

Title:
**The teaching of Grade 7 Mathematics through the use of
multiple means of representation**

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Faculty of Education

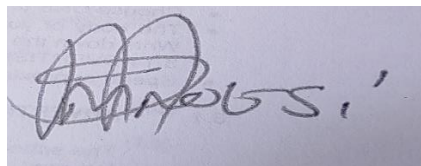
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Declaration Masters student

I, Irene Mpho Mmotsi, declare that the Master's Degree research **dissertation** or interrelated, publishable manuscripts/published articles, or coursework Master's Degree mini-dissertation that I herewith submit for the Master's Degree qualification in subject education in Mathematics at the University of the Free State is my independent work, and that I have not previously submitted it for a qualification at another institution of higher education.



Student's Signature

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Abstract

The study aimed at exploring how Grade 7 educators in the Thabo Mofutsanyane district in Circuit 8 use multiple means of representation in mathematics lessons. The reviewed literature gave insight into the incorporation of multiple means of representation in mathematical lessons. The literature review covered the teaching and learning of fractions, South African curriculum, and inclusive education. The study was guided by the Universal Design for Learning (UDL) framework. The research adopted qualitative design. Four Grade 7 mathematics educators from Thabo-Mofutsanyana district in Circuit 8 were purposively chosen to participate in the study. The participating educators were invited from four different schools. Two lessons per educator were observed with the aid of an observation schedule. The observations were followed by semi structured interviews. Three educators were interviewed based on what they would have taught during the lessons (the fourth participant withdrew at the interview stage). The findings in this study show that educators have the potential to use multiple means of representation in their lessons, to make challenging mathematics concepts such as fractions accessible to all learners. Together with real life materials, educators used prescribed textbooks and DBE workbooks. While UDL principle (multiple means of representation) was helpful in this study, it is recommended that two other principles should be considered when studies of this nature are conducted.

KEY WORDS: Multiple means of representation, Universal Design for Learning, Mathematics educators, representations.

Preface

The work carried in this dissertation was carried out in the Department of Mathematics, Natural Sciences and Technology education, University of the Free State, Qwa-Qwa campus, in July 2024, under the supervision of Dr Nkosinathi Mpalami.

The dissertation is the original work of the researcher and has not otherwise been submitted in any form for any degree to any institution. In cases where the researcher has used the work of others, it is duly acknowledged in the text.

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List of abbreviation and acronyms

ATP	Annual Teaching Plan
CAPS	Curriculum Assessment Policy Statement
CAST	Centre for Applied Special Technology
DBE	Department of Basic Education
DoE	Department of Education
FET	Further Education and training
MMR	Multiple Means of Representation
NSC	National Senior Certificate
TIMSS	Trends in International Mathematics and Science Study
UDL	Universal Design for Learning

Chapter 1: Background and overview of the study

1.1. Introduction

Educators have the important responsibility of ensuring that all learners from different backgrounds feel welcomed and supported during learning, and that they are given equal opportunities during learning (DBE 2011:4). One of the strategies for teaching a diverse classroom is curriculum differentiation. The Curriculum Assessment Policy Statement (CAPS) (DBE 2011:4) defines the curriculum differentiation as a process that involves changing, modifying, adapting, extending, and varying teaching methodologies, teaching strategies, assessment strategies, and curriculum content to ensure that all learners succeed. Educators need to differentiate learning materials, methods of representation, learning activities, and lesson organization.

In this study, the researcher focuses on multiple means of representation and how educators in Grade 7 utilize them. The CAPS document further states that different strategies can be used to make education accessible for all learners, including learners who have barriers to learning. These strategies include using a picture or diagram which is simplified, a picture or diagram to replace a written text or a diagram replaced by real item or model. The CAPS document allows learners to use representations such as drawings to show their solutions in mathematics. The multiple means of representation are important in teaching and learning mathematics.

According to Mainali (2020), utilizing multiple means of representation in teaching and learning mathematics has gained momentum in recent years as it caters to learners with different abilities. Mainali (2020) made an example of geometry, highlighting that geometry can only be taught with some kind of representation as a pedagogical strategy. Learning difficulties in mathematics teaching have been linked to various sources, including inadequate teaching, teachers not using the correct language, and poor teaching strategies (Ramsingh, 2020). This study explores how Grade 7 educators employ multiple means of representation to make mathematics accessible to all learners in their classrooms.

1.2. Problem statement

Considering all the changes to the South African education system, the education department still has challenges that need time and resources to be solved. According to International Mathematics Union (2020) mathematics education is weak in South Africa in both primary and secondary schools. The Trends in Mathematics and Science Studies (TIMSS 2019) show that South African learners still perform below the expected average. In 2019 it is reported that the average score of South Africa in mathematics was 372 points ranking South Africa 38th out of 39 countries (TIMSS 2019). Maree & Van der Walt (2007) posit that the reason mathematics results are poor is because a great number of educators in the senior and FET phase do not efficiently implement meta-cognitive strategies, use multiple means of representation, exploit multi-cultural diversity in the classrooms. Several studies on teaching and learning mathematics in schools have focused mainly on educators' content understanding and curriculum implementation rather than on educators' methods, practices, and strategies for teaching mathematics (Strawderman, Webb, 2010). One of the factors might be educators' failure to recognize that learners are different and, as such, require varied teaching methods and the use of multiple representations in lessons (Mainali, 2020). According to Gagatsis & Elia (2004), the four-way presentation involves verbal, decorative picture, informal picture, and counting line representation, and learners achieve better problem-solving skills when the four representation methods are used.

1.3. Research Question

How do Grade 7 educators use multiple means of representation in mathematics lessons?

Secondary Research Questions

1. What instructional resources do Grade 7 educators use in mathematics lessons?
2. What examples/analogies do Grade 7 educators utilize during teaching?

1.4. Research aim

The study sought to explore how Grade 7 educators in Thabo-Mofutsanyana District used multiple means of representation to make mathematics accessible to all learners.

Objectives

- 1.To identify instructional resources that Grade 7 educators use in mathematics lessons.
- 2.To highlight examples and analogies that Grade 7 educators use in mathematics lessons.

1.5. Value of the proposed research

It is hoped that the study would provide information for mathematics educators on implementing multiple means of representation in mathematics lessons. The study is premised on the belief that learners are not the same and, therefore, must be given diverse opportunities to learn mathematics. According to Dalton (2017), the original curriculum does not meet the needs of all learners, and there should be a change in the delivery of instruction to accommodate all learners.

1.6 Definition of key terms

Ary et al. (2010) state that uncommon terms used in research should be defined and clarified for the reader's benefit. Key terms used in the study are explained below.

1.6.1. Multiple means of representation

The process of presenting the same concept in different ways to make mathematics accessible to different learners.

1.6.2. Universal design of learning

An essential tool for proactive lesson planning in today's diverse classrooms that is both interesting and approachable (CAST, 2018).

1.6.3. Mathematics educators

A person who inspires their learners to look beyond the textbook pages to become problem solvers and critical thinkers. As a mathematics educator, you want your learners to have knowledge and skills to assist them in their future careers.

1.6.4. Representations

Are signs, graphs, diagrams, or objects that can be used in teaching and learning (Mainali, 2021:1).

1.7 Outline of the chapters

This study consists of five (5) chapters. Each chapter focuses on a particular feature of the study.

Chapter 1: Introduction and Background

The chapter outlined the research problem, background, the aim of the study, and the research questions.

Chapter 2: Literature Review

In this chapter, related literature is reviewed. The researcher discusses the following themes: teaching and learning of mathematics, Grade 7 mathematics curriculum, inclusive education, Universal Design for Learning (UDL), and curriculum material. The literature review provides insights into previous work and how this study is relevant to the existing knowledge. The theoretical framework for this study is the Universal Design for Learning, and focus is on multiple means of representation and their dimensions of perception, language, and comprehension (Spencer 2011).

Chapter 3: Methodology

This chapter presents the research methods employed in this study. The research approach, research design, sample and sampling procedures, data gathering instruments, data presentation, ethical considerations, and trustworthiness are discussed in this chapter.

Chapter 4: Analysis of data

This chapter analyses data that were collected through lesson observations and semi-structured interviews. The analysis was guided by UDL principle namely Multiple means of representation.

Chapter 5: Discussion, conclusion, and recommendations

The last chapter presents a summary of the findings. Conclusions are drawn based on the findings of the research. This chapter provides recommendations and suggestions for future research.

1.8. Conclusion

This introductory chapter highlighted the aim of the study, research questions, and value of the study among others. The definitions of commonly used terms throughout the research were given in this chapter followed by the summary of chapters. The next chapter focuses on the review of relevant literature.

Chapter 2: Literature review

2.1 Introduction

In this chapter I discuss the following themes: teaching and learning of mathematics, Grade 7 mathematics curriculum, inclusive education, mathematics representation, Universal Design for Learning (UDL), and the role of curriculum material. The review assists to locate the research in what other researchers have done in the past and how they are related to the study.

2.2. Teaching and learning mathematics.

Teaching is sometimes wrongly considered to be about educators and their roles only, but the most important aspect of the educational process is the learner and what they can learn (Sequeira, 2012). It is important that we understand the meaning of “learning” and “teaching”. Sequeira (2012) explains learning as change, and this change is bought by new skills, understanding of scientific law, and changing attitudes. Behlol & Dad (2010:231) defines learning as “quantitative increase in knowledge, memorizing of facts, skills and methods that can be retained and used as necessary”. In the senior phase (Grade 7-9) learners in mathematics are expected to know how to organize previous mathematical experiences, understand the nature of numbers, understand nature of variables, know characteristics of geometric shapes, understand the relationship between analytical geometry and geometry numbers, develop measurement and practice different patterns (Abuasad, 2020). It is the role educators to certify that instructing and learning takes place in the classroom. Teaching is described as contact between more matured and less matured persons, where information or skills are shared (Rajagopalan, 2019). Al-Taal (2021) defines teaching methods as components of the curriculum which educators use to achieve expected behavior among learners.

There are different types of teaching methods that educators can use based on the type of learners they have in their classrooms. AL-Rawi (2013) identifies the different teaching methods as follows: (1) lecture method- it is one of the teaching methods that is teacher-centered. The educator presents to learners while learners listen with minimal interaction with the educator, (2) brainstorming methods- groups are formed by the educator where

learners can learn from each other. The educator should ensure that members of the group are heterogeneous to promote academic and social benefits, (3) Hot chair method- is a method like a confessional. It is based on the educator asking questions to develop certain skills in learners, (4) investigative methods – overcoming problems by studying a number of ideas about a certain topic, and (5) discovery methods- it allows learners to search for knowledge and discover it, and contribute to learners being positive during the learning and teaching process.

The South African education system's current curriculum is the Curriculum and Assessment Policy Statement (CAPS) that is meant to redress the inequalities and imbalances of the past. CAPS can be interpreted as "a single, comprehensive, and concise policy document" that is introduced by the Department of Basic Education for all the subjects in the National Curriculum Statement (NCS) for Grade R-12. The CAPS document guides educators on what they should teach and how they should assess. The aim of the CAPS document is to produce learners that can:

- i. solve problems,
- ii. work independently,
- iii. manage time,
- iv. collect data,
- v. use symbols or visuals to communicate, and
- vi. Understand and interpret a set of related systems.

The CAPS curriculum is advocated in the country because it assists educators in teaching low-achieving learners using more structured educator-directed instruction. Mathematics is taught in the Foundation Phase (Grade 1-3), Intermediate Phase (Grade 4-7), Senior Phase (Grade 7-9) and Further Education and Training (FET) (Grade 10-12). The CAPS document (2011) aims to have learners' function effectively as individuals and as teams, and to gather, examine, organise and carefully assess important information. The Curriculum Assessment Policy Statement is utilized in South Africa because it is conducive in teaching learners with barriers who come from socio-economic disadvantaged backgrounds. If the CAPS (2011) curriculum is effectively implemented as it was conceptualised, learners would be equipped with the skills for the 21st century and

develop learners for the demands of the 4th Industrial Revolution era. The educator should aim to teach Mathematics for conceptual understanding and procedural fluency, develop learners' strategies, and create a learning-centred classroom to transform the instructing and learning of mathematics in South Africa. In the classroom, learners are taught and assessed, and according to the CAPS document (2011:143), assessment is defined as a "continuous planned development of classifying, collecting and translating information regarding the performance of learners, employ different types of assessment.

In this chapter, the focus is on mathematics education in South Africa. The model of mathematics teaching and learning in South Africa is composed of four key dimensions namely: conceptual understanding, mathematics procedures, strategic procedures, and reasoning and learner centeredness. Key concepts are interlinked and should be used to ensure efficient teaching and learning in the classroom. Groves (2012) affirms that conceptual understanding is the knowledge of patterns, concepts and relations; mathematical procedures are skills needed to carry out procedures efficiently and appropriate; strategic procedures is the ability of a learner to solve mathematical problems; and reasoning is explained as justification or explanation of how and why mathematics problems are solved in a certain manner. Groves (2012) includes productive disposition as the fifth intertwining strand of mathematical proficiency. Productive fluency is explained as perceiving the usefulness and worthiness of mathematics.

The main focus of current curricular in South Africa is to ensure that learners are able to solve problems and to share and communicate their idea, which promote learning centred classroom. Olugbenga (2021) states that learner centred methods shift the focus from the educator to learners, where the interest of learners are put first learners' voices are the centre of learning experiences. In the learner centred classroom, learners become an active agent. Bas & Beyhan (2019) elaborate on different learner centred approaches in the classroom like: cooperative learning where learners work in teams to solve problems; inductive learning where learners are presented with challenges; gamify learning where an educator introduces mathematical games such as chess to improve critical thinking; expeditionary learning which is getting the learners out of the classroom and into the real world such as road trips; active learning that allows learners to brainstorm during class;

and the flipped classroom where learners are given instruction which transcends the individual. It has been shown that learner centred methods produce measurable benefits. Rani (2020) opines that the learner centred classroom assists in building learners' self-esteem and social skills, and allows learners to get emotional and cognitive support from educators, and to motivate one another to succeed together. Educators also benefit from learner-centred classrooms because they become facilitators and guide, while learners work on their own. Educators have less traditional work to do. Olugbenga (2021) notes that there are benefits to learner-centred approaches. However, there are some issues that need to be considered when promoting learners centred in the classroom. Most challenges of learner-centred methods are related to organizational structure of classrooms and schools. In a public school where there are 60-80 learners in a classroom, it is difficult to engage all learners at the same time, especially when learners have to work in groups (Miller & Metz, 2014). Olugbenga (2021) argues that educators have been allocated 30-45 minutes teaching learners, but learner-centred classrooms expose learners to hands-on activities which need longer periods. One of the challenges of learner-centred classrooms includes assessment, where standardized tests like NECO and TIMSS are still traditional.

