needed to communicate efficiently to be able to complete the learning task.

Within this learning task, attainment of the fundamental interpersonal human virtues of humanisation, communication and dealing with feelings, together with the intrapersonal human virtues of self-motivation, perseverance and responsibility was observed (Table 4.2). Some of the 21st century skills that were observed, included critical thinking, collaboration and communication; the disciplined mind was also visible (Table 4.2). I specifically chose this learning task of measuring time because I wanted to connect science with mathematics, to make learners aware that mathematics is more authentic then they expected it to be. I wanted learners to realise that they should never guess their answers, as they had done previously in the mathematics class and on the playground.

My aim with research cycle one, was not only to improve my professional practice in facilitating learning, but also to engage learners in authentic mathematics to reach their full potential and to support learning of the highest possible quality. With all the above in mind, I was still not sure what I, as the student and researcher, was doing or needed to take from this journey as I have not applied facilitating learning in the field of mathematics before. Within this learning task, learners had to find a way of testing and proving that their prediction was right without me providing them with the steps or the solution. Table 4.3 represents the Learning Task Design of the study, for the first action research cycle in facilitating learning.

Table 4.3: Cycle 1 - Learning Task Design 1

LEARNING TASK DESIGN: Learning Task 1

Name	Herné Labuschagne				
Student number	29599378				
Date	September 2015				
No of LTs in each paradigm already designed	**Total**	**Transmit**	**Transact**	**Transform**	**Transcend**
	1			x	X
Sequence number of this LT, its paradigm (P) and category (CAT)	1	**PAR**		**CAT**	
Phase and Grade	Intermediate Phase – Grade 6				
Learning Programme/Area/Subject	Mathematics				
Curriculum content (Copied from the official Curriculum or Syllabus documents)	Measurement: Time Measurement focuses on the selection and use of appropriate units, instruments and formulae to quantify characteristics of events, shapes, objects and the environment. It relates directly to the learner's scientific, technological and economic worlds, enabling the learner to: □ make sensible estimates; and □ be alert to the reasonableness of measurements and results.				
Time to operationalise LT	3 sessions of 30 minutes each				

Learning outcomes and assessment standards (Copied from the official Curriculum or Syllabus documents)

Learning Outcomes	**X**	**Assessment Standards**	**X**
6.4.2.4 Time: Learners should be introduced to the use of standardised units of measurement and appropriate instruments for measuring. They should be able to estimate and verify results through accurate measurement. □ Learners should be exposed to a variety of measurement activities that will make it possible to select and convert between appropriate units of measurement and to use common fractions and decimals in context.		**Solve problems involving time**	

Real life challenge (In one or two sentences: Answering the fundamental learning questions)

Why do learners need to learn this curriculum content?

Learners work with time every day of their lives, following timetables, calculating how much time they have left to prepare for school and daily life situations. Learners are also directly involved with different sport activities, where the time intervals between two hurdles can differ very slightly but make an immense difference to the results.

What is the role, function and value of this curriculum content in the lives of the learners right now?

They need to know that every interval of even a second makes a difference. From this lesson, they should comprehend the value of one's reaction speed and how to utilise different time intervals effectively when repeatedly working with stop watches on the same event. They should also discern that the different reaction speed will influence their results. Therefore, when it comes to group work, punctuality and communication is crucial, as is to respect one another's decisions.

Where/when in the lives of the learners will they be required to do what you expect them to do?

It is important that learners are able to comprehend that in any situation, there might be exceptions (such as some of the measurements taken at first that might not make sense when looking at the rest of the data gathered), that one would sometimes need to ignore when making a generalisation. In this case, learners needed to calculate the mean of each ball's falling time, within a hundredth of a second, leaving a few readings to stand out from the repeated readings. Here, learners needed to use transgression to which readings they would need to use in calculating the mean.

What is the challenge (problem) you want the learners to solve (resolve)?

I would like learners to be able to work with a stopwatch, being able to read time in time intervals as small as a hundredth of a second. I would like learners to be able to calculate the mean of their results to the best of their ability, and to keep persevering until they are satisfied with the data, so they can explore different reasons for their results and force them to reflect on their actions and thoughts, helping them in the process of attaining humanisation.

Critical Cross-Field Outcomes (Copied from official Curriculum or Syllabus documents)

CO 1	Identify and solve problems and make decisions using critical and creative thinking	x
CO 2	Work effectively with others as members of a team, group, organisation and community	x
CO 3	Organise and manage themselves and their activities responsibly and effectively	x
CO 4	Collect, analyse, organise and critically evaluate information	x
CO 5	Communicate effectively using visual, symbolic and/or language skills in various modes	x
CO 6	Use science and technology effectively and critically, showing responsibility towards the environment and the health of others	
CO 7	Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation	x

Developmental Outcomes (Copied from official Curriculum or Syllabus documents)

DO 1	Reflect on and explore a variety of strategies to learn more effectively	x
DO 2	Participate as responsible citizens in the life of local, national and global communities	
DO 3	Be culturally and aesthetically sensitive across a range of social contexts	
DO 4	Explore education and career opportunities	
DO 5	Develop entrepreneurial opportunities	

Fundamental human virtues

Intrapersonal		**Interpersonal**	
Self-confidence		**Humanisation**	X
Motivation	X	**Communication**	X
Initiative		**Dealing with feelings**	X
Effort		**Justice and forgiveness**	
Perseverance	X	**Love**	
Common sense		**Leadership**	
Responsibility	X		
Independence			
Curiosity			
Joy			
Love			

LEARNING TASK PRESENTATION

Verbal presentation

On the desk, we have six different balls. Each of them is made from a different material and has a different size. We know that when we throw these balls, they all don't reach a place at the same time. Now, I want you to predict which one would hit the floor first. You can look at each ball, feel it, pick it up, or whatever it is that you feel you need to do to choose your winning ball.

Now that you have chosen your desired results, I need you to tell me how we are going to measure whether your choice is correct or not. How are we going to test your prediction? We will now endeavour on our quest to find out the truth.

Written presentation

Only the names of the different balls will be written on the board with the choice of each learner as to what they expect will happen at the end of this experiment.

LEARNING TASK OUTCOMES

Assessment Methods, Tools and Techniques

Assess Met, Tools, Tech
Learners will present their calculations of finding the mean of the different time intervals taken repeatedly and how they reached their findings, in written format. Learners will then need to write a short summary of what they have learnt from this learning task. They should conclude that each person's reaction time has an influence on the results

of an experiment, and that the experiment should therefore be repeated until a conclusion can be made. Their results should also show that it is the hockey ball that hit the ground first.

AUTHENTIC LEARNING CONTEXT

Organisation of learning space	We will be conducting this experiment outside the classroom on a highest platform that learners can use to throw the balls from. Learners will actively be involved within this task.
Roles, functions and organisation of participants	All participants should work together to accomplish the goal of interpreting the different time intervals of each ball, repetitively and accurately. I, the researcher will need to be the facilitator of learning with every step of the learners' reactions.
Material and equipment	A golf ball, bouncing ball, netball ball, tennis ball, hockey ball, sponge ball, a piece of paper with a pen and two stop watches will be used within this task.

END PRODUCT OUTCOMES

(As would be expected/required to be produced by a learner exceptionally well)
The learning process

1	Learners will need to comprehend the task at hand and by themselves, recognise what steps they will need to follow to be able to provide evidence for their prediction.
2	Learners will need to identify the appropriate learning space to carry out their experiment for verification of their prediction, identifying problem areas within their process.
3	Learners will need to grasp how to work with a stopwatch by themselves, after they have identified the importance of its use within this process. Learners should be very vigilant in the taking of the time, as two learners will simultaneously be working in small time intervals.
4	Consideration must be taken to the above flaw, as learners should compensate by repeating the experiment repeatedly in order to obtain the most representative results (by calculating the mean of the most representative time values).
5	Learners will need to identify any possible flaws within their experiment and rectify it as soon as possible (For example: to ensure that the ball being dropped, is dropped from the exact same position with every drop. This includes the position for each different ball, improving the accuracy of their results.)
6	Learners will need to persevere in keeping the results accurate and repeating the experiment until enough data has been collected as accurately as possible.
7	Learners will now need to comprehend that they are working in hundredths of seconds, and that single readings that doesn't fit with the group, should be eliminated in their calculations of the mean.
8	Learners should be able to identify that each person's reaction can influence results and that there is more than one factor that can play a role in their quest to finding the truth.

The learning product

Learners will need to conclude that the hockey ball hit the ground first. They will also need to comprehend how they calculated this, considering the reaction times of different people.

The learning content

Learners presented their calculations on paper of how they concluded their answers. Here, their working with the small time intervals can be visible.

Resources

Calculator Soup 2015. Sphere calculator. Retrieved from: http://www.calculatorsoupcom/calculators/geometry-solids/sphere.php.

Hall, N 2015. Free falling objects: No air resistance. Retrieved from: https://www.grc.nasa.gov/www/k-12/airplane/ffall.html.

Hall, N 2015. Terminal Velocity: gravity and drag. Retrieved from: https://www.grc.nasa.gov/www/k-12/airplane/termv.html.

Hewitt, LA, Hewitt, PG & Suchocki, J, eds, 2008. Pearson International Edition: Conceptual Physical Science (4th ed.), pp 38-44. San Francisco: Pearson Addison Wesley.

Shipway, A & Shipway, S 2008. Terminal velocity finds the maximum falling speed of an object. Retrieved from: http://www.calctool.org/CALC/eng/aerospace/terminal.

The Engineering Toolbox. Drag Coefficient. Retrieved from: http://www.engineeringtoolbox.com/drag-coefficient-d_627.html.

(Derived from Slabbert et al 2009, CD-ROM, p 22 – 34)

4.4.2.2 Act: Learning Task Presentation

The task was presented as seen in the Learning Task Design in the section above (4.4.2.1). As one of the time keepers at the athletics sprints, I was still in possession of two stop watches in my drawer. I placed them on my table to be used in the learning task, if learners chose to utilise it out of their own initiative. The different sized balls were also placed on one of the class room desks, which I utilised in the verbal presentation of the learning task. We initiated the learning task in the classroom, keeping the decisions of the learners' execution in mind (with the anticipation of learners electing to execute their experiment outside on a higher platform to drop the different balls from). Figure 4.1 illustrates the predictions that each learner made at the beginning of the learning task, before they were informed that they needed to prove their prediction.

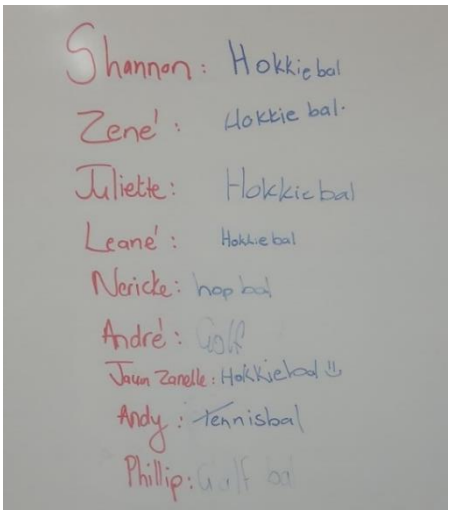


Figure 4.1: Predictions written on the white board
(Own photograph: 2015)

Learners did not know where to start with the learning task and they became aware of my sudden change in behaviour (only answering their questions with another question); they became frustrated that I was not providing them with answers to the problem. As we started the task with our usual class rituals in how we greeted, the learners did not suspect anything different that day. *"It was only until they realised that they did not need to take out their books but listen to my problem statement before they could do anything, that they were very surprised…"* (Reflective journal, p 8). They could not understand why I was asking so many questions and *"…why I did not give them examples"* (Reflective journal, p 8) or explanations. Learners were very curious, and I felt compelled to give them instructions, as I was used to, but I had to prevent this from happening, as it would defeat the whole purpose of the learning task. This left both me, as the facilitator of learning, and my learners in a curious state of mind of how this learning task was going to progress.

4.4.2.3 Observe

1. Learning Task Execution

The learning task was executed over a longer time period than a usual hour session, as learners had to immerse themselves in the learning task until satisfied results were established.

At first, the learners were clueless in how they were supposed to solve this problem, as they had to devise a solution on their own, without me spoon feeding them. From my observations and field notes, one can tell that I experienced a lot of dependency from the learners on a daily basis, as

they *"…tried to rely on me to give them more answers. Instead of trying themselves…"* (Reflective journal, p 8). Learners seemed to not *"…know what to do when I put them in control of their own experiment"* (Reflective journal, p 8). Being the facilitator of learning, I realised that learners needed plentiful encouragement and emotional support.

When I asked learners how we could confirm which ball hit the floor first, one learner realised that time was playing a role in this challenge and asked me for the stop watches on my desk so that they could measure time. This learner noticed the stop watches in the classroom earlier and used own initiative to come up with a possible solution, even though there was some uncertainty. When I smiled, I could notice the feeling of confidence and pride on the learner's behaviour. This small reaction started to proliferate, as learners finally realised that they could accomplish something and get closer to the solution. They decided to use two stop watches to improve their accuracy. The learners measured and recorded the different falling times of the different balls and tried to calculate the average time for each ball, dropped from the same position and height for every drop. Learners decided *"…to retake the results, to make sure that they get accurate results. Learners started to throw the balls one at a time while recording the time, as they decided that throwing all the balls down at once would interfere with their accuracy"* (Field notes, p 1). The learners therefore demonstrated perseverance in their quest to determine which ball would hit the ground first. Some attempts were made to drop two different balls at a time, comparing their times of the fall. Another attempt was to drop *"…the same ball separately but repeatedly to get the average of the falling time"* (Field notes, p 1).