Once teaching and learning has taken place in the classroom, learners need to be assessed on what they were taught. Assessment is defined as the process where educators record learners' marks using different tools for accountability (Olusola & Luneta 2018). On the same note, Luneta (2016) defines assessment as a process where quality, value, and the impact of learning are analysed. Mathematics consist of different types of assessments and educators are motivated to utilize these types of assessments to serve the motive associated with each. We have baseline assessment that is mostly utilized by educators to find out what learners know (prior knowledge) and is done at beginning of the year; diagnostic assessment, mostly utilized to find difficulties that learners might experience about a certain topic; formative assessment used to accommodate the process of teaching and learning; and summative assessment that is usually used at the end of term to determine what learners have learned (Dreyer 2017).

2.3 Grade 7 mathematics curriculum

Teaching and learning in South African Schools is guided by the Annual Teaching Plan (ATP). The ATP was developed because of Covid-19 to create Education system across the country. As a solution to the disruption caused by the pandemic, the DBE developed the ATP to recover the time lost for teaching and learning. According to Department of Basic Education (DBE), ATP is a document that guides educators on the implementation, minimum content and skills to be taught. The ATP assists educators to ensure their instruction is aligned with the intended curriculum, standards and learning objectives. The annual teaching plan is divided into four terms; Term 1, 2, 3 and 4. In each term, there are 11 weeks. In term 1 and 2, learners are taught from week 1 till week 9, and weeks 10-11 are revision and assessment. However, in term three, educators are expected to teach from week 1-8 and revision is done in weeks 9-10 followed by a control test. In term 4, learners are expected to write the final examination that is separated into two papers each with a total of 50 marks. The final examination consists of the curriculum which was taught throughout the year.

2.3.1. Content taught in term 1

According to ATP 2023/24, learners should be taught two topics; whole numbers and fractions. Whole numbers consist of calculation techniques such as division, multiplication, addition, and subtraction of whole numbers. Part of the whole numbers include factors and solving problems of percentages and financial contexts. Fractions include common and decimal fractions. Fractions can be defined as a number that tells us about the relationship of two quantities. These quantities consist of information about parts, units, and the whole number (Bruce, Chang & Flynn, 2011). According to Moleko & Sepeng (2023), fractions are difficult for learners to grasp. Fractions form part of the Mathematics curriculum (Curriculum assessment policy statement), from the Intermediate to the FET phase. Therefore, learners must understand fractions at an early stage. The difficulties of fractions are identified from the early age of primary years. Fractions are concepts that are difficult to learn and to teach (Empson & Levi, 2011). The two researchers state that the difficulty of fractions begins at an early age and persist through

middle school into secondary school. The field of science, technology, engineering, and mathematics (STEM) emphasize that it is essential for learners to understand fractions because fractions lay good foundation for understanding advanced mathematics in the future. Moleko & Sepeng (2023) observe that one of the reasons that make fractions difficult to learn is that learners lack proportional and spatial reasoning skills. Siemen et al. (2015) argue that learners find fractions difficult because they are used to characterizing the relationship between numbers rather than absolute numbers. Chamane (2016) posits that learners assume that fractions are characterized by knowing routine procedures, which is often inaccurate. Regardless of these challenges, some strategies can be utilized by educators to simplify fractions. Moleko & Sepeng (2023) suggest that educators can use manipulative and real-life problems to make fractions accessible to all learners. Learners who actively participate in activities that require manipulation of objects develop an understanding of concepts.

2.3.2. Content taught in term 2

Learners are expected to know exponents, which consist of mental calculations. Learners are expected to find squares to at least 12^2 and their square roots, and determine cubes to at least 6^3 . Exponents in Grade 7 according to ATP 2023/2024 include comparing and representing numbers in exponential forms. Learners are expected to perform calculations using numbers in exponential form. Integers are any numbers including zero, positive numbers and negative numbers. Learners should be taught the properties of integers, counting, ordering, comparing, and calculations with integers. Patterns are repeated arrangements of numbers, colours or shapes. Numbers should be related to one another in a specific rule or manner. Learners in Grade 7 are taught both numeric and geometric patterns. Numeric patterns are about numbers which are repeated and arranged in a specific manner. Geometric patterns are a sequence of numbers that are based on division and multiplication operations. Learners should be taught functions and relationships in term 2. It is important that these two terms be defined differently to make sense. Relations is a rule which involves each element of one set with at least one set from another element, whereas functions is a rule that associates the element of one set with the element of another set, and each element in set maps to only one element in set

(siyavula). At the end, learners should be able to find the input, output, or rules for patterns and relationships using flow diagrams, tables and formulae. Educators should teach learners to determine and interpret equivalence which can be presented verbally or as flow diagrams, tables, formulae, or number sentences.

2.3.3. Content taught in term 3

Learners are taught construction of geometric figures, where they are expected to measure and construct angles such as acute, right, obtuse, straight, and reflex angles. Learners define the geometry of straight lines such as line segments, ray, straight, parallel and perpendicular lines. Geometric 2D shapes can be defined as figures on a flat surface with two dimensions; length and width. In Grade 7, learners are expected to classify 2D shapes, differentiate between similar and congruent shapes, and solve problems involving unknown sides and angles in triangle and quadrilaterals using known properties. The last topic in term 3 is transformation geometry. Transformation means change, and changes would be done in the given geometric shape. According to ATP 2023/2024, learners need to know three types of transformation which are translation, reflection, and rotation.

2.3.4. Content taught in term 4

In the last term, learners are exposed to area and perimeter of 2D shapes, surface area and volume of 3D objects, and data handling. Learners use correct formulae to calculate perimeter and area of squares, rectangles, and triangles. It is expected that learners will be able to solve problems that involve perimeter and area of polygons. Educators are expected to teach learners formulae that the learners can use to calculate the surface area, and volume and capacity of cubes and rectangle prism. The last concept is data handling. In this term, learners acquire skills in collecting data, organising, summarising, representing, and interpreting the collected data. Learners are expected to summarise data in short paragraphs which can include drawing conclusions about data, predicting what the data is based on, establish sources of error, and selecting the correct summary statistics.

2.4. Inclusive education

Kirschner (2015:2) defines inclusive education as “[T]he inclusion of a physical and mental impairment, such as sensory or mobility limitation, intellectual disabilities, learning disabilities, language disorder, behaviour disorder and autism spectrum disorder”. The constitution of the Republic of South Africa Act no 108 of 1996 (RSA 1997, S29) affirms that everyone has a right to basic education, and that no person should be directly or indirectly discriminated against on the grounds of physical disabilities. In South Africa, inclusion is well elaborated in White Paper 6, of the Department of Education, to support both learners and educators within the education system and ensure that their needs are met (Department of Education 2001). The purpose of the White Paper 6 is to address learners’ different needs and to eliminate barriers to learning (Dalton 2012). Inclusive education policies have two major components explained in the form of guidelines. The first component is SIAS (Screening, Identification, Assessment, and Support); a process where learners with barriers are identified and support is established. Once the first component is complete, there is differentiation of curriculum, where educators ensure learners with barriers are given support (McKenzie 2020). The diversity in the classroom has resulted in curriculum differentiation. According to Sibiya (2021), differentiation is teaching and assessing methods that are varied and adopted to cater for the learning needs of learners with barriers. Inclusive education does not focus on separate classrooms or schools for children with special needs, but assumes that all learners are equal and should be in the same educational space (Sibiya 2021).

The Department of Education organizes support into different programs that include the following: provision of specialist services; specialized professional staff; curriculum differentiation that includes inclusive assessment; specialized teaching and learning support material; and training and monitoring of teachers, managers, and support staff. There are three support levels described within the program of curriculum support. These are: low, medium, and high-level support. McKenzie & Dalton (2002) further elaborate on the support levels. Low Support Needs (LSNs) are barriers that can be addressed in the short term; Moderate Support Needs (MSNs) are needs where the educator is required for additional planning, adopting instructional strategies, and providing teaching support

material with the help of a curriculum advisor. High Level Support Needs (HLSNs) require constant support and consultation.

2.5. Universal Design for Learning (UDL)

The centre for universal design (2015) states that the term Universal design (UD) was first recognized by Ronald Mace in the year 1970s, and was referred to as design of the product and the environment to be used by all people without the need for adoption. The idea of universal design in architecture aims to create environments that are accessible and usable by everyone, regardless of age, ability, or another characteristic. The UD consists of three frameworks; Universal Design of Instruction (UDI), Universal Instructional Design (UID), and Universal Design for Learning (UDL) (Rao et al., 2014). Universal Design for learning has been revised over the past years, and in 2011, UDL 2.0 was proposed (CAST 2011). Universal Design for Learning (UDL) is a framework utilized to support educators in a diverse classroom (Carrington et al., 2020). According to Capp (2017), UDL can be used as an inclusive teaching methodology to accommodate all learners in a diverse classroom. The UDL was first introduced by Rose and Meyer in the year 2002 at the Centre for Applied Special Technology (CAST). It is used to provide various opportunities to ensure all learners are exposed to learning, including learners with special needs (CAST 2018).

UDL consists of three principles which guide educators to address learning in their classrooms namely: multiple means of engagement, representation and action and expression. Learners have different characteristics, needs, and abilities. The different features of an individual could affect a learner's performance academically. Burgstabler (2011) states that learner diversity involves physical, visual, hearing, sensory, attention, and community impairments. These limitations should not be barriers to equal opportunities in education. Universal design can be used as a solution to address diverse learners' needs. Spencer (2011:10) defines UDL as “[a] valuable tool for proactive planning of engaging accessible lessons in today's diverse classroom.”

Orkwis & McLane (1998) define UDL as “the design of instructional materials and activities that allows the learning goals to be achievable by individuals with wide differences in their abilities to see, hear, speak, move, read, write, understand English,

attend, organize, engage, and remember”. Rose et al. (2006) affirm that UDL is developed to tackle the limitations of the learning environment, rather than dealing with learners’ limitations. Researchers such as Capp (2017) have conducted research based on the effectiveness of UDL and concluded that UDL has the potential to engage learners more, and improve learners' academic and social outcomes. UDL aims to move away from teacher-centred lessons to learner-centred approach by providing knowledge expression, learner engagement, and multiple means of representation (Al-Azawe, Serenelli, 2013). The Centre for Applied Specialist Technology (CAST 2018) developed UDL as a method of lesson planning that assists educators in creating a lesson that can cater to all learners in the classroom. According to CAST (2018), UDL is based on three principles that educators need to consider when using UDL: Principle 1- representation, principle 2- Action and expression, and principle 3- Engagement and interaction.

PRINCIPLE 1- Representation: the teacher needs to know how to present the content to make it accessible to learners. If a learner is presented with a written text only, then content information is unavailable for learners who cannot read or see the language in which the book is printed.

PRINCIPLE 2- Action and Expression: learners need to be given a chance to present what they were taught and what they learned.

PRINCIPLE 3: Engagement and Interaction: the educator needs to engage learners by drawing them into learning, providing choices, and rewarding effort.

Dalton (2017) further explains multiple means of representation as when an educator uses a variety of media, visuals or auditory, to meet a range of learning needs. With multiple means of action and expression, the educator can allow learners to work with a partner or a small group to demonstrate what learners have learned. In multiple means of engagement, the teacher can design and plan instruction that arouses interest. In this study, I only focused on principle 1: multiple means of representation.

Table 2.1. Universal Design for Learning: principle, guideline, and checkpoints (CAST 2018)

Principles	Guideline	Checkpoints
Provide multiple means of representation	Provide options for perception	Offer ways of customizing the display of information
		Offer alternatives for auditory information
		Offer alternative for visual information
	Provide options for language and symbols	Clarify vocabulary and symbols
		Clarify syntax and structure
		Support decoding of text, mathematical notation, and symbols
		Promote understanding across language
		Illustrate through multiple media
	Provide options for comprehension	Activate or supply background knowledge
		Highlight patterns, critical features, big ideas, and relationships
		Guide information processing and visualization
		Maximise transfer and generalization

Learners differ in the manner in which they receive information that is presented to them. It is, therefore, important that educators use different strategies that cater for all learners in diverse classrooms. Multiple means of representation have three guidelines (see Table 2.1).

2.5.1. Guideline 1: Provide an option for perception.

Perception consists of three checkpoints. When an educator is using multiple means of representation during the lesson, they should be able to offer ways of customizing the display of information. According to CAST (2018), materials that are in print are fixed and permanent. This may be a barrier to learners as learners receive information and learn differently. Teaching material can be changed to suit diverse learners in the classroom. For example, information can be displayed in different locations, enlarged, or highlighted.

According to CAST (2018), examples of perceptions are as follows: presentation of data in a versatile layout to allow for easy comprehension; the size of text, pictures, diagrams, or any other visual elements; the backdrop, the text, and the images should all have distinct colors; Colors can be utilized to emphasize ideas or provide information; the rate or loudness of sound or speech; timing of animation, sound, and simulations; print material typeface; and video speed.

The second checkpoint of perception is to offer alternatives to auditory information. Sound plays a critical role in teaching and learning. However, if information is perceived only through sound, it will not be accessible to all learners (CAST 2018). Learners who have hearing problems, or who take time to process information, and learners who have memory problems, will not perform well if a lesson is only based on sound. Alternatives that can be used instead of auditory information include the use of text alternatives like captions or automated speech-to-text technology; offering visual representation such as diagrams, charts, or musical notations; using written transcripts for videos or audio recordings; utilizing visual representations such as bolding to convey emphasis and prosody.

Visual information is important, especially when information is about the relationship between objects or events. Cast (2018) states that visual information is not accessible to all learners, especially to learners who have visual disabilities or are not familiar with graphics. To assist such learners, it is important to use non-visual alternatives. The third checkpoint of perspective is to offer an alternative for visual information. Examples that can be used are: offering explanations for all visuals, such as images, graphics, or videos, through text or speech; animated graphics using tactile graphics or reference objects as alternatives for key touch interaction; and visuals that depict ideas offering tangible items and three-dimensional representations to communicate a point of view.

2.5.2. Guideline 2: Provide options for language, mathematical expression, and symbols

Learners differ in their ability to use different types of representation, both verbal and non-verbal. Some words can enhance and clarify ideas for a learner. For example, some learners might find significance in a picture or diagram that others may not. The guideline

consists of five checkpoints. The first one is clarity of vocabulary and symbols. Words can be used as meaningful elements for the information presented. Different visuals such as representing symbols, numbers, and icons are not accessible to all learners. To make education accessible to all learners, there should be a connection between key vocabulary, labels, icons, and symbols. Examples include teaching terminology and representation in advance, particularly in ways that encourage understanding the relationship between learners' past experiences and existing knowledge; offering visual symbols along with alternative text descriptions; emphasizing how intricate phrases or mathematical expressions are constructed from basic words or symbols; and incorporating vocabularies and symbols directly in the text and include assistance for unknown citations in the text.

The second checkpoint of guideline 2 (language, mathematical expression, and symbols) is to clarify syntax and structure. Words and numbers can be combined to develop new meaning. The new meaning depends on understanding the rules and structure of how these elements are put together. Examples that can be implemented are: explaining syntax or structures that learners are not familiar with, through alternatives that establish links with structures that have been previously taught; and clarifying the connections between elements.

The third checkpoint is to assist in decoding symbols, mathematical notation, and text. Learners need to practise efficiently interpreting words, numbers, or symbols that have been presented in a way that is difficult to interpret (CAST 2018). Learners need to be regularly exposed to symbols to use them effectively. It is important to reduce the decoding barrier as not all learners can decode easily and fast. Text-to-speech, automated speech using digital mathematical notation, and digital text combined with a human voice recording are a few examples of applications.

The next checkpoint is to promote understanding across the language. The language used for curricular material usually is one, and in most cases, learners do not use one language. Information cannot reach all the learners if no linguistic alternatives are used. Strategies that can be implemented to overcome the barrier are: ensuring that key information is in the dominant language and also available in the home language of

learners; connecting key terminology to definitions and pronunciations in the language of teaching and the home languages; defining vocabulary that is used more frequently employing both general and domain-specific terminology; introducing learners to computerized translation resources; and providing visual, non-linguistic resources to help learners understand language. The last checkpoint of guideline two is illustrated through multiple media. Most of the information in the classroom is based on text. This becomes a barrier to learners who cannot read or have language barriers (CAST 2018). It is important to use alternatives for text such as illustrations, simulations, images, or interactive graphics to make information accessible to learners. Alternative forms such as illustration, dance, diagrams, tables, or models can be used to present key concepts and form connections between verbal information presented and that information represented in pictures or diagrams.

2.5.3. Guideline 3: Provide options for comprehension.

According to CAST (2018), making education accessible is not the purpose of education. Rather, learners should be taught how to use accessible information. The process of changing accessible information to usable information is active. The researcher went further to state that usable information is information that is accessible for future decision-making. Proper presentation of information can lead to accessible information for all learners. The guideline consists of four checkpoints. The first checkpoint is to activate or supply background knowledge. Information becomes accessible to learners if it requires prior knowledge. When learners lack prior knowledge, barriers may exist where the prior knowledge is needed to access new knowledge. Some learners may have the necessary background knowledge but no idea how to use it. It is important for the educator to supply or activate background knowledge to reduce these barriers (CAST 2018). Examples that can be implemented to supply or activate background knowledge are: utilizing advanced organizers; pre-teaching difficult concepts through practical or models; making explicit cross-curricular connections; using visual imagery to link, activating necessary prior knowledge, and connecting concepts with relevant examples and metaphors.

The second checkpoint is to emphasize patterns, important characteristics, concepts, and connections. To make education accessible to learners, it is critical for learners to be able

to identify features that are most important and least important. This will assist them to allocate time efficiently. Implementation examples include: emphasizing critical concepts in text, graphics, and diagrams; utilizing numerous examples and non-examples to draw attention to key aspects; employing cues to highlight key ideas; highlighting previously acquired abilities that can be applied to problem-solving; and highlighting important ideas with graphic organizers (CAST 2018).

The other checkpoint is guiding information processing, visualization, and manipulation. Information should be effectively organized for learners to easily summarize, organize, and highlight important aspects. However, not all learners can complete the full range of these techniques. Material that is well-developed can offer personalized solutions. Implementation examples include: providing options for organization methods and approaches; breaking information into smaller parts; removing unnecessary information unless it is important to the instructional goal, providing different ways in which a lesson can be introduced through content, introducing graduated Supporting frameworks for information processing techniques, successively releasing information, and providing models that interact to guide exploration and new knowledge.

The last checkpoint is to escalate transfer and generalization. All learners need to be able to generalize and escalate information into new contexts. Learners have different abilities to memorize and transfer information to improve their ability to access prior knowledge (CAST 2018). Examples that can be implemented are: providing chances to go back to important concepts and connections between ideas; offering support that links previous information with new information; integrating unfamiliar concepts into familiar concepts and settings; providing tools like templates, graphic organizers, and concept maps to assist with note-taking; availing specific chances for review and practice what is learned, and encouraging mnemonic techniques and tools.

Multiple means of representations are the manners in which learners receive information and knowledge. Schools can meet the requirement of the UDL principle by ensuring that material used for teaching and learning includes images, concept maps, maps, graphs, diagrams, and a variety of other specialized graphical representations. Moleko & Mosimege (2021) affirm that the MMR seeks to make it possible for mathematics to be

accessible to all learners, and different possibilities for comprehension, language, mathematical expressions and symbols, and perspectives must be offered by educators. Providing different options to learners is important because learners are different, and receive and analyse information differently. MMR can be regarded a promising strategy for flexible teaching but CAPS does not indicate how the MMR principle can be applied, which leaves the responsibility to the educators to use their discretions. Rao et al. (2014) state that the UDL principle is a promising strategy to eliminate or reduce learning barriers, and if more effort can be put on implementing UDL, it can provide equal opportunities to all learners.

2.6. Representation in teaching and learning mathematics.

Multiple means of representation refer to the process of presenting the same concept in different ways to make mathematics accessible to different learners. For example, educators can use concrete materials, draw diagrams, write equations, and draw tables to teach a mathematical concept. Mainali (2021:1) defines representation as signs, graphs, diagrams, or objects that can be used in teaching and learning. Representations are important in the context of mathematics as well as the cognition associated with mathematical activity (Kaput 1998). There are benefits to representation. Representation can be a powerful thinking tool as it makes mathematical ideas more concrete and available. Representation assists learners to recognize the common elements in different situations, and assist learners in building understanding and communicating information. External and internal representations are the two different categories (Mainali, 2021). Mathematical relationships, such as number lines, graphs, and algebraic equations, are communicated and demonstrated through external representation, whereas internal representation is the actual image of the mathematical concept that learners and educators have in their mental structures (Mainali, 2021). The two representations are interrelated.

2.6.1. Manipulative models

Learners actively interact with the environment to discover the objects around them that assist them to structure their knowledge. Manipulatives can be defined as physical or visual objects used as teaching tools for learners to have hands-on experience

(Carbonneau & Marley 2012). Lerman (2020) affirms that mathematical manipulatives can be defined as objects used in mathematics lessons. They can be touched by learners to explore or investigate mathematical concepts. Liggett (2017) states that manipulatives are objects utilized for instructional purposes and come in different shapes, sizes, and colour. Manipulatives in mathematics can be used to close the gap between formal and informal mathematics. Pictures, diagrams, and manipulatives can assist learners to visualize mathematical concepts and link them to their prior knowledge. According to Lerman (2020), mathematical manipulatives can be grouped into categories that are concrete and virtual. Concrete manipulatives are physical objects that can be touched and felt while Virtual manipulatives are computer or laptop-based digital items that mimic real-world things and may be controlled with a mouse. Historical manipulatives are concrete and have been created in the longstanding history of mathematics to solve a certain or explore problem. Artificial manipulatives are created by educators for a specific purpose or educational aim.

Manipulatives are important in a lesson because they assist learners to learn, explore, and investigate using a variety of hands-on learning (Lange 2021). Fambaza (2012) affirms that using manipulative models appropriately can play a major role in developing meaning and clear communication in mathematics. Naidoo (2011) states that, when visual presentation is correctly used, it can improve the learners' ability to solve problems, and both educators and learners can develop their understanding of operations through manipulating concrete material. According to Lange (2021) research has shown that virtual manipulatives like computer software are very useful in teaching mathematics, and increase enjoyment of learners during the lesson. Fambaza (2012) argues that learners' performance improves when computers are used as virtual aids. However, most schools do not have computers, especially in the rural areas, and even when computers are available in schools' educators still need to be trained to use those (NEIMS 2021).

Naidoo (2011) attests that educator who used visual aids during lessons made mathematics interesting and accessible to all learners, and assisted learners to memorize key ideas and procedures. English & Halford (1995) argue that for some learners, controlling tangible items might not be sufficient. If they cannot understand the concepts,

meanings, and associated symbolism. Learners should be able to relate real life problems and written symbols. Dlamini (2017) opines those learners need to be given enough opportunities to deal with a problem using manipulative models before they are given the rules and procedures. The other disadvantage of using manipulatives is that educators use symbolic notation more, and even when other types of representation are utilized, they serve to demonstrate the solution to the problem rather than creating meaning (Lee, Brown & Orrill 2011).

2.6.2. Diagram representation.

Winn (1987) defines diagram as a 2-dimension, virtual object that occupies space in a meaningful manner, and which enables structure to be represented. Cellucci (2019) affirms that diagrams have been traditional ways to communicate formal and informal mathematical concepts. Drawing a diagram can be used in problem solving. Uesaka & Manalo (2012) opine that visual presentations such as models and diagrams are the most effective ways of problem-solving. According to Stylianou (2011), representation in mathematics plays a major role in learners' problem-solving activities. The benefits of using representation in mathematics are: (i) it acts as a tool to reduce cognitive load in learners' memory, (ii) it can be used to monitor and assess progress in problem-solving, (iii) diagrams allow learners to create and find more information about mathematical problems. Diagrams serve as bridges between mental representation and physical representation of particular concepts. Moreover, diagrams can also highlight the connection between quantities and operations in a given problem (Manoharan & Kaur 2022).

2.6.3. Real-world situation

Dlamini (2017) notes that use of real-world situations assists in grasping mathematical concepts in our daily experiences. This makes mathematics ideas accessible to learners. Metaphors are used to establish the relationship between real-life problems and mathematical concepts. Presmeg (2013) states that metaphors develop understanding of mathematical concepts and procedures that are difficult to present using concrete objects. Mathematics educators utilize word problems to bring real-life applications to the classroom. However, most learners dislike word problems (Premadasa & Bhatia, 2013).

The authors further state that there are various reasons why learners find word problems difficult. These include the fact that learners struggle to read with comprehension and translate English words into mathematical symbols.

2.6.4. Symbolic representation

According to Mainali (2021), mathematical concepts can be presented in symbols such as numbers, operations, connection signs, and algebraic signs. Mathematics consists of characteristics which do not allow a person to learn by observing the actions of others. According to Yani and Chih-Huang (2017), mathematics can be presented in verbal and symbolic form. The symbolic form is explained as the use of symbols of mathematical logic to understand and solve mathematical problems. Yani and Chih-Huang (2017) emphasize that certain steps need to be followed when solving problems related to symbols. These steps are: making sure to carefully read definitions and theorems, understanding the intention behind every statement, identifying compound statements (definitions or classifications), providing a hyphenated word that is used logically in a compound term, formulating a statement utilizing symbols only, and combining individual sentences into one coherent statement.

2.7. The role of curriculum materials in teaching

Remillard and Heck (2014) state that the official curriculum consists of curriculum goals and objectives, content of assignments, and the designated curriculum. The curriculum goals and objectives include expectations of learners' learning, performance, and curricular resources. Instructional materials are an important tool for teaching and learning to enhance educators' efficiency and improve learner performance. Tety (2016) agrees that instructional materials are tools that educators utilize to make teaching more interesting and memorable. He further opines that if educators use relevant instructional material, it will increase the chances of quality teaching and learner performance. Curriculum material can be defined as any substance that represents and guides pedagogic approach, content, and the sequence of teaching. These include class activities, lesson plans, assessments, and schemes of work (Moore, Coldwell & Perry, 2020). Moreover, curricular material (2021) explains instructional or curricular material as material utilized by educators to provide information to learners regarding academic

subjects and content. According to Ordu (2021), there are two types of teaching aids; traditional and modern teaching aids. The author further elaborates that the traditional teaching strategy was used years ago when technology was not available as it is now. There was no electricity, cellphones, computers, chalkboard, mud, and dust were used as teaching aids. Meanwhile, modern teaching methods include use of computers, whiteboards, television, and multimedia. Educators use various instructional material like textbooks, charts, models, graphs, and real objects, to promote learning. Korchhar (2012) affirms that curriculum materials are important tools for teaching and learning and educators need necessary and relevant materials to complement classroom interactions, and textbooks to broaden learners' interests. Tomlinson (2012) state that five features of teaching materials should be included in a teaching material to guide both educators and learners. The instructional material should be informative.

Ljeta (2013) note that teaching and learning have common characteristics like availability in textbooks, multiplicity, presenting the essence of subject content related to the curriculum, and ease of application. The purpose of using teaching and learning resources is to assist educators in delivering educational content to learners. Teaching and learning materials motivate learners, develop creativity, assist in remembering prior knowledge, encourage the process of understanding, and contribute to acquisition of new skills (Ljeta 2013). Teaching learning materials (TLMs) can be classified into three categories; audio, visual and audio-visual teaching-learning materials. The author further states that audio material stimulates the hearing sense of the learner. It includes audio tapes, radio broadcast, and human voice. Visual material stimulates a sense of vision. It includes visual prints, textbooks, newspapers, documents, case studies, etc. The projected aids known as audio-visual TLMs use both visual and aural components to improve learning. These include motion picture films, videos, and multimedia computers. Ghafar et al. (2023) argue that standard classroom material should have common characteristics and they include visuals such as posters, commercially produced material such as textbooks, and handmade material by the educator or learners. The authors further state that creating materials has the ability to assist learners with barriers to learning. Textbooks are books written by authors for learners to learn new things, and to meet the needs of the syllabus. Textbooks plays an important role in teaching and

learning since they determine the content and what needs to be taught. According to Van Garderen, Scheuermann & Jackson (2012), textbooks address three important aspects; the sequence of topics, content to be taught, and activities used to determine learner understanding of a certain topic. Ghafar et al. (2023) note that textbooks are used as a resource for representing material, a source of activities for learners, a source of incentive and ideas in the classroom, a syllabus that educators consider, and they assist educators who are inexperienced. Textbooks use text as a method of communicating. The Department of Education in South Africa introduced the DBE workbook in 2011 for Grade 1-9 and siyavula textbooks for Grade 10-12. The workbook covers different subjects and Grades and is used to support teaching and learning. These workbooks were developed to improve performance in literacy and mathematics (DBE, 2013). The workbook consists of lesson plans, activities, and assessment aligned to the curriculum. It consists of Book 1 that covers the assessment activities for Terms 1 and 2, and Book 2 that covers the assessment activities for Term 3 and 4. The Australian Council for Educational Research (ACER) conducted research on DBE workbooks and showed that DBE workbooks intend to assist educators and learners by providing worksheets, and activities, to monitor learner performance and focus on curriculum delivery.