Table 4.4 on the following page, presents the observation schedule used as a criterion of success to evaluate facilitating learning that took place during learning task 1.

Table 4.4: Observation schedule – Learning Task 1

FACILITATING LEARNING

OBSERVATION SCHEDULE

Learning Task: .....

FUNCTION	ACTION	NUMBER OF TIMES: //// = 5 OR QUALITY: 0=absent; 1=poor/low 5=excellent/high						Total
		0	1	2	3	4	5	
Learning Task Presentation (LTP)	Clarity				✓			
	Importance			✓				
	Urgency			✓				
	Action				✓			
Learning task execution (LTE)	How well is metalearning (ML) maintained (time and actions)		✓					
	How well is cooperative learning (CL) maintained (time and actions)				✓			
Authentic Learning (AL)	How well was authentic learning in general maintained				✓			
Learning Task Feedback (LTF)	Giving recognition and approval for staying engaged	///						3
	Reverting learners' questions back to them for answering	//// //						7
	Asking for clarification	//// //						7
	Elicit critical reflection	//// //// ///						13
	Requiring resourcefulness	///						3
	Evoking resilience	/						1
	Advising auto-education							
	Providing edutainment							
Learning Task Consolidation (LTC)	Learners consolidate what they have learned				✓			
	Learners critically asses peers' consolidation				✓			
	FOL assess				✓			
Fundamental human virtues	Attaining fundamental human virtues				✓			

2. Learning Task Feedback

At the beginning of the first learning task, the learners easily followed the new class rituals of standing on attention when greeting, etc. Learners knew what was expected of them in terms of the way they treated one another, but I realised that I was not yet confident with facilitating learning. At the beginning of facilitating learning, I asked learners to tell me how they were going to prove their prediction of which ball would reach the ground first, and the communication between us were as follows:

Learner 1: *We can throw two balls lightly between two people and the one that comes down first, is the one that landed first.*

Me: *Do you think it is going to be accurate to throw the ball from one person's hand to another person's hand?*

Learner 2: *It might not work because what if you look at the other person's hand and the other ball goes high into the air.*

Me: *So how can we find the best way to determine this?*

Learner 3: *We can measure it with a scale.*

Me: *Remember, it is not the weight that we are interested in.*

Learner 4: *What if someone counts how long it takes to drop the ball?*

Learner 5: *We can look at the time it takes to drop.*

The above discussion was captured from the audio-visual recordings made during the learning tasks. It demonstrated the type of feedback provided during the learning task. One can see how meta-learning is stimulated. Learners wanted to use two watches to take the time of each fall. This was suggested by the learners themselves, as they became more confident. At a later stage I asked learners if they were going to drop all the balls together at once, but they disagreed. When I asked them why, the replied by saying: "*The balls might bump into one another and they won't be able to time each ball."* (Field notes, p. 1). I also asked learners what they were going to use the second stopwatch for. One learner replied that it is to test the reaction of one another. Another learner replied that it is to get the average of the falling time. The two learners in charge of the stop watches started to communicate to ensure that both utilise the stopwatch as identically as possible.

I realised I had mistaken when I asked: *"Who is going to write down the times?"* Instead, I rather should have asked how they were going to use the time intervals that they collected (Reflective journal, p. 7). The following feedback were also provided: *"Do you think we need to redo it, or do*

we need to continue?" Learner one and two responded: *"I think we must redo it"* (Reflective journal, p. 7). Learners were told that they were going to redo it until they got it right. Every time they dropped a ball, *"I reminded them to make sure that they used the same hand position for each fall"* (Reflective journal, p. 7). At the second session, *"I already told the one learner that he had to throw both balls and make sure that his hands are on the same height* " (Reflective journal, p. 7). This was not facilitating learning executed correctly, as this was once again a suggestion , instead of asking a guided question. One can easily recognise, that it was very difficult for me to stand back and not help learners by giving instructions and explanations. Even though I responded in question format most of the times, it seemed that I still made statements in my posed questions, concealing the instructions within these questions.

After the third time of repeating the same experiment, I asked the learners who were dropping the ball: "*When you throw the ball, where are you holding it? Do you think it is accurate? Do you think you are going to get the same readings? Where are you going to hold it?" What do the rest of you think is the best way to hold it?*" A learner suggested that the person that drops the ball should: "*Hold your hand on the railing*". One learner asked if she should hold it in a certain position and I answered with: *"What do you think?"* But then a learner asked if her position was correct and I told her: *"It is going to make a difference."* (Reflective journal, p. 7). In hindsight, I should not have made this statement but rather have asked it in a question. The learners, who were recording the falling time, were asked what the best way would be to take the time. One learner said that they should *"…lie down on their tummies."* So, the learners - taking the time - tried it. At this stage, facilitating learning was visible within this learning task. As strenuous as it was to make this mind shift as a facilitator of learning, I have learned from this.

I could observe the following changes within the reactions and behaviours of the learners during this learning task:

1. Learners seemed to become more confident in taking control of their own learning.
2. As the learners took control of their learning, they demonstrated responsibility for their own learning.
3. When learners took responsibility for their own learning, the urge to solve the problem increased and so did their curiosity, leading a higher level of perseverance than what they have showed in any of the lessons I ever gave in the classroom.

4. Persevering meant that learners had to start thinking critically in order to get to the correct results and not only a solution to finish the learning task – achieving the 21st century skill set out in the learning task design.
5. This meant that leaners continuously worked hard to become better at what they wanted to achieve, which means that the disciplined mind has visibly been activated with the learners.
6. Learners were forced to communicate with one another, as they had to work together to reach the desirable results. Many times, one could recognise their frustrations with one another, but also the effort they put in not to take it out on the person, but to rather respect the person.
7. Communication with one another therefore improved as their dealing with frustration in a respectful manner improved.
8. In saying the above, though improvements can still be made, it seems that the virtue of humanisation can be visible in their reactions towards others.

The above observations made me realise that I had to have more faith in the learners and enable them to take responsibility for their own learning; I had to act only as a facilitator of learning, thus guiding learners, without explaining and instructing them on what to do next. Though the implementation of facilitating learning was still very challenging and perhaps not completely successful, I still seemed to have gotten positive results, which made me aware of the importance of meta-learning and facilitating learning within authentic mathematics learning tasks.

3. Learning Task Consolidation

At the end of the task, learners had to look at a part of the video recording to see that the hockey ball landed first. When I asked learners, after the task was completed, what they have learnt during it, they came up with the varying reaction times recorded by themselves and their peers. They had also learnt that *"you can't only do an experiment once to make a conclusion"* (Field notes, p 2). Learners were also asked to name the ball that they found hit the floor first.

For the learners to identify the correct ball, they first had to start: *"…working out the average time that each ball fell, and then wrote down what they concluded"* (Field notes, p. 2). Learners really grappled with the calculations of the average time interval for each ball, as some of the learners still used the intervals that did not fall in line with the other times taken for a single ball. I feel that I was perhaps not very successful in facilitating learning when it came to this part of the task, as I pointed out to learners that they needed to look closely at the difference in the time intervals they took before doing their calculations. This was a very vital aspect that I did not expand on.

Figure 4.2 illustrates the work of three (anonymous) participants. Although it is in Afrikaans language, they simply stated that each person's reaction time was different from each other and that the speed of each ball was also different. They illustrated some steps they followed to work out which ball hit the ground first, looking at the total amount of time each ball fell with the different attempts. With this learning task, 5 out of the 9 learners chose the hockey ball, 2 chose the golf ball and 1 learner chose the tennis ball. When taking terminal velocity and surface area into consideration in this learning task, the hockey ball would hit the ground first, with the golf ball as the second ball to land. This means that more than half of the learners, without knowing it, made the correct predictions.

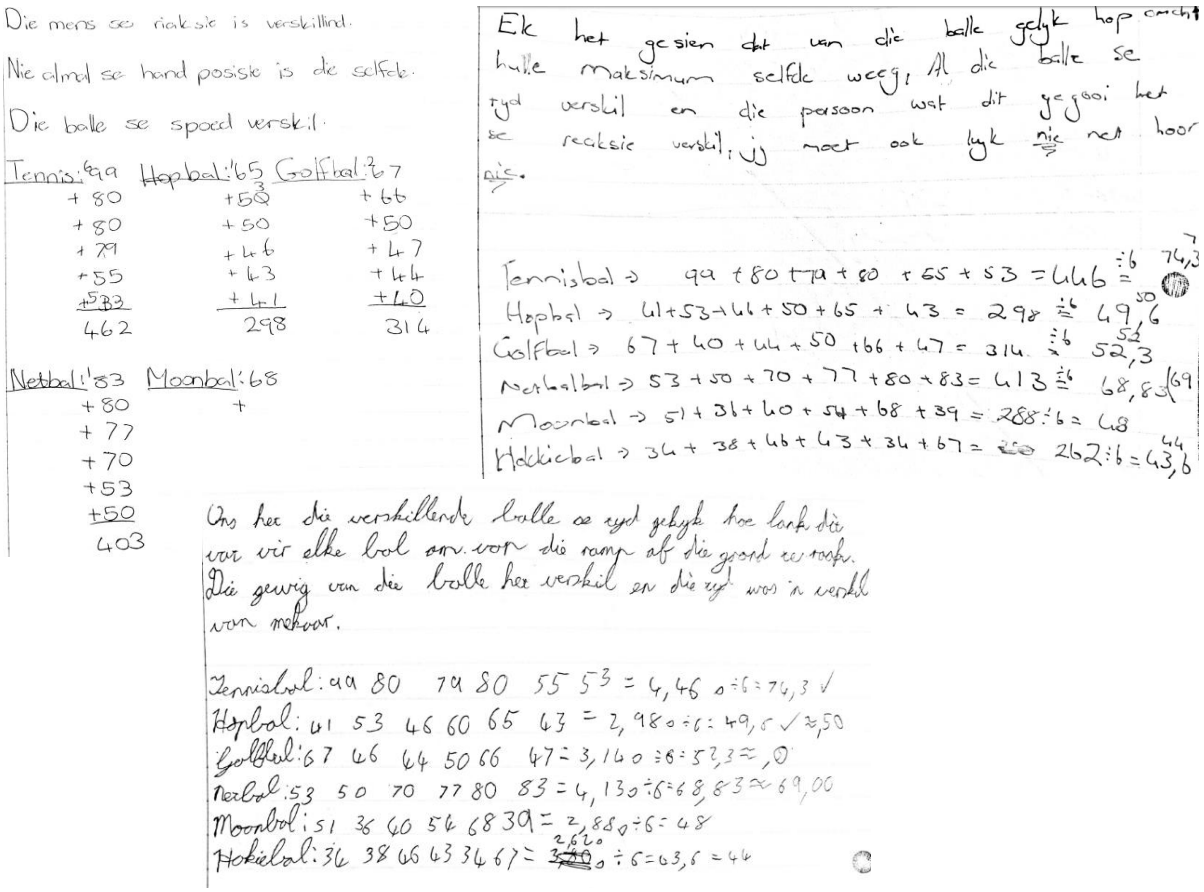


Figure 4.2: Observation of Cycle 1 – Learning task 1

(Anonymous participants' work)

4.4.2.4 Reflect

During the first learning task, learners struggled a bit with the challenge, but eventually got on with it. At first, learners thought that they could simply guess the answers, but they realised that they would need to derive a plan of action. They were very hesitant about their answers and asked me what they should do. This was a good start, as they slowly started to come up with ideas and became captivated with finding the solution. When it came to the part where learners had to time the fall with two stop watches, the two learners communicated before-hand on how they were going to press the timers. When they wanted to write down the average time of the fall, one learner told another learner what they should try next*: "…you should write down tennis ball and then…"*, which meant that their communication improved a lot and they started working together as a team. With learning task 1, I managed to get the learners to accept more responsibility for their own learning and to start thinking critically and not merely regurgitate what I say. This task was a learning curve for me as a professional teacher, as I needed to improve my facilitating learning and should have guided learners more by asking questions and not making suggestions. I felt unsure of *"…which questions to pose to the learners when they gave me feedback, and out of nature, started to explain, where I quickly needed to stop myself* (Reflective journal, p 8). I wanted learners to challenge themselves, however, learners are constantly *"…relying on teachers to do the thinking for them and only instruct them what to do next"* (Reflective journal, p 1). It seems that I should have paid more attention to facilitating learning when the calculations for the average timing were calculated, as I can see that I confused a few learners in this regard.

Although facilitating learning was still a challenge for me, I became a better reflective teacher in facilitating learning. I have learned a lot from the learning task and learners were exposed to a challenge that, for the first time, they had not been instructed on. Although I think that I successfully have activated the human virtues of self-motivation, perseverance, communication in learners as they dealt with feelings in the form of frustrations, I have no clear evidence that this is true. However, I sensed a definite positive change in the behaviour of learners, but I will have to make a much better effort regarding the learners' attainment of virtues.

4.4.2.5 Review

Overall, the learners taught themselves how to use a stopwatch and learnt that each person's reaction time is different. They understood that different variables play a role in any situation, and that they would need to employ critical thinking when working with problems. When referring to Table 4.4, one can clearly observe that critical reflection was elicited in profusion, emphasising

the critical thinking of learners employed within this task. They also learned that they would need to repeat tests in experiments to get more accurate results. It was clear that the learners realised with great surprise that the teachers were not always going to spoon-feed them and that they needed to take responsibility for their own learning.

After Learning task 1, learners were getting used to the rules applied in my classroom: those I set before my action research cycles. Learners therefore already knew that I would only greet them when socks were pulled up, shirts were tucked in, their tables were moved to the correct position on the tiles and they were standing to attention. "*This caused them to leave very orderly out of the class and them not pushing one another and screaming in each other's ears as they move to the next class. This meant that the virtue of justice and responsibility seemed to prevail*" (Reflective journal, p. 9). Even though learners had more respect for one another, and my class was very neat and tidy, I realised that there was still a lot of other human virtues to be focused on, such as responsibility, perseverance and independence.

Despite some successes in executing facilitating learning (as mentioned earlier), I would like to express the fact that my experience of facilitating learning in practice was much more overwhelming than I could ever have anticipated. I started off with presenting the learning task and despite the fact that I thought I had it all under control, I faltered. My presentation may have lacked clarity (Table 4.4) and therefore the learners were confused as to what they had to do. Fortunately, what stuck with me is that I should refrain from giving instructions and avoid giving learners the answer, if they could not do so, and rather pose guided questions. The consequence, however, was that I continued asking questions, nearly without stopping. Two aspects came to the fore: I had not spent enough time to formulate my LTP clearly, and I also completely forgot to have the learners engage in meta-learning, where they needed to plan the execution of the learning task before I allowed them to leave the class to drop the balls outside the classroom. Also, my LTP may not have been clear enough and my responses not functional enough. This caused a kind of 'chaos' to last longer than necessary. Despite the uncertainties, the learners realised that there were certain rules, which were not to restrict, but rather to benefit them. For example, when leaving the classroom, it did not mean that they could misbehave; similarly, when entering the classroom they realised that they were entering a different space that required a different discipline: neatness in their person, their classroom and always respect towards everyone and everything. Lastly, during my LTF, I omitted that the learners' readings were actually accurate, and that the learners could actually engage in a substantial time of the LTC.

After the first learning task, I felt like a failure: I simply did not feel that I accomplished anything. During the task, I realised that the learners did become aware of how difficult it was to find a way in which they would be sure that the balls would fall from exactly the same height and that measuring the time accurately was very difficult. The learners also learned that the reaction time to start and stop the stopwatch was different form one learner to the other. Although my rapid uninterrupted questioning was not necessarily functional in one sense, the learners did come to the understanding that if things are so difficult to execute accurately, that they needed to find the best possible way through critical thinking and ensuring that they are doing it as best as they possibly can. Even then, learners would still need to do many repetitions of the same thing so that inaccuracies could be eliminated – without me telling them this. Although the learners got frustrated with my interfering questions, it seemed as though they started to understand why it was necessary and that they needed to take it to heart as an effort in taking responsibility for their own learning. I realised that my accomplishments in this first attempt at a fully-fledged facilitating learning practice, did not lie in the big things that I have not accomplished, but in the small things, which I have. This inspired me to design the next learning task, bearing in mind and addressing the limitations in the first one as far as possible.

4.4.3 Cycle 2: Learning task 2

This research cycle represents the second learning task that was conducted. This cycle focused on the strengthening of the human virtues, 21st century skills and minds embedded in the previous cycle. However, one will notice in the following paragraph that more virtues have also been added to this research cycle. I also attempted to improve my facilitating learning skills.

The challenge in learning task 2 was chosen for two separate reasons: the first reason was that learners were asking me to bring a wedding photo to class (as I recently got married at that time), and the second reason originated from an incident that took place previously in class. One day, during our Cammi session in mathematics, one of the very perfectionistic learners refused to place an opened coke can on one of the shelves in the computer lab when asked to do so. When I asked why he was behaving unacceptably, he explained that he was annoyed that the shelf was too skew to place anything on it without letting it spill. Receiving sympathy from the rest of the class, they asked how we could fix it. I told them about the 90-degree angle we could place underneath the shelf for support, and we carried on as usual with our lesson that day. When I had to design my second learning task, I remembered this day and decided that using the theorem of

Pythagoras would construct an interesting challenge, when one incorporates the wedding photo frame. The following paragraph describes the design for Learning Task 2.

4.4.3.1 Plan: Learning Task Design

In this learning task, learners were given specific measurements of a photo frame, together with the space available on the shelf for the arm of the frame to fit on the shelf. Learners then had to take the given measurements and utilise them to accurately measure the length of the arm needed for a specific photo frame to stand on a shelf.

The interpersonal human virtues I wanted to focus on is humanisation, communication and dealing with feelings such as their frustrations during their grappling and perseverance that they learnt in the previous task (to ensure accuracy). The intrapersonal human virtues added for this task include independence, effort and initiative, together with the virtues of self-motivation, perseverance and responsibility focused on in the previous cycle. With critical thinking, collaboration and communication focused on in the previous cycle, I decided to add creative thinking to the 21st century skills I wanted to embed (refer to Table 4.2). I was determined to refrain from giving any answers, but to rather answer learners with a question that would lead them to a deeper reasoning than in the previous task.

The Learning Task Design can be found in the learning task folder, within the fieldwork folder of the flash disk attached.

4.4.3.2 Act: Learning Task Presentation

We entered the classroom and waited for everybody to stand on attention so that we could greet each other. This took quicker than usual, improving the quality of the Learning Task Presentation, as the attention of learners were captured from the beginning. The task was presented according to the Learning Task Design. Learners were asked to place an arm on my photo frame, so that I could place my wedding picture on top of my book case, but that I specifically wanted it to be placed up right and not at an angle, as it will be placed on the top of the book case. Learners were given the height of the frame (18 cm) and the distance available on the shelf for the arm to rest on the bookcase (10 cm). They were also informed that the arm of the frame needed to be attached in the middle of the frame (height-wise, therefore 18 cm divided by 2).

Learners used Pythagoras in a practical manner, without knowing they were proving the theory practically, as the angle between the frame and the shelf needed to make a right triangle of 90 degrees. To measure the length of the arm very accurately, learners needed to think of a way to keep the “frame” 90 degrees with the floor’s surface, while measuring the arm’s length (refer to Figure 4.3). They needed to find a tool more flexible than a ruler to measure the arm, as the ruler would not be able to fit in the space. Learners needed to do all this on their own.

4.4.3.3 Observe

1. Learning Task Execution

At first the learners did not know what to do with the specifications given to them, but immediately took on the challenge. During this learning task, learners asked a lot of questions, hoping that I was going to give them direct clues to what they should do next. Though they became frustrated, they enjoyed being challenged as they started to wait for me to ask the next question. The only instruction I gave was to read the guidelines (presented in the LTP) again carefully.

Learners began to craft different plans on their own, taking more responsibility for their own learning. They realised themselves that they needed to represent this frame to be able to know what they were working with. “*I left learners to choose whatever they could find to use, whether it would work or not, as this is what helps them to think and rethink: grappling with the process*” (Reflective journal, p 9). Though this can be frustrating to both me and them, they needed to reach this point, so that they could start to reason logically and think critically about their decisions and learn to deal with these feelings of frustration. It is interesting to note that, *“Even though it was adequate to draw the lines on a piece of paper and measuring the paper, nobody even thought of going that route”* (Reflective journal, p 9) and they all chose to represent it physically. This task challenged learners to use what they know to do things in everyday life, without being told what to do. They had to make their own adjustments. At this stage it was noticed that meta-learning seemed to have taken place more visibly within this learning task.

The learners ended up reasoning by holding up different objects, realising that all the upright objects form an angle of 90 degrees. The learners focused on measuring accurately and incorporating the different specifications as best they could. Whenever learners struggled “*I led them back to their process instead of only overviewing the solution*” (Reflective journal, p 10). Figure 4.3 represents the teamwork of the learners in their representations of the photo frame.

Figure 4.3: Presentation of frame using paper
(Screenshot task 2.2, 2015)

Table 4.5 on the following page, presents the observation schedule used by me for evaluation purposes of the facilitating learning that was observed in learning task 2.

Table 4.5: Observation schedule – Learning Task 2

FACILITATING LEARNING

OBSERVATION SCHEDULE

Learning Task: .....

FUNCTION	ACTION	NUMBER OF TIMES: /// = 5 OR QUALITY: 0=absent; 1=poor/low 5=excellent/high						Total
		0	1	2	3	4	5	
Learning Task Presentation (LTP)	Clarity				✓			
	Importance				✓			
	Urgency				✓			
	Action					✓		
Learning task execution (LTE)	How well is metalearning (ML) maintained (time and actions)					✓		
	How well is cooperative learning (CL) maintained (time and actions)				✓			
Authentic Learning (AL)	How well was authentic learning in general maintained					✓		
Learning Task Feedback (LTF)	Giving recognition and approval for staying engaged	𝍸 𝍸 ///						8
	Reverting learners' questions back to them for answering	𝍸						5
	Asking for clarification	𝍸 𝍸						10
	Elicit critical reflection	𝍸 𝍸 ///						13
	Requiring resourcefulness	𝍸 𝍸						10
	Evoking resilience	//						2
	Advising auto-education							
	Providing edutainment							
Learning Task Consolidation (LTC)	Learners consolidate what they have learned				✓			
	Learners critically asses peers' consolidation	✓						
	FOL assess				✓			
Fundamental human virtues	Attaining fundamental human virtues				✓			

2. Learning Task Feedback

Whenever a learner was seeking my help, their question was answered with another question about what they thought and why. *"Learners asked me what they have to do, and I told them that I want them to tell me what to do and that I want to know how they got to their answers"* (Field notes, p. 3). Multiple times, my feedback would be questions such *as "What do you think?...How are you going to do that?...Why do you think this is so?"* (Field notes, p 4). Other times "*I repeated their suggestion and asked if it made sense…*" (Reflective journal, p. 9). Then there were times where: "*I left learners to choose whatever they could find to use, whether it would work or not, as this is what helps them to think and rethink: grappling with the process*" (Reflective journal, p. 9). Eventually, when they really got off track, *"…I went to ask them questions on what they are doing and why they think it is important to do it."* (Reflective journal, p. 10). I regularly asked learners what they thought was wrong in their attempts, which helped them to reflect on their own steps. It is important to recognise that the above questions (in place to activate meta-learning), cannot be set up before the task, as each reply from each student will change the context of the question, therefore leading the facilitator of learning to ask different questions.

Within this learning task, the human virtues and 21st century skills started to unfold and became more visible within the behaviours of the learners. The following list indicates the changes visible after the duration of this research cycle.

1. Learners started to communicate with respect towards one another.

2. When it came to the measurements of the arm of the frame, learners tried to use their rulers, but soon realised that *"…a ruler could not bend into the required spot to measure the arm very accurately"* (Field notes, p 4). They grappled with this problem, as they did not know where to start looking for something that they could use instead. Learners therefore persevered and willingly grappled to solve the challenge.

3. *"One of the quieter learners now suggested that she had to turn her paper to the side and use the corner of the paper"* (Field notes, p 3). Another group decided to use a ruler as the frame and another ruler behind it to ensure a 90-degree angle. These observations indicated that learners were starting to become more confident and motivated.

4. The above point advocated learners to think critically and creatively. Learners therefore started to reason and think on their own, becoming more independent learners.

5. Learners tried their best, putting effort into the real-life problem and using their own initiative.

6. "*Learners are starting to relate what they've learned during mathematics periods, to practical things that they are exposed to in everyday life"* (Field notes, p 4). Learners could therefore start to think about what they have learned and utilised it in another manner, which also strengthened their meta-learning.

Throughout the task, I encouraged the learners to keep trying, making sure that I supported and encouraged them as any good facilitator of learning would do. Though I still felt the urge to go back to my traditional teaching method of explaining and demonstrating, I succeeded in only answering learners with supporting questions, allowing learners the opportunity to learn from their own steps.

3. Learning Task Consolidation

After this task was completed, I asked the learners to tell me what they had learnt. They responded that taking measurements was very important if you wanted something to function properly. Most learners replied that they had learnt that "*accuracy is very important*" and that "*even if they get things wrong, that they should never give up*" (Field notes, p 4). Another learner said that she had learned *"…that it is sometimes needed to do things repeatedly until you get it right"* (Field notes, p. 4). I also asked them to write down what they will remember from this task. Figure 4.4 illustrates notes made by anonymous participants after completing the learning task. What these learners concluded from the task was that measurement is important and that there is a difference between when something is straight and when something is upright. One can see that accuracy was very important in the way learners completed this task which also demonstrated their perseverance in getting to the solution of the problem.