ACER (2013) indicates that 80% of South African schools are using DBE workbooks as effective tools, and the other 20% do not use the workbooks because of late or non-delivery. Matthew et al. (2014) and ACER (2013) argues that, even though educators use DBE workbooks as their daily tool, they do not use workbooks as intended by the Department of Basic Education (DBE). The two authors suggest that educators need training on how to use workbooks to implement effective teaching and learning. According to Tety (2016), schools that have sufficient instructional material perform better compared to schools with insufficient resources. He further makes an example that private schools accomplish better than public schools because private schools have sufficient syllabus material. Instructional material plays an important role in the academic performance of learners. Although instructional material plays a major role in the performance of learners, there are certain schools, especially in the rural areas, with insufficient resources. Tety (2016) states that educators have difficulties in accessing instructional materials in the rural areas. There is a shortage of textbooks and no internet connectivity that leads to low

performance in such schools. Some researchers claim that instructional material contains much information that is difficult for learners to understand on their own, and educators need to explain it to learners, which is time-consuming. It is also difficult for educators to select authentic learning material, and the process requires much time.

2.8. Conclusion

In this chapter, six themes were discussed, namely; teaching and learning mathematics, Grade 7 Mathematics curriculum, inclusive education, universal design for learning, representation in teaching and learning mathematics, and the role of curriculum material in teaching. The next chapter discusses the methodology.

Chapter 3: Methodology

3.1. Introduction

This chapter focuses on the research methodology that includes research design, data collection, description of instruments used to collect data, methods used for data collection, and ethical considerations. The study aimed to explore the teaching of Grade 7 Mathematics using multiple means of representation, Qualitative research was used. Observations and interviews were used as data collection methods. Ethical considerations are discussed and necessary steps are taken to protect participants.

3.2. Research Approach

Qualitative research consists of collecting and analyzing words or meanings to understand concepts, opinions, and experiences (Bhandari, 2020). This approach can be used in different fields such as humanities and social sciences, within subjects such as education, sociology, history, and health science. Qualitative research, according to Ugwu & Eze Val (2023), is a phenomenon that involves quality, and usually uses description, reasoning, and words. Qualitative research aims to get the meaning or feeling, and describe a situation. Bhandari (2020) states that qualitative research aims to understand an aspect of social life, and generates words rather than numbers. Qualitative research often answers the why and how questions of human behavior, perspectives, and experiences. Islam & Aldaihani (2022) state that you can use qualitative research when you need to understand the setting or contexts in which participants can address or outline a certain issue. Qualitative research aims to penetrate deeply into the research area to acquire a clear understanding of the way things are, why they are that way, and find a solution to the identified problem (Gay et al 2011). Babbie & Mounton (2010) observe that the goal of qualitative research is to describe and understand rather than explain and predict human behavior.

There three types of primary qualitative research purposes are exploratory, descriptive, and explanatory. Bhandari (2020) states that qualitative research is flexible, and voices out the perspective of the participant. Leavy (2011) further elaborates that exploratory research is an investigation in an area in which there is a lack of studies; descriptive

research describes an aspect of social reality; and explanatory research attempts to explain the relationship between social phenomena and various components. The researcher used the qualitative research method because it is a research approach aimed at developing theories and understanding. The researcher wanted to understand how educators use UDL, particularly the multiple means of representation in mathematics lessons. Qualitative research is a descriptive study that refers to studies that describe a situation or a phenomenon (Dlamini, 2017). Qualitative research allows researchers to observe a situation and give a clear description. The descriptive study seeks to answer questions of What, Where, and How. The aim of the study is to explore multiple means of representation in the classroom, and can be considered the “how” of the phenomenon. Qualitative research is used to make sense of how individuals view their surroundings (Ugwu & Eze Val 2023). The study is also an explanatory study because the study seeks to understand why educators use or did not use representational tools to address the “Why” question.

3.3. Research paradigm

Qualitative research consist of three paradigms namely, positivism, interpretism and critical theory (Rehman & Alharthi, 2016). Positivism is counted on the philosophical stance of natural scientist that is working with observable reality withing society leading to production of generalizations (Alharahsheh & Pius, 2020). Asghar (2013) affirms that critical theory is particularly concerned with the issue of power relations in the society and other issues such as race, class, gender, education and other issues that contribute to a social system. According to Pham (2018), interpretivism provides a deeper understanding of the phenomenon and its complexity, in its unique context without generalizing to the whole population. The researcher chose Interpretivism paradigm to understand how Grade 7 mathematics educators used multiple means of representation during the lesson. Ikram & Kenayathulla (2022) note that interpretivism is based on the ontology that reality is subjective and interpreted by people differently based on their beliefs. Berryman (2019) state that the interpretivist paradigm answers the qualitative question of ‘How’ and ‘Why’. Interpretivism combines different methods that include social constructivism, phenomenology, and hermeneutics. Interpretive research is based on understanding that

social reality is shaped by human experience and social background. Human experience and social backdrop contribute to human behavior and are related to the context of social-cultural issues, and that truth and reality can be created but not discovered (Rehman & Alharthi, 2016). The paradigm will assist the researcher to answer the question of how Grade 7 educators use the multiple mean of representation to make Mathematics accessible to all learners. The interpretivism paradigm is suitable for the study because it is based on human experiences, which contribute to human behaviour. The study is based on experiences of four educators in using multiple means to accommodate diverse learners in Mathematics lessons.

3.4. Research design

Qualitative research strategies consist of phenomenology, ethnography, ground theory, critical studies, and case study. I conducted a case study, focusing on multiple means of representation by four Grade 7 educators teaching mathematics. Dlamini (2017) notes that a case study may involve one case or several cases. Edward & Kenny (2013:11) describes a case study as “the in-depth study for one or more instances of a phenomenon in its real-life context that reflect the perspective of the participants involved in the phenomenon”. According to Starman (2013), case studies can be classified into time dimension and theory formation. Classification according to time and theory takes place when a researcher investigates one or more case studies. In a single case study, the researcher has three options; restorative, snapshots, and diachronic case study. In multiple cases, Starman (2013) identifies the nested case study described as a comparison of elements within one case. In nested studies, the breakdown is within the principal unit of analysis. The researcher chooses a case study because the case study looks beyond a limited number of behaviors to the entire range. The case study assists the researcher by looking at the process, the interaction that takes place within the process, to generate more meaning and better understanding of the phenomenon under study. The research design chosen by the researcher is suitable for the study because case study allows the researcher to understand the operations of the school or the performance of the selected category of educators which can be studied and concluded based on what the research is about (Kumatongo & Muzata, 2021).

3.5. Target population

Target population refers to all people at which the study is aimed (Dlamini, 2017). It is individuals who have common and desired characteristics to take part in the particular study. The target population for this study were educators from Thabo-Mofutsanyana district (in circuit 8) teaching Grade 7 mathematics. Grade 7 is the entrance phase of the senior phase in South Africa and educators must ensure that all learners' educational needs are accommodated.

3.5.1. Sampling and sampling procedures

Gentles, Charles & Mckibbon (2015) explain sampling as a selection type utilized to collect data that will support the researcher in achieving the research objectives. If the sample size is great amount, there is a small chance of random sampling error; and there is little information to be gained from studying a large sample (Marshall 1996). Since the study is qualitative, I did not use random sampling because large samples tend to give little information, and there is a high chance that errors can occur. Qualitative research is associated with non-probability sampling, which is defined as a sampling method that does not randomly select samples (Parveen & Showkat 2017). There are four types of non-probability sampling; quota, judgment, snowball, and convenience sampling. For this study, the researcher used judgmental (purposive) sampling because participants were selected based on the fact that they were information-rich, which means they were likely to generate useful data for the study. Purposive sampling was employed to select four Grade 7 mathematics educators to take part in the study. Schumarcher & Mcmillan (2010) state that, in purposive sampling, participants are sampled considering how well-informed they are about the topic of interest.

The study aimed to explore how Grade 7 mathematics educators used multiple means of representation during teaching. It was important to select only educators who were teaching mathematics in Grade 7 and attended a series of workshops on UDL principles that are conducted by UFS for practicing educators in Thabo-Mofutsanyana district. The four educators were from different schools, each representing the types of schools found in Thabo-Mofutsanyana (circuit 8). Convenience sampling was used to select the schools.

Convenient sampling is a type of non-probability sampling where participants are easily accessible because of geographical proximity, and are available at a given time, or participants who are willing to take part in the study (Etikan et al., 2016). All schools were in circuit 8 which was convenient for the researcher. The four schools are described as follows:

School A

School A is found in a rural area about 21.2 km from the city center (Phuthadithjaba). It is a section 21 school and funds are allocated to the school by the Department of Education. It is classified under quintile 1 where learners do not pay fees. The school begins from Grade R to Grade 7. Southern Sesotho is the home language for most learners in the school. Most learners come from poor socio-economic backgrounds. The school had 405 learners and 14 educators.

School B

School B was also a public school found in a rural area situated about 21.4 km from the city center (Phuthadithjaba). The school had Grade R-7. Southern Sesotho was home language to most learners. Learners came from different backgrounds but from low-income families. The school had 652 learners and 20 educators.

School C

The school is situated 15.5 km from the center. It is situated in the rural area of Thabo-Mofutsanyana where most learners speak Sesotho as their home language. The school had Grade R-9. Learners came from different backgrounds but were mainly from low-income families. It is under section 21 schools and is fully funded by the Department of Education. The school had 245 learners.

School D

School D is in a rural area situated about 13.7 km from the center. It is a section 21 school and funds are allocated to the school by the Department of Education. It was classified under quintile 1 where learners do not pay fees. The school starts from Grade R to Grade

7. Southern Sesotho was the home language for most learners at the school. Most learners came from poor socio-economic backgrounds. The school had 683 learners.

Table 3.1: description of qualifications and experiences of four educators who participate in the study.

Educators	Qualification	Mathematics teaching experience
Educator A	Post Graduate Certificate in Education (Senior& FET)	6 years
Educator B	Post Graduate Certificate in Education (Senior& FET)	6 years
Educator C	Senior Primary Teaching Diploma (SPTD)	19 years
Educator D	Post Graduate Certificate in Education (Senior& FET)	6 years

3.6 Data collection instruments

In the study, the researcher used primary data collection instruments. The primary data was collected through observations and interviews. To collect data two instruments were employed; observations followed by interviews.

3.6.1. Observation schedule

Observation is a process where one or more people keep an eye on an individual or events taking notes of physical changes as they occur in the wild (Ugwu & Eze Val, 2023). According to Michael (2015), participant observation is employed for the researcher to gain a deeper understanding of phenomenon. The observation tool is constructed and used during lesson observations. Observation can be used where people's actions are better than mere words.

3.6.2. Interviews schedule

The interview questions designed addressed the research question the means of representation educators used and why they used certain means of representation during their lessons. The interview provides an opportunity for educators to explain in detail how and why they employed multiple means of representation in mathematics lessons.

3.7. Data collections methods

Data collection is a process of gathering information to answer the research question, test hypothesis, and evaluate outcomes (Kabir, 2016). Data collection was meant to get quality/rich data and have a concrete, convincing, and credible answer to the research question. The study investigated the implementation of multiple means of representation in Grade 7. I interviewed educators on how they represent their mathematics lessons. The type of interviews were semi-structured with pre-planned questions to give the interviewer a chance to elaborate and explain particular issues (Consalvo, 2023).

3.7.1. Observations

The observation method is defined as a data collection method in which a person (usually trained) observes subjects of a phenomenon and record information about characteristics of the phenomenon (Kumar 2022). The researcher further explained the two types of observation: structured and unstructured observations. Structured observations are often used to test causal hypotheses, and unstructured observation is flexible and extremely useful in exploratory research. The study employed unstructured observation where the observer became part of the classroom during the lesson and had a direct observation. The observation tool was used to observe whether educators implemented what they learned during workshops facilitated by the University of the Free State (UFS). The observation tool consisted of questions such as the kind of representations educators use when teaching mathematics, and how educators identified instructional resources. These questions sought to answer the research questions. The researcher did not take part in any activities during the lesson but the participants were fully aware of her role. The educators were observed in their natural setting: the classroom. During the lesson, there

was no interruption with the educator or learners. Two observations per educator were conducted to ensure accuracy and consistency.

3.7.2. Interviews

Interviews are the most commonly used method to collect data. There are three types of interviews; structured, semi-structured, and unstructured. Semi-structured technique is the most frequently used in qualitative research (Gibbs et al., 2007). Semi-structured interviews were popular because they proved to be versatile and flexible (Kallio et al. 2016). The advantage of semi-structured interview is that it promotes successful co-operation between the interviewer and participants which assists the interviewer to improvise the follow-up questions based on the participants' responses (Galletta 2012). Bryman (2008) states that an interview guide consists of a list of questions of a specific topic. The interview guide assists to avert deviation from the topic and collect unnecessary data. All interviews took place in the first term of the school calendar. Educators were interviewed at their respective schools. The interviews were carried out the day after lesson observations.

3.8. Data analysis procedures

In qualitative research methodology, data can be analyzed through five data analysis approaches: content, grounded theory, narrative, conversational, and discourse (Richard 2014). Data analysis was guided by UDL framework with the main focus on multiple means of representation (CAST, 2018). The focus was on perception, language & symbols, and comprehension.



Figure 3: Universal design for Learning (UDL) instrument, Adopted from CAST (2018)

Data is collected using observation tools and interviews. An audio recorder was employed for interviews. Pictures were used to show how educators used multiple means of representation in their lessons.

3.9. Ethical consideration

According to Fleming & Zegwaard (2018), for research involving the participation of human beings, ethical issues should be considered and approved by the relevant ethical committees. Ethical issues include informed consent, risk of harm, confidentiality, and conflict of interest. A researcher must have a plan on how these ethical issues are managed. Ethics guide the norm or standard of behavior of people in relation to others. It is the researcher's responsibility to ensure that participants do not feel vulnerable and exposed (Cacciattolo 2015). The researcher applied to the University of the Free State (UFS) for ethical clearance to conduct the study. The ethical clearance application was

approved, and the ethical clearance number is UFS-HSDV2023/2260. In addition, letters were sent to the school principals of the educators who would be taking part in the study. All educators participating in the study signed a consent form, and were assured that if they felt uncomfortable in any way, they were allowed to withdraw. The consent forms inform participating educators of the study and assure them that their real names would not be used in the study.

3.10. Reliability and validity

Reliability and validity are important concepts in research, used to assess the quality of research. The two concepts specify how well a methodology, data collection or data analysis is planned to measure study variables (Ahmed & Ishtiaq, 2021). The data collection instrument are carefully selected with assistance of the supervisor. To ensure credibility more than one instrument was used to collect data which are observations and interviews. Before data collected, each participant was requested to sign consent forms in which it was clearly stated that educators can withdraw at any time they may feel uncomfortable.