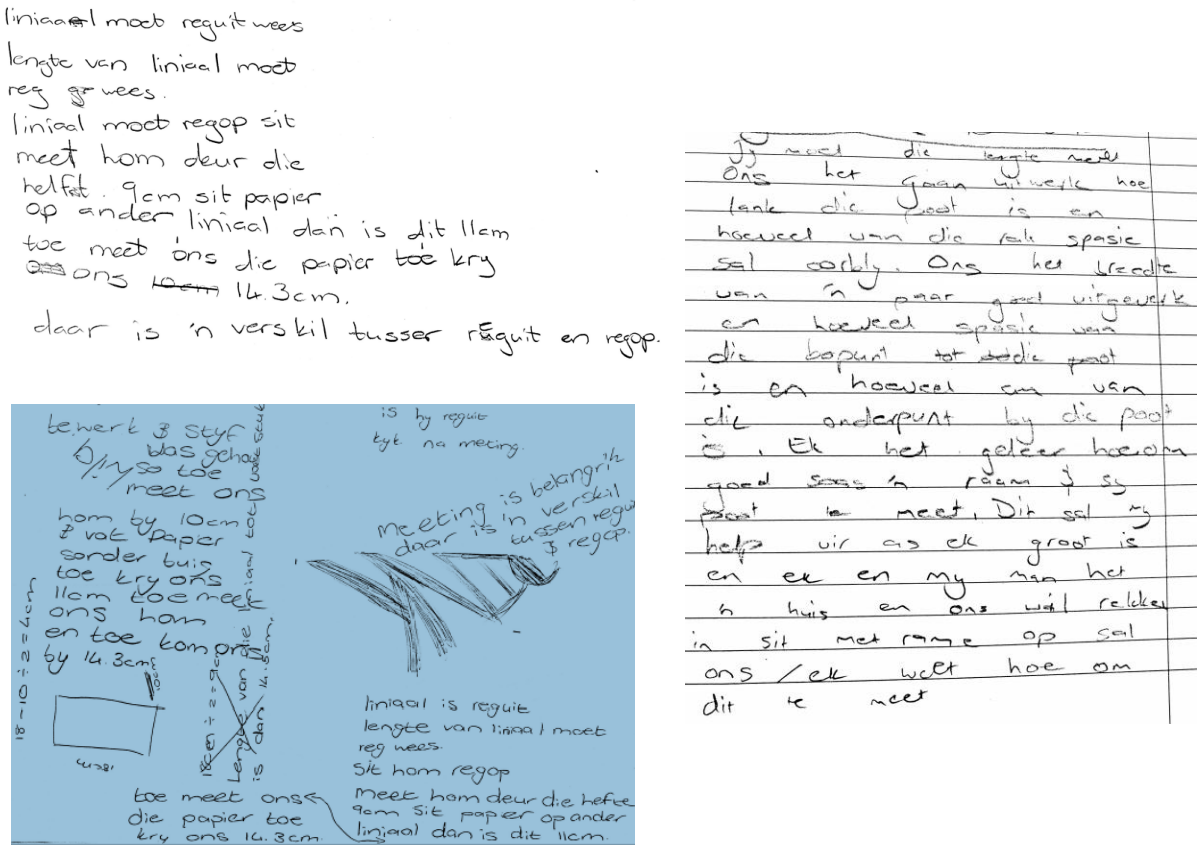


Figure 4.4: Observation of Cycle 2 – Learning task 2
(Anonymous participants' work)

4.4.3.4 Reflect

This task was certainly an improvement from the first learning task, as I was more confident and knew what I wanted to achieve in my role as a facilitator of learning. *"…as I didn't instruct learners on what to do, but constantly answered their questions with another question to lead them into thinking critically about their response or decisions"* (Reflective journal, p. 10). Learners were "*…getting used to me asking them to give me an explanation for their decisions"* (Reflective journal, p 10). This was a very positive observation, as I felt that my approach was starting to show positive results, where both myself, and the learners, were learning.

For the first time, I focused on the process and not their end-result as much, as I was focused on their thinking and not the problem at hand. Though this learning task was very time consuming and took a lot of patience, learners enjoyed reckoning the answers and became desperate to solve the problem, challenging themselves to do better. What was most satisfying of this task, was that one of the academically weaker mathematics learners flourished in this task. *"Even the*

'weaker' learners immersed themselves in this challenge. They also tried different ways and not only got stuck to one way of doing it. They also started to think!" (Reflective journal, p 10).

However, this task did reveal that communication is very important, as there were two groups who gave up very easily as they *"…were stuck with what they knew, as they didn't put effort into working together and didn't want to persevere* (Reflective journal, p. 10). This gave me the impression that *"…learners always only follow what they know and what they are taught if they don't persevere"* (Reflective journal, p. 10). The process made more sense within this task, as the needed guidelines were specified from the beginning of the learning task and was present during the entire task for learners to look back on.

4.4.3.5 Review

The learning task in this cycle was a much simpler task and one which could be formulated with much more clarity. In this sense my facilitating learning was much more successful. I was very conscious about meta-learning and planning this time (refer to Table 4.5). I provided extensive time for planning: initially individually through meta-learning and thereafter a shorter time for co-operative learning. Although I had allowed for a long planning time during meta-learning, the session was not very efficient, as I had to interfere among several learners with the same kind of questions. That is why, in general, the number of questions I asked was relatively higher than in the first learning task, but it still remained inefficient. The reason for this, I discovered, was the same for the deficiency of the planning time allowed during the first cycle. I did not put in enough effort of at least thinking through in detail all the steps to be taken in order to ensure an appropriate and efficient planning to eventually execute and resolve challenge. Neither did I go through the trouble to execute the plan I devised in order to ensure that such a plan will be successful. In facilitating learning, the facilitator of learning has to facilitate the learning process of learners in the most efficient way and in the shortest possible time, to achieve the highest possible quality of learning. This was not achieved in either the first or second participatory action research cycle.

What has become evident during this learning task is the way in which the learners had put in effort to respect one another and the way in which they were working. The success was also visible in the learners' reactions as they started to challenge themselves, grappling with the task, dealing with their feelings of frustrations in a constructive way and using their own initiative. It is also evident that I required more resourcefulness and increasingly asked learners for clarification of their attempts within this learning task (refer to Table 4.5) which contributed to the success of

facilitating learning in this task. However, I still felt that learner's communication skills and skills to analyse information by using common sense, could still be improved on.

This inspired me to have them working with something where the reality is much more tangible in terms of a monetary consideration in resolving a demanding real-life challenge.

4.4.4 Cycle 3: Learning task 3

The third research cycle represented the third learning task conducted. For learning task 3, the learners had to do accurate calculations to conceptualise how their calculations could affect the cost of something that they needed to buy. After one of the learners lost their expensive school blazer, we had a class discussion on the importance of taking care of your belongings, bearing in mind that money is something their parents are working very hard for and that they work with only a certain amount of money every month. This discussion made me realise that learners did not yet grasp the concept of working within a budget or working with money on a bigger scale – other than tuck shop money. This directed me in my selection of the third learning task. *"I chose to work with a budget as it is something that they will need to work with and most of the learners in my current classes have not heard of a budget…"* (Reflective journal, p 10). For learning task 3, I therefore decided that learners would have different options of items to buy, from which they would need to choose the best one - taking a budget into consideration. Learners should realise that the school is also working on a budget and that they should reconsider vandalising any property, as this costs money that could be used for something else.

4.4.3.1 Plan: Learning Task Design

This Learning task was designed for learners to calculate the cost of a wooden and sealed shelf for files, while working within a budget.

For this task, (as can be seen in Table 4.2) I aimed to strengthen the intrapersonal human virtues of self-motivation, responsibility, effort, initiative, perseverance and independence together with the interpersonal human virtues of communication, dealing with feelings and humanisation of the previous tasks. As mentioned earlier, the responsibility and humanisation virtues continue to be worked on through the way we behave towards one another in the class. The intrapersonal human virtues I wanted to introduce in this task was one of self-confidence and common sense, together with the interpersonal human virtues of leadership. This would also be the final task for this study. All the 21st century skills mentioned in learning task 2 were embedded further, which include:

critical and creative thinking, communication and collaboration. As I had experienced success with the previous learning task, this task would provide clarity on the success of facilitating learning in mathematics for Grade 6 learners.

The Learning Task Design for this learning task can be viewed in the learning task folder within the fieldwork folder on the flash disk provided.

4.4.3.2 Act: Learning Task Presentation

The task was presented according to the Learning Task Design. From the moment the learners lined up in front of the classroom, learners seemed comfortable with the strict daily routine and they were becoming very respectful towards me, one another and their environment (learners pick up papers on their way into the classroom without any involvement from me). When learners sat down, they were told that I needed to put up a shelf at the back of the classroom for all the test files for all 4 of the classes. I told them that preparation for 15 files for each class should be made. The shelf should also be painted with a sealer paint to prevent water damage. We only had R1 300 available for putting up these shelves. I asked learners to pair up and gave each pair a catalogue from which they had to choose the shelf and paint from. I then told learners that each litre of paint can cover 10-12 m^2. This task would therefore assist them to think realistically about spending money every-day.

According to the Learning Task Design, learners first needed to calculate the space that the total number of files would take up, to know the size of shelf they needed. To choose the paint bucket size, learners needed to calculate the surface area of the total shelf. The catalogue given to them, showed different wooden planks and options of sealer paint. Learners needed to choose the best possible option, spending as less money as possible. Figure 2.5 illustrates the presentation written on the board by the facilitator of learning (me), Figure 2.6 presents the catalogue given to each pair of learners and Figure 4.7 illustrates the space where the shelf had to be put up within the classroom.

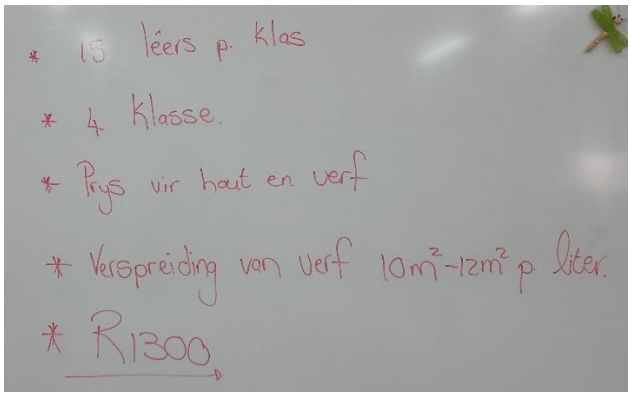


Figure 4.5: Presentation written on the white board – Learning Task 3
(Picture: taken by researcher, 2015)

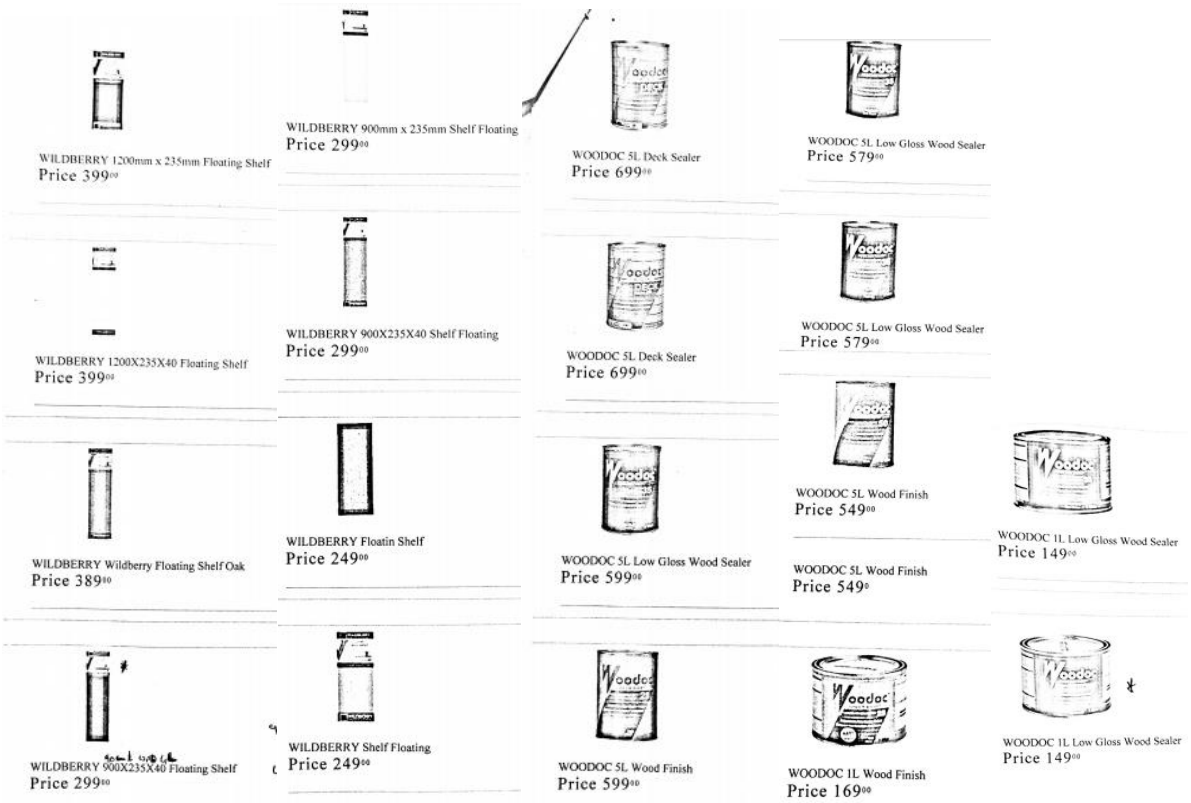


Figure 4.6: Catalogue given to learners
(Builders warehouse, 2015)

Figure 4.7: Place where the shelf must go
(Screenshot task 3.1, 2015)

4.4.3.3 Observe

1. Learning Task Execution

When the learners received their guidelines on the files, they at first "…*knew that they had to measure it, but they didn't exactly know what to measure and what to do with the measurement"* (Field notes, p 5). It was clear, that they knew from the beginning to measure the file somehow. Learners themselves "…used their common sense…" (Reflective journal, p 11) to take the test files from my storeroom and *"…asked for permission to before they took anything…"* (Reflective journal, p 11) to measure. *"One learner measured the width of the arch but didn't know how to do the sum to get the total length needed"* (Field notes, p 5). Another learner measured the width of the file to ensure that *"…the width of one wooden plank would be sufficient, by also testing until what point the file can hang over the edge of the shelf without dropping"* (Reflective journal, p 11). This was very valuable thinking, as this learner estimated whether only one plank width (of the planks shown on the catalogue in Figure 4.6) would be enough to hold the files. "*One learner asked about the coverage of the wood sealer. So, I asked the learner why she thinks it is important to know, so the learner replied that it will show us how far the paint can go*" (Field notes, p 5). One group of learners attempted to *"…start at the prices and work their way back…"* (Field notes, p 6) to get to the measurements. When I asked them if they would be able to know how much wood they needed, they realised that they first needed to start with their calculations. Learners used their calculations, and *"Some of the learners packed the files on my bookcase, to test*

whether their calculations were correct…" (Field notes, p 6). The learners therefore tried to test their calculations by using the physical objects so that they would know whether they were reasoning correctly. This illustrated learners' strong urge to make sure that they were doing their best, taking full responsibility for their learning and thinking about their own thinking, which in turn demonstrated that meta-learning was taking place. The meta-learning started to take place automatically, as learners now had the self-confidence to make mistakes and try again, without the facilitator of learning needed to step in to motivate them. It was good to see that the learners could use my questions constructively. It was as if learners now started to ask themselves the same type of questions that I had asked them.

Table 4.6 on the following page, represents the observation schedule used as a criterion of success to evaluate facilitating learning that took place during learning task 3.

Table 4.6: Observation schedule – Learning Task 3

FACILITATING LEARNING

OBSERVATION SCHEDULE

Learning Task: .....

FUNCTION	ACTION	NUMBER OF TIMES: /// = 5 OR QUALITY: 0=absent; 1=poor/low 5=excellent/high						Total
		0	1	2	3	4	5	
Learning Task Presentation (LTP)	Clarity					✓		
	Importance				✓			
	Urgency					✓		
	Action				✓			
Learning task execution (LTE)	How well is metalearning (ML) maintained (time and actions)				✓			
	How well is cooperative learning (CL) maintained (time and actions)					✓		
Authentic Learning (AL)	How well was authentic learning in general maintained				✓			
Learning Task Feedback (LTF)	Giving recognition and approval for staying engaged	1//						3
	Reverting learners' questions back to them for answering	////1						6
	Asking for clarification	////1///						8
	Elicit critical reflection	///						3
	Requiring resourcefulness	//						2
	Evoking resilience	/						1
	Advising auto-education							
	Providing edutainment							
Learning Task Consolidation (LTC)	Learners consolidate what they have learned				✓			
	Learners critically asses peers' consolidation	✓						
	FOL assess					✓		
Fundamental human virtues	Attaining fundamental human virtues				✓			

2. Learning Task Feedback

I kept the learners in a constant state of challenge, questioning their thinking every step of the way. Though in the beginning, there were times that learners were communicating with one another instead of asking for my help. To ensure that they were on the right path, I had to go to these groups and *"…ask them what they have found so far"* (Reflective journal, p 10). When I approached these learners, they knew that if they did not have a valid explanation for their actions, they needed to rethink their steps. There were therefore learners that could go on with their own reasoning, feeling self-confident, knowing that I would guide them, even though I did not give them the answer, making it worth trying and priding themselves in their challenge to see if they could get to the solution on their own.

Some of the learners that were not as confident as the others, still repeatedly asked me what to do, but I just *"…referred learners back to the guidelines"* (Field notes, p 6). One learner did try to guess the answer, but I then asked *"…how they would know for sure whether it will work or not"* (Field notes, p 6). Without giving a direct answer to these learners: *"I therefore persisted in only answering them with questions like 'What do you think?' and motivating statements such as 'You can do this, you know what to do, you'll figure it out now'"* (Field notes, p 6). These learners therefore still needed motivation and support, which the facilitator of learning should always provide. The fact that they did not give up and persevered through to the end was already a big accomplishment and visible change in their behaviours.

3. Learning Task Consolidation

After the completion of this learning task and handing in their papers illustrating their calculations, I asked the learners to write a short summary of what they have learnt. Some learners wrote that they now knew how to do calculations with money. Others wrote that it was important to work within a budget. Figure 4.8 demonstrates the work of one group of the participants. One learner wrote that *"…one had to think carefully when trying to work something out and that one can use different things to calculate the solution to a problem"* (Field notes, p 6).

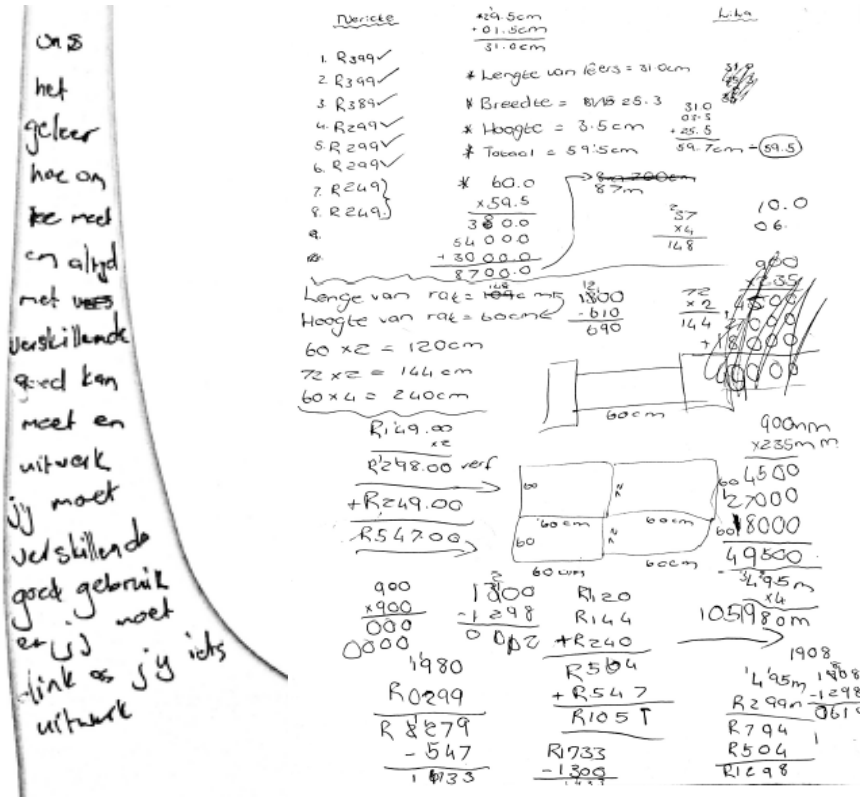


Figure 4.8: Observation of Cycle 3 – Learning task 3
(Anonymous participant's work)

4.4.3.4 Reflect

For the first time in all the learning tasks, this specific learning task highlighted learners trying to rectify themselves, while they were busy solving the problem, without any motivation or input from the facilitator of learning. *"As the one pair of learners explained to me how they got to the answer of 60 cm, they realised themselves that they've made a mistake"* (Field notes, p 6). These learners started to re-measure and recalculate, without me rectifying or asking them to redo it. They were taking responsibility for their own work, willingly grappling with the challenge, thinking about what they were doing and whether they were conducting it to the best of their ability. The fact that learners asked for permission before they used anything in the class, demonstrated that the *"…humanisation virtue is starting to become prominent in their actions* (Reflective journal, p 11).

Learners worked hard to stay within the budget, illustrating that they were trying their best to find the correct solution to this challenge. To me, the process of this Learning Task Design was the most successful, as learners *"…were more independent…"*, though certain learners *"…still needed a lot of facilitating learning, they didn't wait for me to help them"* (Reflective journal, p 11). Learners practically measured the space they needed by using my bookshelf

as a representation, to test whether their calculations were correct and accurate. *"Even though I never referred them to measure anything, but only asked them how by referring to their process, they still decided to measure the files and even the bookcase instead of guessing"* (Field notes, p 6). Learners also *"…used their own initiative to use my bookcase…"* as well as to *"…test their own calculations and to verify it…"* (Reflective journal, p 11). For periods of time, certain pairs of learners *"…didn't ask me to help them…immersing themselves in the task"* (Reflective journal, p 10), demonstrating their self-confidence. During this task, learners were *"…communicating well and were more self-confident in their choices than the previous task"* (Reflective journal, p 10).

Overall, as a facilitator of learning, I am of the opinion, that the above task was successful in not only the visibility of the fundamental human virtues, but also by the quality of learners' thinking and reasoning. One can clearly notice an immense improvement between the first learning task and the third learning task in the meta-learning and co-operative learning structures, as my skills in facilitating learning improved, though it is not yet perfected. Going forward, I will need to focus on providing a more structured design of the Learning Task Consolidation.

4.4.3.5 Review

This was evidently the most successful cycle. The overall outstanding aspects of this cycle were the LTP that best fulfilled the other presentation requirements (refer to Table 4.6). Time for both meta-learning and co-operative learning, and subsequently planning and execution was more successful. It was very clear that learners started thinking themselves, as they asked fewer questions; my much fewer feedback questions were also much more focused and functional. It was also noticeable in the way the learners executed the learning task, that they independently began to persevere in their attempts to solve the problem at hand and dealt with their emotions of frustrations in a constructive manner. *"They didn't only try to complete the exercise to get it done with, but they were thinking and kept on trying without giving up"* (Reflective journal, p 11). It seemed that learners started to challenge themselves and were reflecting on their own steps. It seems that the Learning Task Consolidation were more successful, when referring to Table 4.6. One can observe from these three learning tasks, that learning took place when learners tried something different at times when they did not know what to do.

Overall the learners excelled in the following year, where they scored *"…highest in the grade with a 10% average higher than the rest of the grade"* (Reflective journal, p 13). Their mathematics teacher also *"…complimented me on the good foundation that had been laid.*"

(Reflective journal, p 13). The learners still come to my class and tell me that "…*they use the methods that they've learned in my class*" (Reflective journal, p 13). The above provides one with the motivation to be of the opinion, that facilitating learning might improve the way our learners are prepared for their future. I can therefore conclude that "*The results I got from the process of facilitating learning and the incorporation of the human virtues, has made an immense difference in the quality of learners' behaviours and work in class"* (Reflective journal, p 12). I have learned to improve my professional practice by facilitating learning instead of direct teaching. Even though my Learning Task Design and facilitating learning are not perfect yet, I can now continue to develop my professional practice by making facilitating learning part of my daily routine and to continuously incorporate the fundamental human virtues. This research was not intended to change the world, but rather to improve and develop the professional practice of my own teaching within the CAPS curriculum, and hopefully one day to improve that of other teachers of South Africa.

4.5 Interviews with learners and employers in the field of mathematics

4.5.1 Introduction

As mentioned in chapter 3, interviews with learners and employers in the field of mathematics has been conducted. As this is a participatory action research study and these interviews were used to reflect on my own practices - and thus very much needed to asses and substantiate my findings within my own observations and reflective notes - it does not pose a problem to interview learners. In the paragraphs to follow, one would notice interviews done with observed learners and those done with non-observed learners. Although the non-observed learners were not recorded or directly involved in this study, I did manage to conduct the learning tasks with these learners to serve as confirmation of my findings. I therefore only used the interviews with this group of learners within this study, however, no reflective journal or observations were taken from the non-observed group of interviewees, as mentioned earlier in chapter 3.

The following paragraphs summarises the responses of interviews with learners and employers in the field of mathematics, as categorised and coded from the transcriptions of the interviews.

4.5.2 Interviews with observed learners

The following paragraphs provides the most representative results from the interviews conducted with the observed learners with whom the learning tasks were recorded and formally observed.

When learners were asked what they liked least about their previous teacher, it seems that most of them enjoyed the educational computer game that they could play. Participant one responded that she enjoyed the fact that they could do the *Cammi Maths* program on the computer: "*I liked the part most where we did time tables on Cammi Maths because we could talk to our friends"* (Initial coding: Observed participants, p 1). Participant three responded that the teacher tried to use different physical items to explain the work: *"She always explained the work with different things like cards and photos and things"* (Initial coding: Observed participants, p 1).