3.11. Conclusion

Data was collected through observation and semi structured interviews. In this chapter, a clear description of data collection was given. The chapter outlined procedures to be followed when collecting data through observation and interviews. Data collection tools were clearly described. Ethical issues and trustworthiness were discussed. The next chapter analyses the data collected through observations and interviews.

Chapter 4: Analysis of data

4.1. Introduction

This chapter presents the analysis of data collected throughout the study. Data was collected through observations followed by interviews. The study involved four Grade 7 educators in circuit 8 in the Thabo Mofutsanyana District. The researcher observed two consecutive lessons per educator. Eight lessons were observed. Seven of them were on fractions and one was on polygons. The interviews were conducted with three educators. The fourth educator could not be interviewed as he decided to drop out. The chapter analyzes the data collected through lesson observations and reflective interviews. The analysis is guided by the UDL principle known as multiple means of representation. According to the Annual teaching plan (ATP), the topic of fractions is taught in Term 1. The topic on polygons is scheduled to be taught in Term 3, therefore it was surprising that Educator B decided to teach this topic in Term 1. However, during the interview session, when asked about her decision to teach the topic in Term 1, Educator B explained that she wanted to link what learners did in the previous Grade (Grade 6) with what is going to be taught in Term 3.

In this chapter, I used the following key:

() – translation from Sesotho to English

Edu – refers to the educator

R- Researcher

... – pauses or the speaker is interrupted.

4.2. Overview of the lessons

Table 4.1 below provides a summary of what transpired in each lesson. The table shows two lessons per educator. Educators and participating schools are given codes Educator A-D. For example, educator A is teaching in School A.

Table 4.1: Lesson synopses

Educator A

Lesson No.	Duration	Lesson topic	Content	Descriptions
1	60 minutes	Common fractions	Adding and subtraction of common fractions	<p>In this Grade 7 class, there were 32 learners. The average age of learners was 13. The class was told about the topic they were going to do on that day. The educator introduced the topic by defining a fraction to learners and giving examples such as pizza. Fractions should have a numerator and denominator. She reminded learners that fractions can be compared using $>$, $<$ or $=$. The educator highlighted the different types of fractions, namely: proper, improper, and mixed fractions. The educator introduced fraction bars to represent different types of fractions and to emphasize how a whole is formed using two halves.</p> <p>Fractions with the same denominator were first added. The educator explained to learners that when adding fractions with the same denominator, they must just add the numerators and the denominator will be the same.</p> <p>The educator reminded the learners of multiples such as multiples of 2: 2, 4, 6, 8, 10....she indicated that learners were going to need them when solving fractions with different denominators.</p>
2	60 minutes	Calculations with decimal fractions	Multiply decimal fractions	<p>The educator introduced the topic by stating that decimals have place value just like whole numbers. She made an example of 3.6. The place value of 3.6 is tenth because 3.6 has one number after the comma. The second example was 54.79 and she asked learners what the place value of 7 be in 54.79 and learners answered by saying it's a hundredth because it has two numbers after the comma. The educator displayed posts on the board to show learners the different place value unit, tenth, hundredth and thousandth. The educator then emphasized that learners should not confuse the value with the place of value because they do not mean the same thing. The educator told the learners that that day they would be doing multiplication of decimals. She made an example of 0.2×1.4</p>

Educator B

Day	Duration	Lesson topic	Content	Descriptions
1	60 minutes	3D shapes	Polygons	In this Grade 7 class there were 39 learners. The lesson was introduced to learners by simply differentiating between a shape and object. The educator indicated that an object should have three views while a shape consists of only one view. She mentioned that 3D objects include polygons and prisms. The 3D shape should have length, height and breath. The educator took a rectangle shape and a cube and asked learners the difference. Learners answered using various reasoning. The educator went further to explain that in polygon the “poly” indicates the name and “gon” indicate the sides. She made an example of pentagon. The educator differentiated between prism and pyramid and stated that a pyramid is a 3D shape with a polygon as its base and surfaces as triangle that meet at a point called the apex. Learners were showed different prisms and pyramids and how to name them. Once the educator finished presenting, learners were seated in groups of 8 and given a shape. Learners were tasked to provide the name of the 3D object and the reason why. Two learners from each group were asked to come in front of the class to present their answers.
2	60 minutes	Whole numbers	Sharing in ratio	The educator told learners that they are going to revise the topic of ratios. The educator asked learners what ratio is. Learners gave various answers of what they understood by the term ratio. The educator then emphasized that ratio was when two things are compared. She made an example of class 7A that the class consisted of boys and therefore, we can have a ratio of boys to girls. She continued with more examples like ‘Thando and Sibi need to share R25 in the ratio of 2:3.’ She asked learners how she would divide it between Thando and Sibi. Learners answered that the first step was to add the two ratios. Once the ratios have been added, we first calculate the ratio of Thando by using 2 divided by the added ratio and multiplied by the number that needs to be divided in this case it is R25. It gave learners fractions that need

				to be multiplied. Learners were reminded how to multiply fractions. Once learners got the answer, they physically shared the money in ratios using the R25 money that the educator gave them. The educator went further to make it more practical by using counters. She gave learners 30 counters and asked them to share the counters in the ratio of 1:20. Learners worked together to solve the given problem. Learners were then given an assignment to write.
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Educator C

Day	Duration	Lesson topic	Content	Descriptions
1	60 minutes	Common fractions	Adding and subtraction common fractions	<p>In this Grade 7 class, there were 25 learners. The educator introduced the topic by asking learners prior knowledge of fractions using definitions. The educator first d an apple as a whole number. She then cut the apple into 2 equal parts to represent a halve ($\frac{1}{2}$). The same apple was then cut into 4 equal pieces to represent a quarter ($\frac{1}{4}$) and so on.</p> <p>The educator used a packet of sweets with different colors. She asked the learners to count how many sweets were in the packet and group them into their different colors. Learners were asked to give the number of blue sweets in fraction form and any other colors. Educator C asked learners to add and subtract the fractions of the sweets provided.</p> <p>The other instructional material that the educator used is primitive building blocks (sets). Learners were requested to sort the building blocks into different colors, put together ten yellow blocks and 3 green blocks to present ($\frac{3}{13}$). Learners demonstrated different fractions using these sets.</p> <p>The educator used different colors of chalk to represent fractions with different denominators</p>
2	60 minutes	Solving problems in context involving common fractions	Grouping and sharing of fractions	<p>The educator commenced the lesson by writing a problem statement on the board and asked learners to read it out loud together as a class. She used different color chalk to emphasize the important concepts. The problem statement on the board was “Thapelo has R2, Manini has R3 and Karabelo has R1. They used this money to buy a packet of carrots for R6?” How must</p>

				<p>they share the carrots if there are 24 carrots in the packet?</p> <p>The educator asked learners to represent the fraction of characters (Thapelo, Manini, and Karabelo) using counters. Once that was done, she asked learners to multiply each fraction with the total number of carrots using counters to give the final answer.</p>
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Educator D

Lesson No.	Duration	Lesson topic	Content	Descriptions
1	60 minutes	Decimals	Division and multiplication	<p>In this Grade 7 class, there were 41 learners. The educator began the lesson by asking learners to do corrections of the previous activity on the board. The educator wrote the question on the board $43.32 \div 12$ and asked learners how they would answer the question. Learners gave the educator various answers.</p> <p>He asked the learners to say the multiples of 12 out loud for those who could not recall the multiples the charts on the wall assisted them with the multiples. The multiples were written on the board. The box is utilized to answer the question. The box consists of diagonals which are used to write the answers to the multiples and also to add all the numbers on the same side of the diagonal line</p>
2	60 minutes	Common fractions	Percentage increase and decrease	<p>The educator asked learners to make corrections on the board. He then informed learners that, for this lesson, they were going to revise the percentage increase and decrease. He wrote a question on the board: R12 to R 20 and asked learners if it is a percentage increase or decrease. Learners raised their hands to answer the question. After numerous questions on the board, learners were taken to the math lab to watch a video on YouTube about percentage increase and decrease. The video was paused numerous times to ask learners questions. Once the video was done, the educator used counters to represent different fractions. Learners were given an informal test to write.</p>

4.3 Educator A

Educator A is a female and was 33 years old. The educator has a qualification of B.Sc. in physical sciences and mathematics and later obtained a postgraduate certificate in education (PGCE) majoring in physical sciences and mathematics. She had been teaching Mathematics in Grade 7 for the past 6 years in school A. The educator presented a lesson on fractions.

4.3.1. Content taught by Educator A

4.3.1.1. Teaching Fractions

The educator displayed a fraction chart on the chalkboard (see Fig. 4.1) which displayed fractions, and learners were asked questions based on fractions. The educator explained that fractions should consist of the numerator and denominator. With the poster, the educator showed learners what a whole look like and that learners can get two halves to make a whole. What this educator is doing here is demonstrating *perception* (the use of a chart) which is a guideline under multiple means of representation. According to Brand & Dalton (2009), spoken words can be accompanied by written words on the chart, smart board, and overhead projector. Using the chart, the educator was able to modify words into pictures.

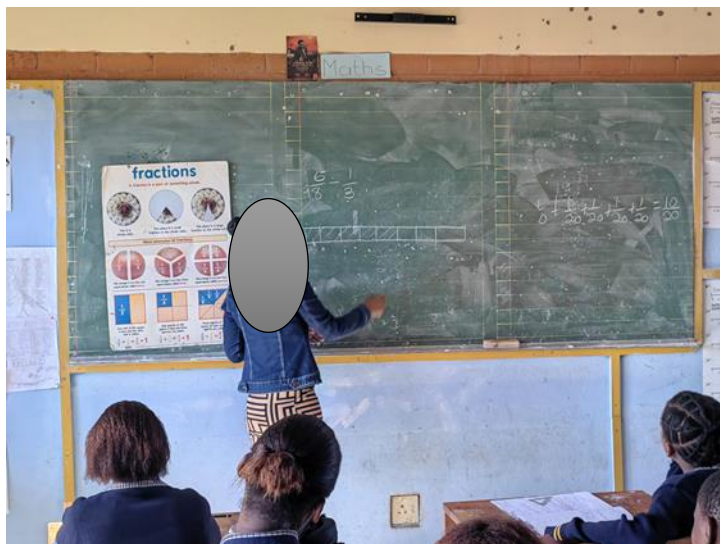


Figure 4.1: Educator A teaching fractions

In this lesson Educator A used fraction bars to explain to learners how a whole look like and how to form a whole using halves. Learners were able to touch and manipulate fraction bars (see Fig. 4.2).



Figure 4.2 Learners using fraction bars.

The educator gave learners a task to demonstrate $\frac{1}{8} + \frac{3}{8}$ using fraction bars. Two learners from the same group were chosen to do the demonstration for the entire class (see Fig 4.2). The two learners were able to demonstrate the mathematical operation to the entire class successfully and obtained the answer of $\frac{4}{8}$ and the educator further explained that it must always be in its simplest form namely $\frac{1}{2}$. The educator illustrated how to simplify fractions on the chalkboard. In the light of the multiple means of representation, the guidelines related to *perception* (alternatives for visual information), *language and symbols* (mathematical notation), and *comprehension* (visualisation and manipulation). Learners were allowed to cut the fraction strips to illustrate the answer (see Fig. 4.3).



Figure 4.3 Learners cutting fraction bars.

4.3.1.2. Teaching ratio

In the second lesson, the educators used counters to represent the sharing ratio. Learners were grouped into six and given counters of different colors. Learners were given a problem to solve from the textbook. Learners were expected to use mathematical procedures to first solve the problem in their books and use counters to present their answer. The question from the textbook stated that “Thabo and Thabang need to share R28 in the ratio of 1:2, how much would each friend get?”. What the educator is doing here is to demonstrate *language and symbols* (mathematical notations and symbols) and learners solve mathematical problems using symbols and notations. The other guideline that the educator is using in this lesson is *comprehension* (visualisation and manipulation).



Figure 4.4 Learners manipulating counters.

Educator used both verbal and written symbols. The written symbols were mostly written on the chalkboard, and during the lesson, the educators used correct mathematical language. For instance, when presenting decimals 5.34, the educator emphasized to learners that it was five comma three four and not five comma thirty-four. What the educator was doing here was to use the guideline of *language and symbols* (clarify vocabulary and symbols). The educator used both English and Sesotho but mostly the educator used Sesotho more than English. This is because the educator wanted learners to understand better by using their home language. The educator used multiple means of representation for language and symbols by using the correct mathematical concepts during the lesson. The concepts were easily explained to learners. At the beginning of the lesson when the educator introduced the lesson, she first explained to learners what a fraction is. She explained a fraction as “a numerical value which is not a whole number”. The educator continued by providing a mathematical representation of the fraction.

4.3.2. Educator’s interaction with the classroom

The educator involved the whole class when presenting a lesson. The teacher proposed a question for the entire class to reply. In the two lessons, the educator grouped learners to work together to solve certain problems. One member from each group was given a chance to present their answer in front of the class to promote learner-centred teaching. Educator A used several teaching methods such as cooperative learning. In both the first and second lesson, the educator tried to put learners in groups (see Fig. 4.5). Learners here were cutting fraction bars to demonstrate answers. What learners are doing here aligns with the guideline *comprehension* (information processing, visualization, and manipulation). According to CAPS (2012), peer learning is a meaningful way learners make sense of abstract mathematical concepts. This provides an opportunity for learners who might miss the mathematical concept taught by educator to learn from their peers.



Figure 4.5 Learners working in groups using fraction bars.

4.3.4. Instructional materials that Educator A used

The educator admitted using different types of material to prepare for lessons, but she frequently used premier, platinum, and DBE textbooks. During the interview the educator was asked why she specifically used those textbooks:

R: Which textbooks are you using when preparing for your lesson?

Edu A: For Grade 7?

R: yes mam.

Edu A: I use premier and platinum.

R: Why specifically do you use premier and platinum?

Edu A: Because they have information that I need and different methods. These books provide different cognitive levels. I also use DBE workbooks.

R: What other sources do you use besides textbooks?

Edu A: overhead projector.

R: What do you do with the overhead projector?

Edu A: I present a lesson using an overhead projector.

The educator was creative because she utilized three textbooks; premier, platinum, and DBE. Different textbooks have different mathematical tasks. Some tasks are of low

cognitive level while others were of high cognitive level (Stein et al., 2000). By using multiple books, the educator tries to accommodate all learners. It is worth noting that other than books she uses the overhead projector to deliver her lessons. This is an important step towards ensuring that for those learners who might not understand Mathematical concepts using a chalkboard are accommodated by using overhead projector. What the educator is doing here is to use the guideline of *comprehension* (activate or supply background knowledge).

4.3.5 Examples Educator A choose to utilize.

Educator A used examples from the textbook. The educator admitted during the interview that she used certain textbooks because of information and different methods



. Figure 4.6: Example used by educator A

4.4. Educator B

The educator was 32 years old and a female. She had been teaching mathematics for the past 6 years. The educator had a B.sc in chemistry and botany and went further by studying PGCE majoring in life sciences and mathematics. The educator presented 3-D shapes and fractions.

4.4.1. Content taught by Educator B

4.4.1.1. Teaching Polygons

The educator used physical 3-D models that learners were able to touch and see when differentiating between a shape and polygons. The reason the educator presented the

polygons, it was a challenging topic for her learners therefore she needed to revise it. The educator had a rectangular prism on her right hand and a rectangle (2D) on the left. The educator asked learners which one was a rectangular prism and why. Learners replied that the rectangular prism was on the right because it had length, breadth, and height (see fig. 4.6). It was explained that a 3D object should have length, breadth, and height while the 2-D only has length and breadth. By the use of real objects, the educator was displaying the guideline of *comprehension* (visualization and manipulation) because learners were able to see and touch it. The other guideline that the educator displayed was *perception* (visual information).



Figure 4.7: The educator demonstrating the difference between 3D and 2D shapes.

4.4.1.2. Teaching ratios

In the second lesson, the educator presented sharing ratios. The educator first explained ratio as a way of comparing two or more things of the same kind. When the educator explained or clarified concepts, she displayed the guideline of *language and symbols* (clarify vocabulary and symbols). She went further to make an example of the number of girls compared to the number of boys in the classroom. She emphasized that in the lesson, they used their prior knowledge of ratio to solve problems involving sharing

quantities. The educator used R20 notes and five R1 coins to demonstrate to learners that two learners needed to share this money in the ratio 2:3 (see fig. 4.7). By doing this, the educator was displaying the guideline of *comprehension* (visualization and manipulation). The educator asked learners to share R25 in the ratio of 2:3. Learners had to solve the problem by first writing it on a paper in their seats, and one learner was chosen to present the answer. The answer that the learners presented was that the first learner would receive R10 while the other learner would receive R15. When learners solve the problems in their books, they use mathematical language and mathematical symbols to understand what is required of them. The educator provided options for *language and symbols* (clarify vocabulary and symbols).

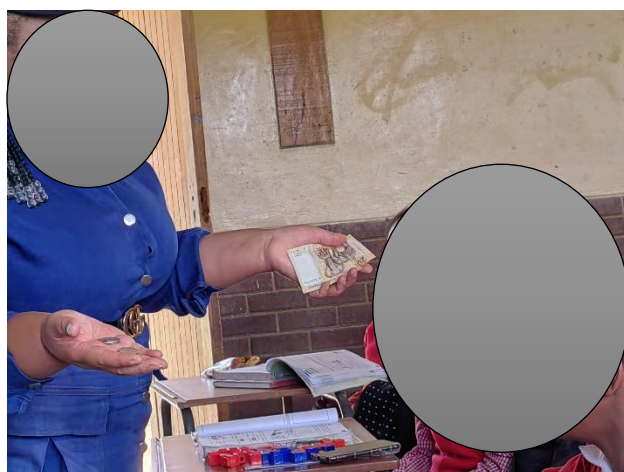


Figure 4.8: Educator is presenting the sharing of ratio using real money.

Learners were given another problem to solve from Spot on textbook on Page 26. The problem is stated as follows:

Share 28 sweets between Amanda and Busi in the ratio of 3:1.

Learners were asked to solve the problem in their respective books and use counters to present the answer. One learner from the class was chosen to present the answer for the entire class (see Fig. 4.8). The solution calculated by the learner was that Amanda would receive R21 while Busi would receive R 7. She then used 28 counters and shared counters into 21 counters and 7 counters to present the ratio of 3:1 (see fig. 4.9). What the learner and educator did promoted the guideline for *language and symbols* (illustrate through multiple media).

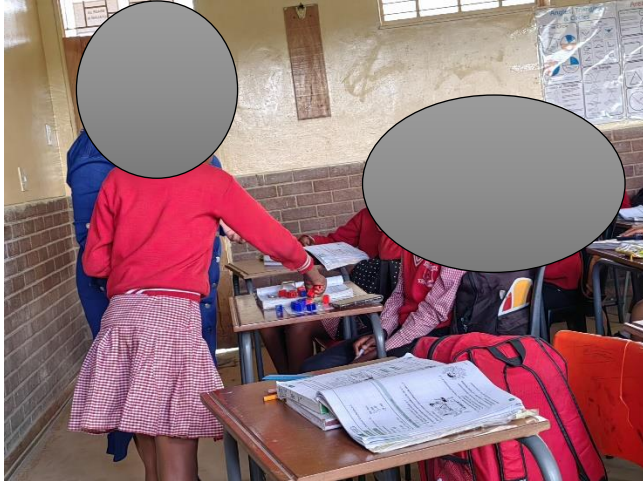


Figure 4.9: Learner using counters.

Throughout the lesson, the educator used the language of teaching and learning, English. Educator B only used Sesotho (home language) to emphasize certain points or to further explain to learners who seemed not to understand. During the lesson, learners asked and answered questions in English. When the educator used the language of teaching and learning, the educator displayed the guideline of *language and symbols* (understanding across language). The educator was using mathematical language for presenting the lesson (see Fig. 4.10). For example, instead of Educator B saying 2 over 3, she would say 2 out of 3 which is the correct mathematical language. Educator B emphasized and explained to learners the relationship between multiplication (\times) and the word “of” in fractions. The educator was displaying *language and symbols* (clarify vocabulary and symbols).



Figure 4.10: Display of symbols

4.4.2. Educator B's interaction with the classroom

In Educator B's class, group work plays an important role in teaching and learning. After the educator presented the lessons, learners were asked to sit in groups, and they were given 3-D objects in each group to discuss the shape, name the object, and give a reason for their decision (see Fig. 4.11). One member from each group would present the answer in front of the class. One learner from each group was chosen to present the same. The learner stated that the shape in hand was a square-based pyramid because it had 5 faces. One face was a square while the other 4 faces were triangular. All these triangular faces met at a point called apex. Learners were learning through the guideline of *perception* (visual information). Learners were using the correct mathematical concept which indicated that they were displaying the guidelines of *language and symbols* (promote understanding across languages).

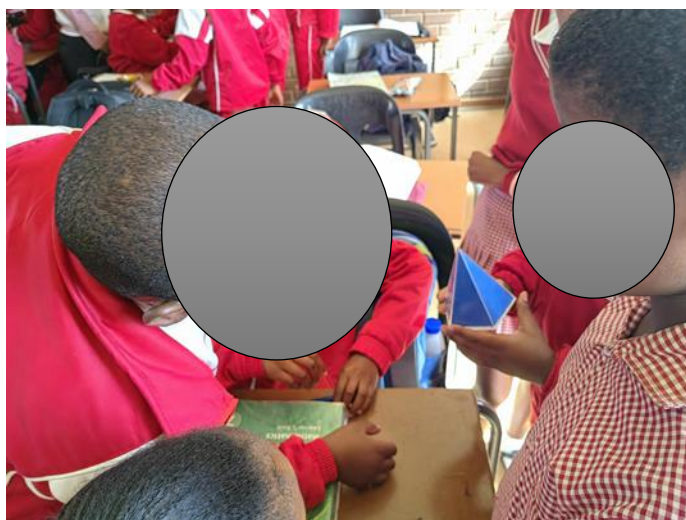


Figure 4.11 a: Learners grouped to discuss the given shape.

Once all the groups presented their answers to the class, learners were then given an activity to write from their textbooks (Spot on) and Educator B walked around between lanes to see learners who were struggling and assist learners individually (see fig.4.12). When Educator B was assisting the one learner that was struggling to complete the given activity, she would speak slow compared to when she was explaining to the rest of the

class. She always referred to the drawing on the chalkboard to emphasise what she is trying to explain to the learner. Educator B was promoting the guideline of *perception* (alternative for auditory information).



Figure 4.11 b: The Educator B assisting an individual learner.

4.4.3. Instructional materials that Educator B use

The educator indicated that she used two textbooks to prepare for the lesson (these were Spot on and platinum textbooks). For additional resources, she used DBE textbooks and YouTube videos. The reason for using those specific textbooks was because they were easy to understand.

R: So, tell me, which textbooks are using to prepare for your lessons?

Edu B: Spot on and Platinum.

R: Why specifically Spot on and platinum?

Edu B: ...uuuh Spot on I love activities, just everything about it is easy for me as well as examples.

4.4.4. Examples Educator B choose to utilize

During the observation, the researcher observed that the educator uses examples from the textbook. The examples used in both lessons were from the same textbook. In the first lesson when Educator A was presenting polygons, the educator used an example from spot on textbook on page 233 (see fig. 12). Fig. 13 indicates the example that the educator drew on the chalkboard. Sketches are important in teaching and learning of mathematics. By drawing sketches on the chalkboard, the educator assists learners who were not able to understand when the educator was explaining verbally through text. What the Educator B was doing here was to use the guideline of *language, mathematical notation, and symbols* (illustrate through multiple media).

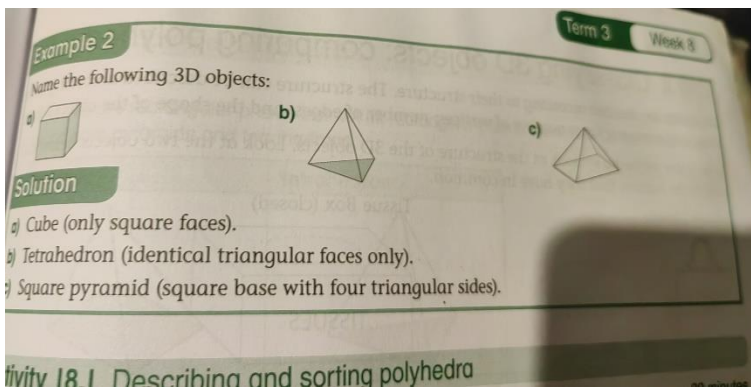


Figure 4.12: Example used by Educator B from textbook.

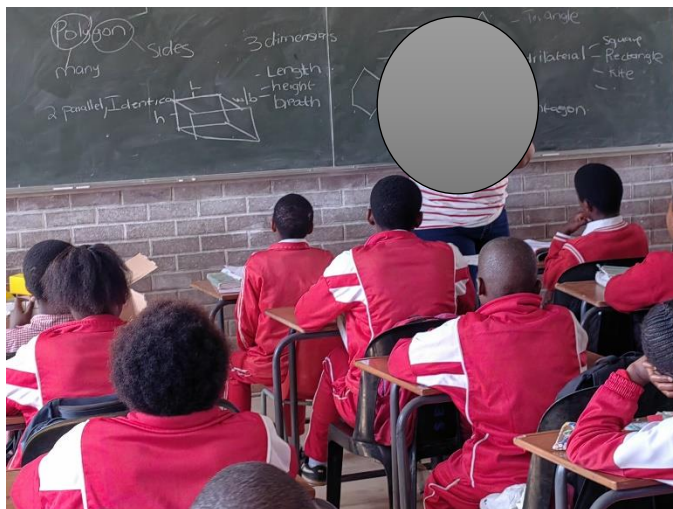


Figure 4.13: Example used by Educator B in class.

In the second lesson observation, Educator B used an example from Spot on textbook on page 26 (see Fig. 15). Figure 14 is an example that Educator B wrote on the chalkboard before beginning the lesson.

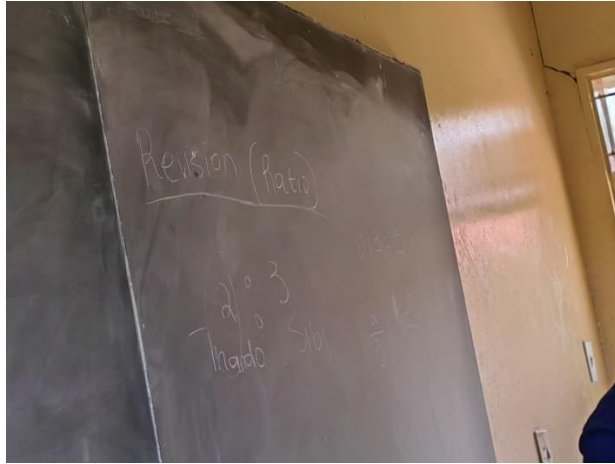


Figure 4.14: Example Educator B used.

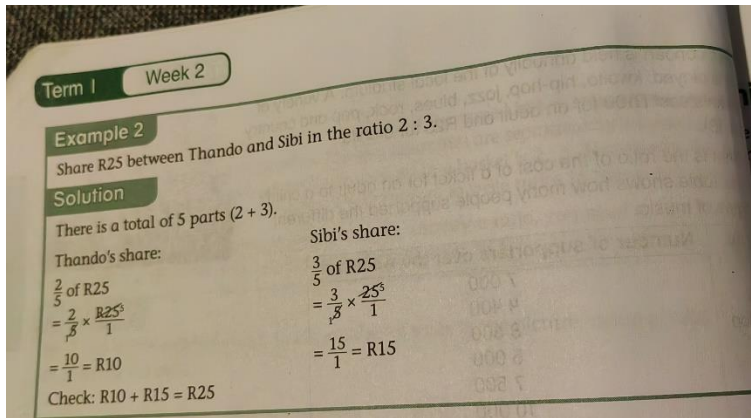


Figure 4.15: Example from the textbook

4.5 Educator C

The educator was 50 years old and female, and had been teaching mathematics for the past 19 years. The educator has qualification of senior primary teaching diploma (SPTD) and had been teaching Grade 7 mathematics for the past 17 years. The educator presented fractions.

4.5.1 Content Taught by Educator C

4.5.1.1. Teaching fractions

In the first lesson, the educator presented fractions. She first explained to learners what a whole number is. She described a whole number as a number that does not contain fraction or integers. She indicated that a whole number should be positive, and made an example of natural numbers such as 0, 1,2,3,4. What the educator was doing here is to display the guideline of *language, mathematical expression, and symbols* (clarify vocabulary and symbols). The educator took out an apple and presented it to the class as a whole number and stated that the very same apple could be shared into parts called fractions. Learners were instructed to sit in groups of 6 and each group was given an apple and a cutter. Learners were asked to cut an apple into two equal parts ($\frac{1}{2}$) and the same apple was also cut into four equal parts ($\frac{1}{4}$) (see Fig. 4.16). Educator C was displaying the guideline of *perception* (visual information). The educator made it clear to learners that the numerator presents the whole number, which in this instance, was an apple, and the denominator is how many parts we have of the whole number (apple).