When learners were asked what they liked least about their previous mathematics teacher, one can hear that learners became frustrated with explanations and them not completing more work in class. Participant three responded that she disliked that they did not get to do a lot of work in class: *"We never got homework, and we also didn't do a lot of work in class"* (Initial coding: Observed participants, p 1). Participant five disliked it when his previous teacher explained all the work from the beginning: *"Sometimes, when we had a specific question, he would start explaining the whole thing, while you only wanted to know a specific thing"* (Initial coding: Observed participants, p 1).

Learners were asked what the most important thing is that they've learned from their previous mathematics teacher, and most of the learners struggled to answer this question. However, Participant five believed that learning *"…how to do the working out*" (Initial coding: Observed participants, p 1) was the most important thing learned from his previous teacher. Participant six responded that one should not rush through the work" *"Don't be hasty to finish"* (Initial coding: Observed participants, p 1). However, Participant three felt that the previous teacher should have increased the amount of work they were getting done: *"That we do more work in class and at least get a little more homework"* (Initial coding: Observed participants, p 2). When asked why, she replied that it would help her to understand the work more: *"So that we can learn and make sure that we understand"* (Initial coding: Observed participants, p 2).

I then asked learners to think of the time when we conducted the three learning tasks and to tell me what they liked most about this time. In general, learners learnt to persevere until the task was completed correctly and found it to make mathematics more practical and fun. Participant one liked that they had to distinguish between what was wrong or right, and that they had to repeat the experiment until the end. *"The learners sometimes fought about the timings being right or wrong and then we went on and on working on it"* (Initial coding: Observed participants, p 2). Participant two liked that they learned how to use their skills properly: *"I've learned how to measure properly with a ruler and how to work things out with*

it" (Initial coding: Observed participants, p 2). Participant three enjoyed *"That we could see how things work in the real life and that we could work together in a team"* (Initial coding: Observed participants, p 2). Participant four was of the opinion that this method of teaching made the subject more practical and fun: *"You made Maths very practical, so that we could learn it quicker, not in a boring way"* (Initial coding: Observed participants, p 2). Participant five liked that they could do an experiment as they could see how things work: *"It was just nice to get out of the class and to physically see what happens and how it works"* (Initial coding: Observed participants, p 2).

When I asked learners what they liked least about these learning tasks, it seems that learners did not like to disagree with one another and that it was very time consuming. Participant one responded that she didn't like it when the learners did not agree with one another's answers: *"I would just like it if the learners weren't that hard on each other and just give it as answers and not be so rough on each other"* (Initial coding: Observed participants, p 3). Participant five responded that he did not like that the tasks were so very time consuming: *"It took very long, and sometimes when we couldn't exactly see when the ball hit the ground and get the precise time of the fall"* (Initial coding: Observed participants, p 3).

I took the opportunity to ask these learners what the most important thing was that they have learned from my learning tasks. It seemed that they valued the completion of the task with accuracy instead of rushing through it. Participant two felt that it taught her to work carefully by working properly and with precision: *"How to work your sums out properly and that you should always show your steps and not only try to work things out in your head"* (Initial coding: Observed participants, p 3). She also felt that we use mathematics every day: *"Everything you do your whole life has to do with mathematics…"* (Initial coding: Observed participants, p 3). Participant five replied that she learned *"To always read my questions carefully and to do the working out properly"* (Initial coding: Observed participants, p 3). *"If you do calculations, don't do it half"* (Initial coding: Observed participants, p 3). Participant six learned that mathematics can be much more interesting: *"That Maths is actually a lot more interesting than what it looks like"* (Initial coding: Observed participants, p 3).

When I asked learners what they would like me to do differently, the only response I received was from participant five that requested that we execute more of these learning tasks: *"Maybe if we can do more of these experiments so that we can see how things work"* (Initial coding: Observed participants, p 4). Finally, I asked learners what they would always remember as the most important thing in mathematics if they had to leave school today. Participant three learned *"That you should never stop trying, you should always keep trying"* (Initial coding:

Observed participants, p 3). Participant one was of the opinion that she will always remember that mathematics is part of your everyday life: *"I still use your ways and methods…why I'm doing so well in maths"* (Initial coding: Observed participants, p 4). Table 4.7 represents the axial coding taken from the transcriptions of the interviews conducted with learners after facilitating learning of the three learning tasks.

Table 4.7: Axial coding from interviews with observed learners.

Axial coding from interviews with observed learners	
Main Category	**Sub-category**
Previous mathematics teacher	The way he/she taught was by explaining the work.
	Learners liked doing *Cammi Maths* in his/her class.
	Learners did not like that he / she yelled a lot and felt he / she should be nicer.
After facilitating learning by researcher	What is important in mathematics is the working out / knowing how things work.
	Learners liked that tasks were fun and interesting / involved working in groups / involved different ways to do things.
	Important aspects learned from tasks is to work carefully and precise / properly / it makes you think.
	Importance of mathematics is that it is part of everyday life / practical.
	Facilitating learning with no answers given was a good thing.
	Learners did not like that the tasks are time consuming.

(Derived from interviews with observed learners)

4.5.3 Interviews with non-observed learners

As can be read earlier in this chapter, only interviews with the non-observed learners were conducted as a method of crystallisation to validate my findings and no further formal observations were therefore executed.

I firstly asked these learners what they liked most about their previous mathematics teacher. It is clear from this paragraph that learners liked that the teacher always explained the work and that they could play the educational mathematics computer program of *Cammi maths*. Participant one responded that she liked that the teacher gave examples of the work: *"We didn't do a lot of homework, but she gave a lot of examples"* (Initial coding: non-observed participants, p 1). Participant two responded that she liked it when the teacher was always willing to explain the work again: *"If we still didn't understand she would explain again and again until we understood"* (Initial coding: non-observed participants, p 1). Participant two, three, and four liked that the teacher allowed them to play *Cammi Maths* on the computer: *"If we didn't understand and if we were struggling with something, she would let us go onto*

Cammi Maths and see if we can try it on Cammi before we get the whole activity wrong..." (Initial coding: non-observed participants, p 1).

Learners were then asked what they liked the least about their previous teacher. Although learners enjoyed the *Cammi maths* program, it is also clear that learners were bored in class and wanted to complete more work in class. Participant two felt that parts of the work bored her: *"If we would struggle with things, we had to sit through boring activities and explanations and stuff"* (Initial coding: non-observed participants, p 1). Participant four claimed that they did not get enough work completed in class: *"...we won't really get any work done. So, we would have like a lot of homework to do, just because of the fact that the people in the class didn't pay attention and they would just go straight and play Cammi"* (Initial coding: non-observed participants, p 1).

When learners were asked what they would always remember from their previous teacher as being important in mathematics, it seems that they found it important to understand work and to work hard. Participant two responded she learned that one should ensure that you understand the concepts covered: *"I think it is to understand a concept, because she taught us that if we understand a concept well in grade 5, that it would help us a lot in grade 6 and grade 7"* (Initial coding: non-observed participants, p 1). Participant 5 learned that you reap what you sow: *"It was to always work hard for the end product, and you will always get something in return"* (Initial coding: non-observed participants, p 1).

I then asked learners what they would suggest the previous teacher change. Participant one felt that the teacher should put more effort into the work. Learners felt in general that she should not lose her temper as quickly and be more rigid, giving them more work during class time: *"She was nice, if we had questions, she would pay more attention to it, but she wouldn't put a lot of effort into it"* (Initial coding: non-observed participants, p 2). Participant two's opinion was that they should have worked more in class: *"We got a lot of homework because she would explain a lot"* (Initial coding: non-observed participants, p 2). Both participant one and five felt that the teacher needed to have more patience: *"…she lost her temper very quickly, just too fast. For maths, it's a subject that takes time and patience so, that doesn't mean you can go shouting at everybody"* (Initial coding: non-observed participants, p 2). Participant four is of the opinion that she could easily be persuaded and needed to be firmer with the learners: *"I would say, to be just more firm, to say no"* (Initial coding: non-observed participants, p 2).

Then I asked learners to think about the time when we conducted the learning tasks for fun. I then asked them what they liked most about the way that I taught them – during facilitating learning of the learning tasks. Most participants liked that they had to challenge themselves. Participant one enjoyed that I was approachable: *"You were approachable, we could ask you any question"* (Initial coding: non-observed participants, p 2). Participant two and three liked that the tasks were fun and practical: *"It was fun going outside and doing experiments as well as doing work"* (Initial coding: non-observed participants, p 2). Participant four liked the process of the work they completed: *"You always made us work and do the working out and think through it, not rush through our work so our work is the best that we can do"* (Initial coding: non-observed participants, p 2). Participant four also felt that I pushed them to be better: *"What I liked mostly of what you did last year, is that you never gave us the easy way out of doing maths"* (Initial coding: non-observed participants, p 2). Participant five liked that I did not give the answers easily. This participant also liked that there were consequences: *"When the final beep went, you didn't care how far we were, you just took the paper. That pushed the ambition inside me, to say no, I have to finish this on time, I was training to get myself on time"* (Initial coding: non-observed participants, p 2).

However, there were certain aspects that learners did not like about my facilitating learning. Participant five did not like following our new class routine, but also acknowledged that it helped him to respect the teacher: *"Standing on attention when greeted, it was really irritating, but at the end of the day, it taught me to respect the teacher like you would respect your parent or elderly"* (Initial coding: non-observed participants, p 3). Participant one and four did not like it when I gave demerits during normal school days, but still acknowledged that it was her consequence to face – even though this was not directly applicable to our learning tasks outside of school hours: *"If there would be something, it is something silly like you gave me demerits, but that is the right thing to do"* (Initial coding: non-observed participants, p 3).

I then asked learners what the most important thing is that they've learned from these learning tasks. It seems that most of the participants were of the opinion that being inquisitive while persevering and grappling until they succeed, is something they have learned to be very important. Participant one learned the importance of being inquisitive: *"To ask questions"* (Initial coding: non-observed participants, p 3). Participant two responded that she learned to take responsibility to get her work done: *"Sometimes you have to sit down and do your work and do it properly before you can play around"* (Initial coding: non-observed participants, p 3). Participant three learned to persevere: *"How we struggle and get the hang of it and it's getting easier…"* (Initial coding: non-observed participants, p 3). Participant four learned that *"…everything that you do has a certain outcome"* (Initial coding: non-observed participants, p

3). Both Participant two and five learned that mathematics is very important: *"Maths is very important and it's going to be everywhere in life"* (Initial coding: non-observed participants, p 3). Participant one and five also added that they have learned to persevere and keep practicing: *"To practice and practice and practice, because practice makes perfect"* (Initial coding: non-observed participants, p 3).

When learners were asked what they would like me to do differently when facilitating learning within these tasks, Participant five responded that I should give the answers quicker, but then felt that it is good that I did not change it as it helped him to think: *"What I would change is that you should give the answers more easily. But then what was good about it is that you made us think. You made us work..."* (Initial coding: non-observed participants, p 4). Participant four mentioned that mathematics should be adapted to each learner's world of reference: *"I think you take something that a child doesn't understand, like long division, and you give that child an alternative like if they like soccer, you put something of soccer in it so that they can understand it better"* (Initial coding: non-observed participants, p 4).

When I asked learners the question of what the most important thing is that they have learned from mathematics if they had to leave school today, Participant six responded that mathematics is part of every person's every-day life: *"Maths is very important and it's going to be everywhere in life"* (Initial coding: non-observed participants, p 4).

The above paragraph indicates that learners started to take more responsibility for their learning after the learning tasks. Learners seemed motivated to do work and try their best. Table 4.8 represents the axial coding derived from the interview transcriptions completed for interviews conducted with the non-observed learners.

Table 4.8: Axial coding of interviews with non-observed learners.

Axial coding of interviews with non-observed learners	
Main Category	**Sub-category**
Previous mathematics teacher	Taught by way of explaining a lot.
	Teaching method that learners didn't like was that teacher gave examples / showed / helped.
	Liked doing Cammi Maths / that they could help each other.
	Most important thing learnt was to work hard for a good return.
	Did not like that it was boring / teacher shouted / teacher lost his/her temper too quickly / doing Cammi Maths with no work done.
After facilitating learning by the researcher	Important thing learned from tasks was that steps are important / to know how things work / to learn from one's mistakes.
	What is important in mathematics is to practice / do homework / ask questions / do work properly / do working out / that the process more important / that mathematics everywhere in daily life / that everything you do has an outcome.
	How teacher taught was to never give answers / push learners / ask questions.
	Learners liked that the tasks made them think / challenge themselves / put in effort / no answers never given.
	What the teacher should change is to make Maths more fun / to give alternatives.
	Learners did not like that the teacher gave demerits before tasks.

(Derived from interviews with non-observed learners)

4.5.4 Correlation between observed and non-observed interviews

When studying both interview groups, it is prominent that both groups disliked being taught by only explanations and not being able to complete work in class. It is also very clear that most learners of both groups did not like it when the teacher was short tempered. Most of the learners in both groups liked when the answers were not given by the facilitator of learning during the learning tasks, and that the learning tasks made them challenge themselves.