Figure 4.16: An apple share into four equal parts

The educator moved to the next example where she used a packet of sweets. Learners were given packet of sweet in each group and they were asked to count how many sweets were in each packet and write the number down. Learners were asked to group sweets according to their respective colours (see Fig. 4.17). The educator used sweets to

represent fractions. Learners were requested to give what fraction of the whole the yellow sweets were, which was $\frac{1}{28}$. There was one yellow sweet in a packet of 28 sweets. The guideline in which the educator is using is *perception* (visual information) and *language, mathematical expressions and symbols* (illustrate through multiple media). Learners used sweets to add and subtract fractions.



Figure 4.17: Sweets grouped into different colours.

Counters were given to learners for addition and subtraction of fractions. Learners were requested to sort counters according to their different colours. Each group was given 60 counters, 30 of each colour.



Figure 4.18: Learners using counters.

In this lesson, the educator was able to use three examples where learners were able to touch and manipulate physical objects. She was able to use three examples to represent a fraction. The educator was displaying the guideline of comprehension (highlight patterns).

4.5.1.2. Teaching ratio

In the second lesson, Educator C presented a lesson on sharing quantities in a given ratio. Educator C explained to learners that ratio is used when we want to compare quantities of the same kind. By explaining terms to learners, Educator C was displaying the guideline of *language, mathematical expression, and symbols* (clarify vocabulary). The educator wrote the example on the chalkboard. She explained to learners that three friends each had R1, R2 and R3 and needed to buy a packet of carrots which cost R6. The packet of carrots consisted of 24 carrots. What the educator was doing here was breaking the question into small parts to make it easier for learners to understand. The educator was displaying the guideline of *comprehension* (guide information processing). Learners were told that the money these friends had could be written into ratios. 1:2:3. In order to solve the given problems, the ratios should be added together to result in 6 (1+2+3). To know how many carrots each friend will get, Educator C then informed learners that they needed to recall fractions. Learners needed to write the fraction of the second friend. Learners replied by saying the fraction was $\frac{2}{6}$ then Educator C asked learners "How many carrots need to be shared?" Learners replied by saying '24 carrots therefore the fraction can be written as $\frac{2}{6}$ of 24.' Educator C went further to explain that "of" means multiplication (see Fig. 4.19). When learners are reminded of fractions. The educator was displaying the guideline of comprehension (Activate or supply background knowledge).



Figure 4.19: Solution of the given example

Learners were given 48 counters in each group. Learners were asked to divide 48 by 6 using counters. Learners grouped 48 counters, in each group there was 6 counters. The number of groups was the answer to 48 divided by 6 (see Fig.20). Educator was using the guideline of *perception* (visual information) and *language, mathematical expression, and symbols* (illustrate through multiple media).



Figure 4.20: Learners using counters.

During the lesson, the educator used English almost throughout the lesson, and minimal home language where it was needed. The educator would switch to Sesotho if learners do not understand the question asked. Learners were more comfortable to answer questions in their home language than using the language of teaching and learning (LoLT). Mathematical concepts were properly used by the educator when presenting a

lesson to the class. The educator emphasized to learners that, when saying fractions out loud, we use “of” instead of “over” for example: $\frac{2}{6}$ is 2 out of 6 instead of 2 over 6. The educator used the correct mathematical language and symbols throughout the two lessons observed. By the use of mathematical language and symbols, the educator was using the guideline of *language, mathematical expression, and symbols* (clarify vocabulary and symbols).

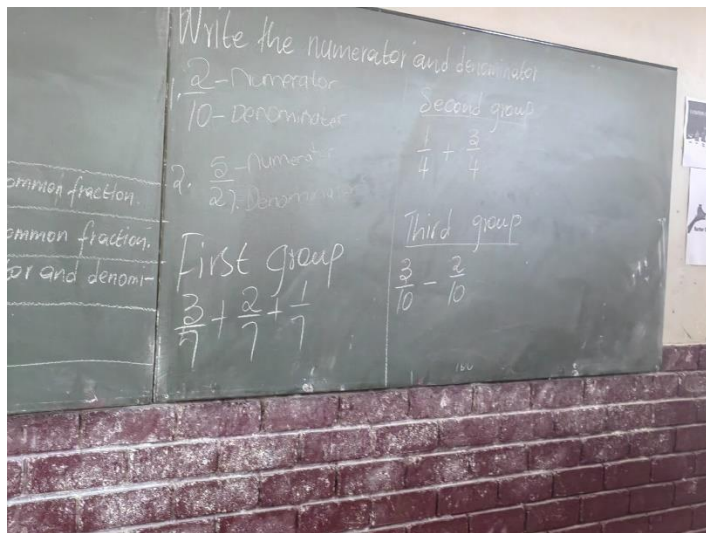


Figure 4.21: Use mathematical language and symbols.

4.5.2. Educators' interaction with the classroom

In the two lessons that the researcher observed, learners were always grouped in groups of six. Cooperative learning played an important role in Educator C's classroom. It was easy for the educator to move from one group to another to explain to learners, especially when given activities to write. The learner was randomly chosen to present answers on the chalkboard.

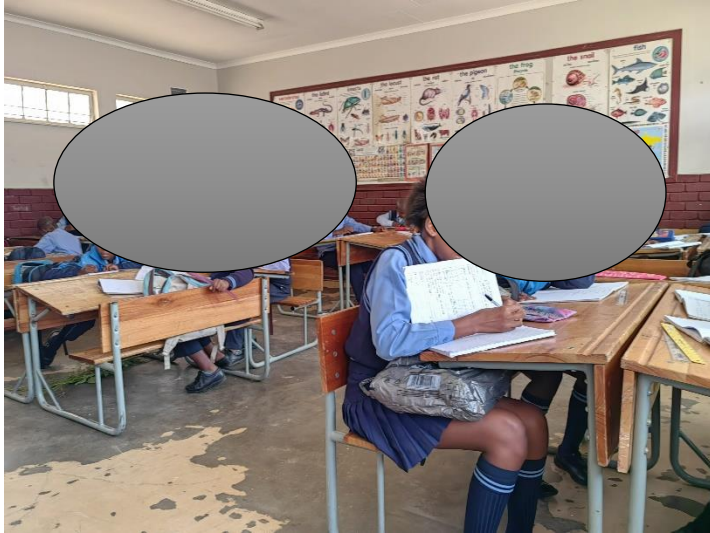


Figure 4.22: Learners seated in groups.

4.5.3 Instructional material used by Educator C

During the interview, Educator C stated that she used three different textbooks to teach Grade 7 mathematics:

R: Which textbooks are using for preparing lessons

Edu C: Am using the Math Today and the DBE book and classroom.

R: So, you are using three textbooks?

Edu C: yes

R: So why specifically these three textbooks?

Edu C: They are using different methods of teaching.

R: How are they different?

Edu C: I usually use Math Today if I don't understand or if Math Today does not explain the concept, then I use the classroom mathematics.

R: So, you use the classroom mathematics for referring?

Edu C: Yes

R: what other sources do you use besides textbooks?

Edu C: I use manipulative objects. If I don't have counters, I just buy something that we can use in the classroom so that they can see or touch it.

The educator is creative because she utilizes three textbooks namely Math today, Classroom and DBE. Different textbooks have different mathematical tasks. Some tasks are of low cognitive level while some are of high cognitive level (Stein et al, 2000). By using multiple books, the educator tries to accommodate all learners. When the educator uses different textbooks, she is displaying the guideline of *language, mathematical expressions, and symbols* (supply background knowledge).

4.5.4 Examples Educator C chose to utilize.

At the beginning of each lesson, the Educator A would write an example from the textbook on the chalkboard (see fig. 4.22). Educator C then solved the problem together with the entire class. Explaining each and every step.

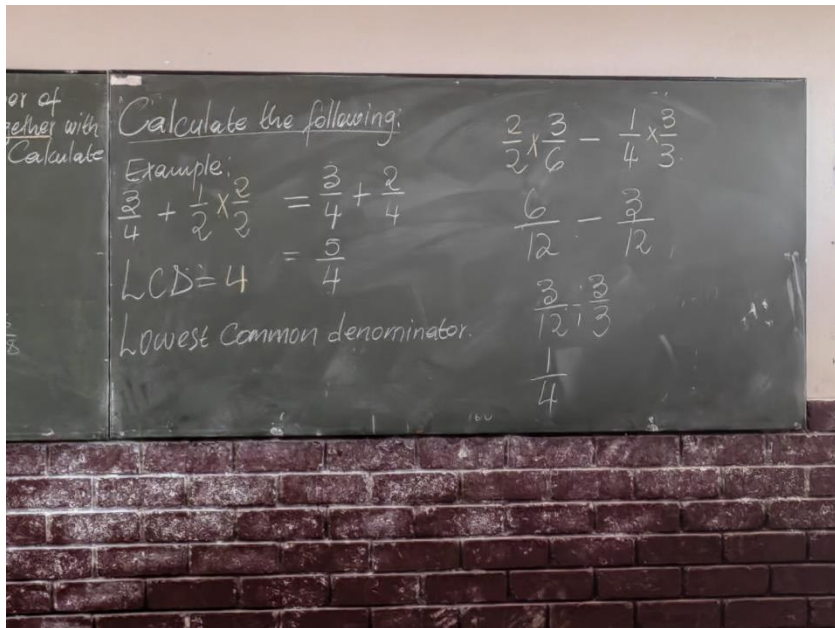


Figure 4.23: Example written on the chalkboard.

In the second lesson, Educator C used the following example to guide her lesson about sharing quantities in ratio (see fig. 4.23). The example was taken from a textbook and was done together with the entire class.

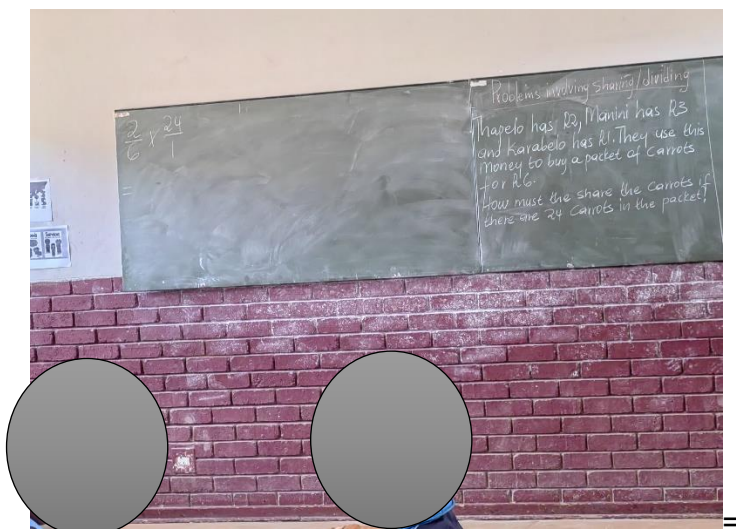


Figure 4.24: Examples used by Educator

4.6 Educator D

The educator is 32 years old and a male. Have been teaching mathematics for the past 6 years. The educator has B.A (Bachelor of Arts) and he further acquired PGCE majoring in life orientation and languages. The educator is allowed to teach mathematics in primary school because he has first year mathematics in his study record. The educator presented multiplication of decimals and percentage increase and decrease.

4.6.1 Content taught by Educator D

Educator D in the first lesson presented multiplication of decimals. He admitted that multiplication of decimals seems to be a challenge to his learners. Since he was done teaching the topics required by Annual Teaching Plan. Educator D was doing a revision with his learners on multiplication of decimals. In this lesson Educator D began by writing $3.32 \div 12$, he then asked his learners to identify a whole number. Learners identified a whole number to be 12 because it does not have a comma. Educator D continued to ask learners how to pronounce 43.32 other learners said three commas thirty-two while other learners said it three comma three two. The educator emphasized to learners that the answer is three comma three two and not three commas thirty-two. What Educator D is displaying here is guideline of *language, mathematical expression, and symbols* (clarify vocabulary and symbols). Educator went further and asked learners how to solve the

given problem. Learners raised their hands to be chosen to solve the problem. One learner was chosen to solve the problem (see fig. 4.25).

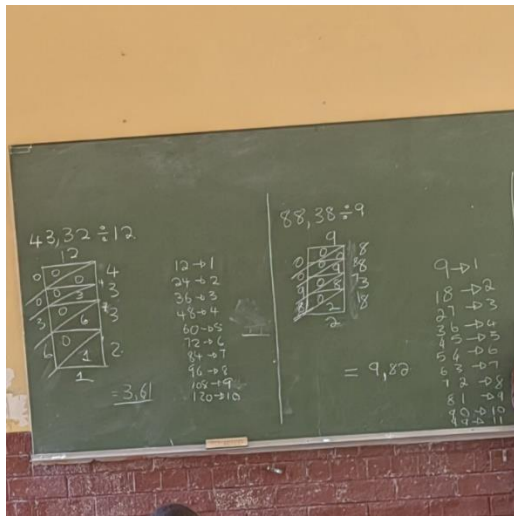


Figure 4.25: Solved problem by the learner

The learner then explained to the rest of class how she got her answer. She firstly reminded her classmate that they need to draw a “box” to solve the problem. Put a whole number on top of your box and the decimal on the right. The decimal number will determine how many rows in the box needed to be drawn. For example, the decimal had 4 numbers therefore 4 rows were drawn. Diagonal lines were drawn in each box to divide the box into two parts. On the side of the table learners are reminded to write the multiples of the whole number. In this case the learner has written the multiples of 12. The multiples of 12 were used to solve the problem. Learner first divided 4 by 12 then explained that 4 is small compared to 12 then wrote two zero in the same box which is divided by a diagonal line. The four was carried to the next number which is three then the number became 43. The 43 was divided by 12 which gave the answer of three and remainder of 7. The learner wrote 0 and 3 in the second box and carried 7. The next number was the 73. 73 was also divided by 12 which gave the answer of 6 but it is written as 06 in the third box, the remainder of 1 is carried to the next number which result in 12. 12 is now divided by 12 which will result in 1. Once multiplication is done then numbers in the same diagonal line are added to one another. For example, first diagonal line consists of 0 which will be 0. The next line consists of $0+0 = 0$. The third line $0+3 = 3$ then $6+0 = 6$, then the last line consists of 1, and the answer will be 3.61(see fig.4.25). Educator D is displaying the

guideline of *comprehension* (supply background knowledge) because learners have to use their prior knowledge of multiples of whole numbers. For learners who did not recall the multiples of whole numbers, Educator D displayed a poster of multiples on the wall of the classroom so that learners could refer to it (see Fig 4.26). The educator used the correct mathematical language and symbols in the classroom and displayed the guideline of *language and symbols* (promote understanding across languages).