Learners felt that the learning tasks taught them to do their work appropriately. The learners did like to persevere and understood that they needed to be less dependent on the teacher and take more responsibility and accountability for their own learning. As mentioned in the previous section, one learner felt that I had done the right thing by giving her a demerit for her incomplete work. This implied that the learner was able to take responsibility and was willing to face the consequences. Another learner accepted responsibility by stating that everything that a person does has an outcome.

The learning tasks demonstrated that learners, even though frustrated at not been given any direct instructions from the teacher, realised the importance of grappling with concepts to enjoy the rewarding feeling of learning something that they have achieved on their own. Most

learners realised that the process, or how something works, is more important than the answer itself. A very important aspect that can be noted is that most of the learners from both groups believed that mathematics is part of everyday life, making mathematics more authentic to them, which was part of the purpose of these learning tasks. In fact, one of the learners stated that *"I still use your ways and methods…why I'm doing so well in maths"* (Initial coding 2016, p 2).

4.5.5 Interviews with employers in the field of mathematics

The interviews with two employers in the field of mathematics was conducted separate from the facilitating learning tasks.

In the interviews with two employers in the field of mathematics, both believed that mathematics is very important for every person, as well as in business. According to participant one, mathematics forms the base of any businesses today: *"Maths forms the basis of all forms of business and is used by most daily"* (Initial coding: Mathematics employers, p 1). Participant two was of the opinion that everyone uses mathematics every day: *"We use it to predict the weather, we use it to tell time, we use it to handle money"* (Initial coding: Mathematics employers, p 1).

According to participant one, school is the only place where mathematics is singled out. Participant one was also of the opinion that each profession needs a different set of mathematics skills. *"...considering where maths will be used in accounting and engineering the qualities required will differ drastically"* (Initial coding: Mathematics employers, p 1). In the field of accounting employers must understand the system: *"In the accounting field a clear understanding of methods and system will be required and coupled to that a high degree of accuracy and attention to detail"* (Initial coding: Mathematics employers, p 1). Whereas in engineering, one needs employers that can assess the impact of a specific action: *"A more daring approach in applying mathematics is required – based on a sound understanding of how things are calculated – than being accurate in the calculations"* (Initial coding: Mathematics employers, p 1). Participant two responded that *"As an employer looking for someone to hire, I would think of trustworthiness, communication, teamwork but as well as ownership, leadership, hard-working, effort and discipline, adaptability and problem solving"* (Initial coding: Mathematics employers, p 1).

When the interviewees were asked about the lack of qualities of workers in the field of mathematics, Participant one responded that it depended on the position of the employee and that the qualities should fit the personality and ability of that position: *"…the ability to be*

accurate would be vital for an accountant but can tie an engineer down in thinking laterally" (Initial coding: Mathematics employers, p 2). One lack that employees do have, according to Participant one, is the lack of applying mathematics to their situation: *"As a wide (and wild) generalisation, the most lacking quality would be in being able to apply maths in practise"* (Initial coding: Mathematics employers, p 2). Participant two perceived that employees do not know how to communicate or solve problems: *"Employees do not know how to write proper sentences"* (Initial coding: Mathematics employers, p 2). *"Another thing that I think is lacking is adaptability and problem solving. Employees use the same method or technique to solve every problem"* (Initial coding: Mathematics employers, p 2). Participant two also responded that employees lack discipline and work effort: *"Work effort in general, not just in mathematical / in the mathematical field, the younger generation shows lack of work effort that leads to a lack of performance"* (Initial coding: Mathematics employers, p 2).

Interviewees were asked what they would change within the mathematics education to provide future employees with the essential skills. Participant one believed that a basic understanding of numbers should be establish first, together with the creation of love for mathematics: *"In my mind the first step would be to establish an understanding of numbers – thirty being larger than eleven, etc."* (Initial coding: Mathematics employers, p 2). Participant one then added that real life situations should be used to teach mathematics: *"Thereafter, establish the system on resolving problems and then tackle real life situations"* (Initial coding: Mathematics employers, p 3). Participant two felt that a balance between the knowledge within mathematics and practical problem solving should be kept: *"I think education in general must find a balance between learning content which leads to knowledge and know-how and the practical problem solving situation which leads to experience"* (Initial coding: Mathematics employers, p 3). Participant two also responded that employees are not able to solve problems on their own because the answers were usually given to them: *"But I think one of the biggest problems is that people aren't given the ability to try and solve a problem on their own"* (Initial coding: Mathematics employers, p 4).

Table 4.9 represents the axial coding of the interviews conducted with the employers in the field of mathematics, as it has been derived from the interview transcriptions.

Table 4.9: Axial coding from interviews with employers.

Axial coding from interviews with employers	
Main Category	**Sub-category**
Role of mathematics	The importance of mathematics is that learners' answers must be accurate and correct.
	The extent of mathematics is that it is present in everyday life / real-life situations
Missing in the workplace	Workers currently lacks problem-solving skills / experience / work effort / discipline.
	Workers need to apply / adapt / do practical mathematics / Gain a better understanding of mathematics.

(Derived from interviews with employers in the field of mathematics)

4.6 Summary of results

The above interviews with employers in the field of mathematics emphasised the importance of mathematics in the work place and confirmed the lack of ability within our current learners / employees - to solve problems and apply mathematics in their work situations - and that this is much needed by employers in the field of mathematics. From the interviews conducted with the learners, it can be observed that they are aware that mathematics is part of their daily life. Once they arrived at a classroom lined with explanations, it seems that both the teachers and learners realised the necessity to challenge themselves. Instead of regurgitated learning and focusing on the product, learners and teachers both implied within the interviews, that it is the learning process that is more significant than the answer. This once again confirms the answer to the second subsidiary question, as was revealed during the first learning task of facilitating learning. This question dealt with the challenging demands in mathematics in the 21st century.

I have constructed a model of mathematics education in the 21st century (Figure 4.9), in an attempt to summarise all the results – found in the fieldwork of my participatory action research study – as demonstrated by different role players in the field of education involved in my study. The role players included all the interviewees, together with the observations recorded by me, as the researcher – as this is a participatory action research study. The findings of this model were therefore based on the researcher's reflective journal and field notes made during observations of the research cycles, as well as the different interview transcriptions. This model represents the implications of education in mathematics in current classes as well as facilitating learning using problem solving of real-life challenges. This model supports the answer to the third subsidiary question, asking how I can improve my professional classroom practice to meet the demands of 21st century education.

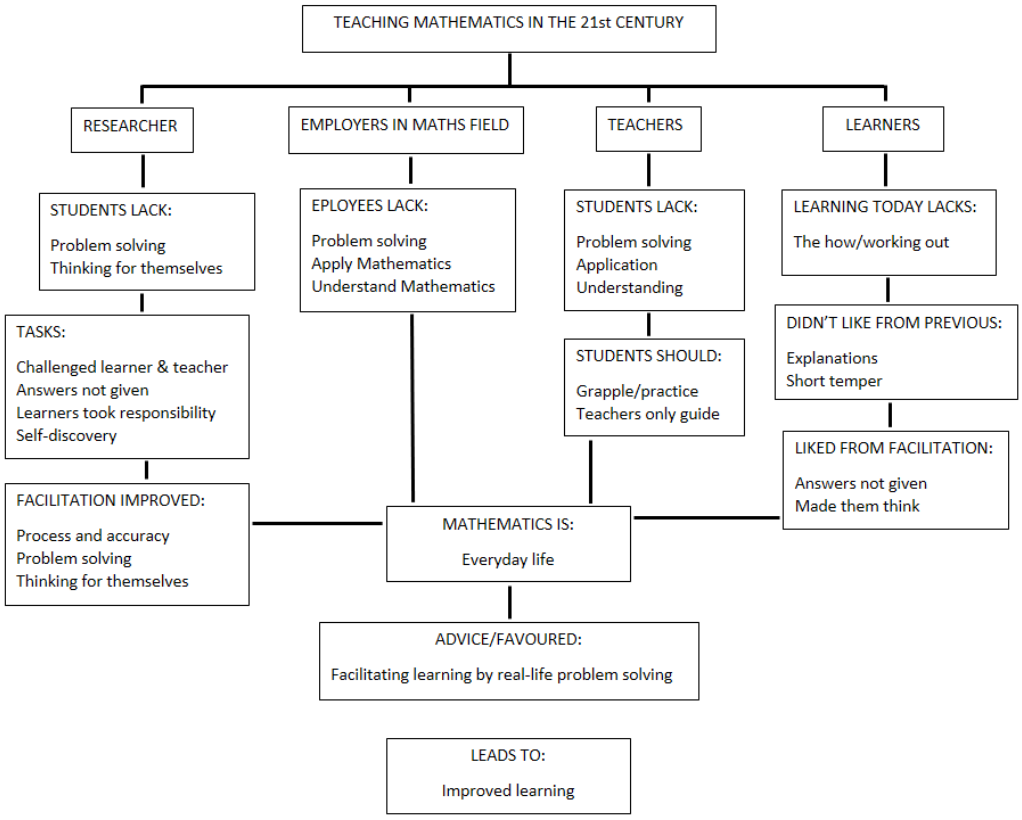


Figure 4.9: Researcher's model developed by data findings.
(Adapted from fieldwork)

4.7 Recapitulation of comments

From the findings in the fieldwork, one can identify that the learning tasks were successful in facilitating learning to solve real-life challenges. It is clear, that learners would persevere in their attempt until they know what to do, in situations where they do not know what to do, only if the teacher acts as a facilitator of learning and if learners were exposed to facilitating learning tasks more often. The learning tasks may assist learners to prepare for the unknown, which is essential in the 21st century, in a world where the future is uncertain: as mentioned earlier in the study, half of the jobs that will exist in their time as employees do not exist yet.

It is important to take note of the influence that teachers have on the implementation of work presented to learners. It is clear from the fieldwork, that facilitating learning of authentic real-life challenges drove learners to a point where they progressively challenged themselves, enjoying the task at hand as they were grappling and thinking things through, every step of the way. This emphasises the importance of the process of learning and not the product of learning in the mind of a learner.

CHAPTER 5
Conclusions and recommendations

5.1 Introduction

As mentioned in Chapter 1, I had an intense desire as a teacher to improve my professional practice, as I recognised that my learners did not function to their potential inside and outside of the classroom, especially in the field of mathematics. Another alarming concern was that in the subject of mathematics, South Africa was ranked second last in general, in an internationally combined assessment conducted in 15-year old learners over 76 countries (BusinessTech, 2015a). When I commenced my background research, a new world of knowledge opened as I learnt how other countries excelled at in their education in general. This encouraged a lot more questions on the curriculum and its implementation in SA and how I, as a teacher and researcher, could have an influence on the improvement of its implementation. By means of facilitating learning and embedding fundamental human virtues, I endeavoured to not only improve the learners' thinking and learning, but also that of my own. That is what made participatory action research so appropriate to this study.

This Chapter presents the conclusions of this study, together with recommendations for future research, after answering the research questions stated in Chapter 1 of this study.

5.2 Answering the research questions

For easy reference when reading of this study, I have repeated my research questions asked in Chapter 1.

The primary research question of this study was:

How can I improve my Grade 6 mathematics education practice to the highest possible quality to meet the challenging demands of the 21st century world?

The three subsidiary research questions were:

a. *What educational quality improvements are achieved in the CAPS curriculum in Grade 6 mathematics in comparison with its predecessor?*
b. *What are the challenging demands of 21st century education in general and in Grade 6 mathematics education in particular?*
c. *How can I improve the quality of my Grade 6 mathematics professional classroom practice to meet the demands of 21st century education?*

To be able to answer the primary research question, I had to answer the subsidiary questions first. I will therefore discuss the answers to my subsidiary questions in the following paragraphs.

5.2.1 Answering subsidiary question (a)

My first subsidiary question asked about how CAPS was an improvement on the RNCS. From my interviews with the mathematics teachers it was clear that RNCS, as the predecessor in curriculum, was very unclear and vague on the expectations in comparison with the CAPS curriculum. Within the RNCS, teachers felt that they were responsible for developing their own learning programmes (OECD, 2008). Even though all the outcomes were listed in the RNCS, it lacked recommendations for the teachers in terms of how to approach teaching. On the contrary, within the CAPS curriculum, clarification notes and teaching guidelines were given, which the teachers felt made their role easier to identify. In fact, one of the teachers commented that within CAPS the "*Concepts, content and skills are set out and structured with explicit instructions on how to reach the goal"* (Initial coding: Mathematics teachers, p. 10).

According to the teachers that were interviewed, the RNCS required a lot of administrative tasks, which were very time consuming: "*The admin around the curriculum was horrendous. Nobody really knew what to do"* (Initial coding: Mathematics teachers, p. 9). In contrast with the RNCS, the CAPS curriculum was set out more clearly on what was expected from teachers and it contained less administration. Teachers commented that the CAPS curriculum had a standard that they could work from and that it led learners to solve more problems than did the RNCS. A clear progression of learner outcomes could also be seen in the CAPS curriculum, which was not clear in the RNCS. In the RNCS the aim to *"Work effectively with others as members of a team, group, organisation and community"* had been replaced in the CAPS with *"work effectively as individuals and with others as members of a team".* This serves as perequisite for working effectively in a team for the simple reason that *intrapersonal* development was fundamental to integrated holistic human development as an ontological imperative (Heidegger 1962; Barnett 2007).

Although the CAPS curriculum was an improvement on the RNCS, there still was a lot of concern on the professionalism of the teacher, as discussed in Chapter 2. As Higgs mentioned: *"The dominant discourse in education has been concerned with social and cultural values and not primarily with human values"* (Higgs, 2008, p 452).

5.2.2 Answering subsidiary question (b)

The second subsidiary question in this study related to identifying the challenging demands of the 21st century. From my literature review, as well as my interviews with employers and teachers in the field of mathematics, it was clear that learners (in this case, Grade 6 learners) and employees of today lack the skill of problem solving, but also human virtues. It seemed that learners as well as employees did not challenge themselves, but would rather wait for instructions on how the problem could be solved. During the first learning task, it was clear that the Grade 6 mathematics learners were relying on the teacher to give them the answer, or formula, instead of working through the problem and thinking about what they were to do.

The employers, the teachers and even the learners observed in this study all suggested that mathematics is something we all use every day in real life, albeit in different ways. For example, an accountant and an engineer would need different mathematical skills to perform their specific, individual, daily tasks. It seemed that today's world demands the application of information instead of only regurgitation and repetition. According to the literature and interviews (discussed in this study) , we have advancements in technology and science, on a daily basis, which results from problem solving and thinking or applying mathematics. This was highlighted within the earlier statement by Barnett (2007) that human dispositions and qualities were key in 21st century education. My results therefore are in line with the statement of Barnett (2007) that *"dispositions and qualities are durable in their nature. They constitute the student's pedagogical being. It is they that have to be the focus of 'teaching'"* (Barnett, 2007, p 101).

5.2.3 Answering subsidiary question (c)

The third subsidiary question on how I could improve my professional classroom practice in order for my learners to meet the demands of the 21st century, could be answered through the many contributions of each of the aspects that constituted this research. However, every contribution eventually culminated into the challenging demands of education for the 21st century. My challenge was to recognise all the contributions from the many research contributors to this research. I was also challenged to ascertain those key elements that identified the nature and structure of the educational intervention, that would most appropriately suffice the challenging demands faced in education in the 21st century. My research identified the improvement of my education practice as the most powerful and most sustainable solution within the 21st century and beyond the context of the Fourth Industrial Revolution . Although I deliberately chose Participatory Action Research (PAR) as the mode for this research, in this study it was my investigation and eventual experience of facilitating

learning as a professional education practice (as conceptualised by Slabbert et al., 2009), that constituted the breakthrough in my research.

What was revealed from this Participatory Action Research, is that:

> "Students should become 'active learners', capable of solving complex problems and constructing meaning that is grounded in real-world experience … It emphasizes that all instructional activities must be rooted in a primary concern for high standards of intellectual quality. We refer to this conception as authentic pedagogy … As to the effects of authentic pedagogy on students with different backgrounds: We found that authentic pedagogy helps all students substantially" (Newman, Marks & Gamoran, 1995, p 1, 8).

As far as authentic pedagogy and children are concerned: children are born scientists, who explores everything that they come across, with everything they have at their disposal (Armstrong, 1991, p. 93). Ackofff and Greenberg (2008) testify that: "Complex problem solving is natural to children. From the moment of birth, nearly all their activity relates to a vast number of interrelated real-life problems. With each passing month the number and complexity of the problems they face increase" (Ackofff and Greenberg , 2008, p 29).

Slattery (2006) attests to the latter in the following way:

> "When the illiterate peasants of Freire's Third World classrooms, as well as uncritical students of First World schools, begin to participate in problem-posing and problem-solving educational experience, they begin to develop a new awareness of self, a new sense of dignity, and ultimately an experience of hope" (Slattery, 2006, p 232).

In summary, the statements above suggest that learners should be guided in authentic problem solving in the classroom.

Although I realised that the current research posed many challenges, it was the security and the integrity of facilitating learning, in the face of the challenges that 21st century education, that compelled me to embrace this new and unfamiliar paradigm. When I started this research, I could not imagine the challenges that it could hold. My research challenged me as a teacher too, as I had to think differently to turn the mathematics task into a real-life situation, making use of everyday problems to be solved, without explaining or demonstrating anything. However, I committed myself to its promise and I was not disappointed. In my view, this participatory action research was only the smallest of introduction to a very demanding but most valuable professional education practice of facilitating learning. However, this statement

also contains an essential paradox in the sense that facilitating learning has, at its foundation and in its fullness (in the way in which learners should be facilitated in their most basic and natural learning process) a function of how the brain operates.

After just three participatory action research cycles, my achievement in this endeavour does not lie so much in my successes, but in discovering what everything means. My successes were few, but my awareness exploded because of the enlightened enrichment it brought to my consciousness of what holistic education – simultaneously activating the inseparable constituents of human nature, namely body, mind, soul and spirit (Dimitrov & Korotkich, 2002) - actually means. Unfortunately, the limitations that language, and even technology used and presented in this research can never do justice to the professional education practice of this comprehension.

From the interviews with the learners, conducted after the tasks, learners proposed that teachers should provide them with more of these learning tasks as they could understand mathematics better in this way, and that it was making mathematics fun, unlike sitting through boring explanations and activities. Learners enjoyed the fact that I did not provide them with the answer and felt that it made them think when they had to work through the problem. From the interviews with the teachers, it seemed that they wanted learners to challenge themselves and felt very strongly about giving learners problems to solve and making mathematics more practical for learners. The way that I followed through with the tasks was to focus on the fundamental human virtues. I therefore agree with Davis and Gardner (2012), that learners should experience the meaning of caring for something bigger than themselves when the teacher is set on nurturing the ethical minds of the learners by setting a trusting tone for social interactions. As Martin Luther King Jnr once said: “Intelligence plus character – that’s the goal of true education” (Gardner, 2008, p 17).

5.2.4 Answering the primary research question

Having read the above paragraphs, one could say that I can now answer my primary research question with confidence by saying that I can improve my professional classroom practice in Grade 6 mathematics in the 21st century by means of embedding the fundamental human virtues while facilitating learning takes place in the solving of real-life problems. This has reflected the true nature of the application of mathematics in daily life situations by using the CAPS curriculum document as a guideline and a standard to measure the progression of the learners sitting in my mathematics classroom. Claxton (2012) stated that *“Education is a moral enterprise…”* (Claxton, 2012, p 1). It was therefore the human virtues within the learners that seemed to have strengthened their learning and thinking within this study.

One should however understand that it was not the external teaching of values from textbooks that contributed to the accepting of human virtues within the learners. The learners needed to internalise these virtues by means of daily gestures. In this study, it was the standing at attention, neatly with shirts tucked in, the picking up all papers in class and moving tables neatly before leaving class, which made the difference. This routine task led to other gestures, such as learners gaining respect for themselves and taking responsibility for their actions, because they realised that if they threw a paper on the floor, they would be the ones to pick it up again. These learners started to recognise the meaning behind human behaviours.

One specific day, a learner accidentally pushed my computer screen onto the floor with her bag. Together with other learners, she carefully picked it up and wanted to know if it was still working, without me having to be angry with them. The next day, all the learners walked away from my desk when passing, without me having to say anything. This behaviour of the students was very different to how they used to behave. They also started to recognise the lack of these virtues outside of the classroom and started to enjoy the rewarding feeling of 'what they do matters', and that they matter.

It is imperative that teachers make a mind shift and be trained in facilitating learning, and at the same time incorporate fundamental human virtues, to guide learners rather than to teach them the old-fashioned way. This study made me realise that it does not matter *how* good your curriculum policy is; it is the *implementation* thereof that set the quality in learning. Teachers should also keep on challenging their learners; although this might be time-consuming, it is worth every minute to make every-day learning count in real life as well as in the classroom.

5.3 Recommendations

I would recommend that teacher training in South Africa should focus more on pedagogical training and less on content knowledge, learning how to use knowledge instead. The more training our teachers receive on a higher level of thinking, the better teaching may take place in the classrooms of South Africa. Teachers should also prepare learners for a world of constant change and the unknown.

5.4 Suggestions for further research

In the South African context, my suggestion is that further research should focus on:

- embedding of fundamental human virtues;
- implementation of facilitating learning;
- implementation of authentic learning tasks

The Singaporean mastery teaching should therefore be considered within the context of South Africa, as my research suggests that learners learn more easily when they need to solve a problem. Moreover, the effects of the above mentioned learning style on learners with Attention Deficit Hyperactivity Disorder (ADHD), with and without medication, should also be investigated, as authentic learning tasks (by means of facilitating learning) could be stimulating enough for those learners with the urge to be constantly active and stimulated. I have highlighted the potential use of facilitating learning of authentic learning tasks, together with the embedding of fundamental human virtues in South African education. Readers should realise the urgency of this matter.

5.5 Conclusions and recapitulation of comments

With this participatory action research study, I can say that actions and practices have been improved in my classroom. As a researcher, I have grown in terms of my own problem solving and am thinking differently about the approach of learning. Through this study, even the poorly performing Grade 6 learners in mathematics got to understand the concept better and quicker, when facilitating learning took place, instead of regurgitating the examples. This is confirmed by statements made by some of the participants themselves.

I agree with Mchunu and Msibi (2013) that the education is leaning towards the teachers being highly professional and able to cope easily with change, if we want to improve the education system in South Africa. I also agree with Mosogo and Pilane (2014) in their study that teacher development in South Africa must enjoy central focus, as they are the implementers of the curriculum documents and the driving force behind the education system. Tertiary institutions should therefore focus on the quality of their teacher training programmes (Mosogo & Pilane, 2014) by transformation within teacher development, and address the shortages of teachers in the 21st century (quality and not quantity, as is currently the problem).

Another statement that I strongly agree with is the study that proposed that teaching in South Africa must evolve to become a profession of preference and pride (Louw et al., 2013). From this study, I could conclude that it is not the curriculum policy of South Africa itself that is problematic, as it is based on both the product and process view of curriculum design (Scales 2013). South Africa still follows the outcome-based curriculum, which is based on product views, and this curriculum recommends facilitating learning of problem solving, which falls within the process view. I do therefore agree with the statement made by the current Minister

of Basic Education in South Africa that it was not the OBE curriculum that was the issue, but rather the teachers' lack of ability to function professionally in general (Mchunu & Msibi, 2013).

One of the interviewees of this study hit the nail on the head, when it was suggested that teachers should *"be innovative and adapt your curriculum to what is needed in the world outside"* (Initial coding, 2016, p 4). The document's assessment requirements must therefore be used as a guideline of the entry level to the next Grade. This will allow for further expansion of the learners that possess the ability to excel, while still providing a national standard for the country. Teachers are the starting point for all the careers in the future. I am of the opinion, that the teaching profession should therefore receive the highest level of respect and attention.

Although my learning tasks was successful in engaging the learners with real-life learning, the implementation of such a teaching model will need to be managed very sensibly when it reaches national levels of implementation, as it will continue to challenge teachers. This is where the professional teachers will be clearly divided from the teachers of poorer quality. I therefore agree with Garner (2015) that the Singaporean mastery teaching of mathematics, where learners need to solve problems in unknown contexts, should be implemented in South Africa, as it has been proven that this type of learning results in learners learning faster than their average classmates. If this could be implemented on a large scale within the current curriculum, it could lead to a breakthrough in the quality of South African education, with schools fulfilling their true function in preparing the learners for the unknown future.

This study also made me realise that the values we teach learners should be directed back to the learner by means of internal realisation. This would not only add value to the topic at hand because the teacher or curriculum requires it, it would also lead the learners to respect all things, starting by respecting themselves and those around them, accepting responsibility for themselves, and in that way adding value to the topics. In fact, respectful behaviour from the learners were demonstrated in my class, after conducting this study: every time a new cleaner at the school came into my class they always asked me how I managed to keep my floors so clean; I was proud to tell them that it was my learners who take their responsibility very seriously.

I still apply the same class rules as at the beginning of this study. I even have two pet birds in my class, and three succulent plants, that my class captains take responsibility for every morning. These class captains ensure that the birds receive clean drinking water and new seeds to eat every day, and clean the cage on a weekly basis, even after I have forgotten that it is cleaning day again. These class captains also took responsibility for watering the class

succulents once every Thursday, which they follow through very well. One cannot help to wonder if this study is the main cause of the improvement of human virtues within my learners. Gardner (2008) mentioned that we need workers of good character, respect and ethics, which is so difficult to measure objectively, but are yet becoming very important in education. These actions therefore prove to have contributed to prepare my learners for the world of work in the 21st century. This study opened my eyes to what is required for a teacher to be professional and to provide learning of high quality. I am standing only on the threshold of exploring and developing, and wishes to become a facilitator of learning that our education system in South Africa so desperately needs.

Hopefully this study will do the same for its readers, helping to improve the teaching profession in every way possible to prepare for our unknown future as best we can. We should start with our own learners, who will become the future generation of our country and who will be sitting in positions of critical decision-making in the 21st century. As Einstein once put it, *"Education is what remains after you have forgotten everything you've learned in school"* (Claxton 2012, p 2).

What would you, the reader, like our future generation to take with them from their twelve years of schooling?

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