Figure 4.26: A poster of multiples

The poster displayed multiplication of whole numbers that assisted learners who could not recall the multiples. Educator D displayed the guideline of *language, mathematical expression, and symbols* (illustrate through media). Learners were given counters to use when they divide whole numbers. For example, if learners needed to divide 48 by 12, they were given 48 counters, and they needed to group the 48 counters. In each group, there were 12 counters (see Fig 4.27). Counters were given only to learners struggling with the poster and with recalling the multiplication of whole numbers. What the educator was doing here was using the guideline of *perception* (visual information).



Figure 4.27: Learners using counters.

In the second lesson, Educator D presented percentage increase and decrease. The educator highlighted few things to remind learners. This session was also a revision because the educator was done with the ATP. Educator D wrote a question on the chalkboard (see fig. 4.28) and asked learners if the question was about percentage increase or percentage decrease. Learners answered that it was percentage increase because the initial figure was less than the final price. Educator D made up a scenario that ‘a loaf of bread was R12 two years ago and now the loaf of bread was R20. What is the percentage increase of the loaf of bread?’ Learners raised their hands to solve the problem. The chosen learner explained to the rest of the class that the first step is to subtract the initial price from the final price, namely $R20 - R12 = R8$. The answer would be divided by the final price and multiplied by 100 to get the percentage increase. $\frac{8}{20} \times \frac{100}{1}$ Learners had to recall the multiplication of whole numbers, that numerators have to multiply one another and the same applies with denominators. The answer the learners got was $\frac{800}{20}$. Because it was a large number, learners were allowed to use calculators to get the final answer. Learners were given two more examples to solve on the chalkboard (see Fig 4.28).

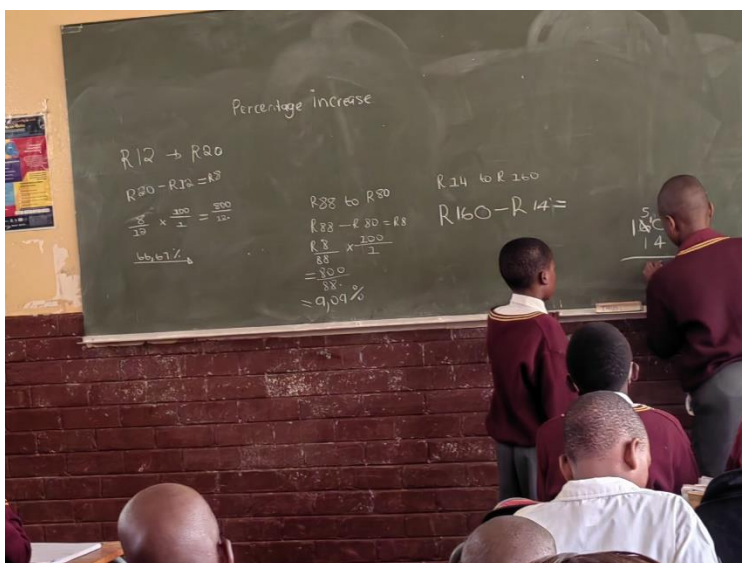


Figure 4.28: Learners solving problems on the board.

Learners were then taken to the math lab to watch a video on YouTube about the percentage increase and percentage decrease (see fig 4.29). Educator D paused the video now and then in order for learners to write down the questions on the video and write their own answer before the video displayed the answer. In the video, the solutions were clearly explained. What the educator was displaying here was the guideline of *language, mathematical expressions, and symbols* (illustrate through multiple media)

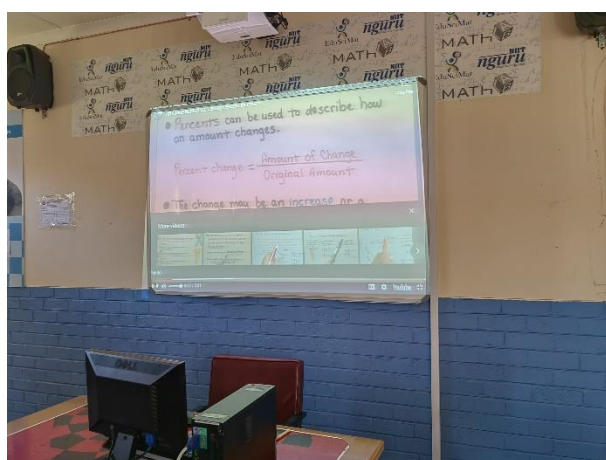


Figure 4.29: Video from YouTube

4.4.2. Educators' interaction with the classroom

In Educator D's classroom, learners were seated in pairs. The seating arrangement promoted peer learning where learners learnt from one another. When an activity was given to learners, the educator would walk around to check learners who were struggling to answer the question and assist them (see fig. 4.31).

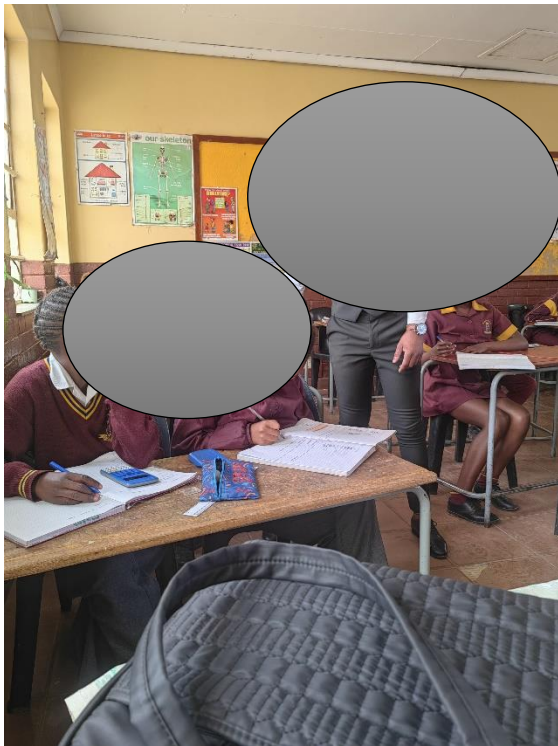


Figure 4.30: Educator D interacting with learners.

Examples Educator D choose to utilize.

The examples used by Educator D in both lessons (see Fig. 4.32 and Fig. 4.33) were taken from an activity book which the educator compiled according to the ATP. The activity book was a guide for educators to know which activity should be written by learners on a specific day.

4.7. Conclusion

In this chapter, the data presented was collected through observations and interviews. The researcher described the portfolio of each educator together with content which was taught during the observation. Moreover, the researcher went further to explain the interaction of each educator with learners and instructional material and examples used by each educator in the eight lessons which were observed. The next chapter discusses findings and recommendations.

Chapter 5: Discussion of findings and recommendations

5.1. Introduction

This chapter discusses the findings and recommendations on how Grade 7 educators in Thabo Mofutsanyane circuit 8 used multiple means of representation during mathematics lessons. The study was set to respond to the following critical research questions:

- How do Grade 7 educators use multiple of representations in mathematics lessons?
- What instructional resources do Grade 7 educators use in mathematics lessons?
- What analogies/examples do Grade 7 educators utilize during teaching?

The findings of the study in this chapter are organized according to these research questions.

5.2. How do Grade 7 educators use multiple means of representation in mathematics lesson?

The findings suggest that the four educators who participated in the study used multiple means of representation in their lessons. Using Universal Design for Learning (UDL) (CAST 2018) discussed in Chapter 2, the researcher found that all the UDL checkpoints of multiple means of representation; perception, language and symbols, and comprehension, were realized. Educator A used the checkpoint of perception, comprehension, language, and symbols. However, the educator used some checkpoints more than others. The checkpoint that was used frequently in Educator A's lessons was Comprehension. Educator A displayed a chart on the chalkboard during her lesson. The chart was based on fractions. Instead of Educator A simply explaining fractions using words only, she used a chart to accommodate learners who struggled to learn through text. Educator B incorporated perception. During the lesson when learners were given an activity to write, the educator would walk between rows and assist learners struggling with the given activity. Her tone toward such learners would change

when she is explaining. She would slow down and speak slower, draw objects on the chalkboard, to develop the meaning of the concepts. CAST (2018) states that material that are in print are fixed and permanent. The educator should be able to offer ways of customizing the display of information. The educator can use different colors from which the printed material is used, or decrease the speed of speech. The educator presented 3D shapes to learners, in which real-life objects were used. The educator used concrete manipulatives. Lange (2021) states that manipulatives assist learners to learn and explore mathematical concepts using a variety of hands-on learning methods.

The educators used language and symbols. In Educator B's class, learners solved mathematical problems using mathematical procedures and used counters to present their answers. In this manner, the educator provided an alternative of language and symbols by allowing learners to manipulate counters. According to CAST (2018), resources in the classroom are based on text, and therefore, it is important for an educator to provide options such as diagrams and manipulatives for learners that have reading and writing barriers. Educator B strictly used the language of teaching and learning (English), which made it easy for learners to interact in English. Mathematical vocabularies were utilized throughout the lesson. When the educator presented 3D shapes, she utilized real objects and explained to learners the difference between pyramids and other objects. Educator B tried to balance all the guidelines during the lesson. In the lessons by Educators C and D, language and symbols played an important role in teaching and learning. The two educators also used all the UDL of multiple means of representation like perception and comprehension. However, the language and symbols were dominant. Educator C explained mathematical terms to learners at the beginning of the lessons. Terms such as a fraction and ratio were defined, and examples were made for learners to understand better. CAST (2018) states that some words can enhance and clarify ideas for learners. Words can be meaningful elements for the information presented. To make education accessible to all learners there should be connections between vocabulary, labels, icons, and symbols. The educator used the guideline of language and symbols to ensure that learners understand the concepts. The educator went further to use real life objects such as

apples and sweets to explain fractions to learners. Most of the information in the classroom was based on text. This became a barrier for learners who cannot read or have language-related barriers (CAST 2018). It is important to use alternatives for text such as illustrations, simulations, images, or interactive graphics to make information in the text accessible to any learners.

Learners were able to learn fractions through manipulating objects as the educator used apples and sweets as an alternative for written text. Through the use of apples, sweets, and counters, the educator displayed the guideline of perception to offer an alternative to written texts. What is outstanding about Educator D is that, not only did he traditionally teach learners, but also incorporated digital learning by exposing learners to different class settings of watching a video about fractions. The video was paused and terms explained to learners. The guideline the educator displayed was perception.

5.3 What instructional resources do Grade 7 educator use in mathematics lessons?

The researcher observed that participating educators used real objects to explain concepts to learners. Apples and sweets were used to explain fractions. The lesson was interesting and learners gave it their full attention. According to Fambaza (2012), using manipulative models appropriately can play a major role in developing meaning and clear communication in mathematics. Educators were able to connect mathematical concepts with the real world by using objects that learners were familiar with, such as apples and sweets. Dlamini (2017) affirms that the use of real-world situations assists to grasp mathematical concepts in our daily experiences, which makes mathematical ideas accessible to learners. In chapter two, the importance of instructional material in teaching and learning was discussed. The Department of Education recommends the use of DBE workbooks in teaching and learning of Grade R-9, and Siyavula textbooks for Grade 10-12. During the interviews, three Educators (A, B, and C) admitted to using the prescribed DBE workbook. Beside the DBE workbook, Educator B and Educator C had one textbook which they commonly used to prepare for their lesson. Both educators mentioned that they used platinum textbooks during the lesson. There are other textbooks educators mentioned in chapter 4 that they used to prepare for their lessons.

Ghafar et al. (2023) note that the purpose of textbooks is as a resource for representing material, activity for learners, ideas in the classroom, syllabus that educators consider for learning objectives, and to assist educators who are inexperienced.

5.4 What analogies/examples do Grade 7 educators choose to utilize during teaching?

The participating educators used different objects and manipulatives as examples in their lessons. Educator B used real money when presenting the sharing ratio. The use of money was relevant to learners because they use money in their daily lives. According to Mpalami and Moleko (2022), educators used fake money to present addition and subtraction of whole numbers. In this case, Educator B used real money for learners to relate. Educators were creative when it came to examples. The other educator used bar fractions to show learners how to get a whole using halves. It was observed that educators frequently used counters in their lessons, especially when adding or subtraction fractions. Counters were used because learners could manipulate them. Manipulatives are important in a lesson because they assist learners to learn, explore, and investigate using a variety of hands-on learning (Lange 2021). One educator used apples and sweets to represent fractions. Learners were able to touch and manipulate these real objects. When introducing concepts during the eight lessons, the three Educators (A, B, and C) used examples from textbooks as shown in chapter 4. Educator A used an example from Spot on textbook, Educator B used an example from Spot on, while Educator C used Math Today. Educator D, however, used an activity book which he compiled using different textbooks.

5.5 Recommendations

The UDL consists of three principles which are multiple means of representation, engagement, Action and expression. However, the study focused on the multiple means of representation. The three principles are intertwined and each principle depends on the others. It is recommended that for future studies, researchers should include all three UDL principles to investigate the teaching and learning of mathematics. The University of the Free State (UFS) UDL workshops play an important role in the implementation of the three guidelines. Educators who attended the workshops were

able to effectively implement the multiple means of representation in their lessons. The study recommend that educators continue attending workshops in order to make mathematics accessible to all learners, and assist educators with the teaching mathematics.

5.6 Limitations

Four educators agreed to participate in the study but only three educators were interviewed, and one educator pulled out. It would have been interesting to have interviewed four educators. There are other methods used by the educator that pulled out, whose justification the researcher was interested to know. The Free State province consists of four districts with several educational circuits. The study involved only four educators in Thabo Mofutsanyana district. The sampled population was too small to generalize.

5.7 Conclusion

The aim of this study was to explore how Grade 7 educators in Thabo-Mofutsanyana District used multiple means of representation to make mathematics accessible to all learners. The study established that educators who participated in this study displayed various components of multiple means of representation in their lessons. Educators used various examples to make mathematical content accessible to all learners in their classrooms. Learners who had difficulty learning through words were assisted using manipulatives of different shapes and colors to ensure that they understood the content of fractions. The study revealed that educators in Circuit 8 could demonstrate knowledge on how to use manipulatives, and they used real-life objects to relate mathematics to real-life situations. Educators were creative with the instructional material used to make concepts easier for all learners. Educators were able to make demonstrations on fractions with objects which learners could easily relate with, such as apples, sweets, and money. It was encouraging that participating educators were able to use different textbooks when preparing for Grade 7 mathematics lessons. The DBE workbooks which are recommended and prescribed by the Department of Basic Education were incorporated into the lessons.

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7. Appendices

Appendix A: Ethical clearance



GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

19-Feb-2024

Dear Miss Irene Mmotsi

Application Approved

Research Project Title:

THE TEACHING OF GRADE 7 MATHEMATICS THROUGH THE USE OF MULTIPLE MEANS OF REPRESENTATION



Ethical Clearance number: **UFS-HSD2023/2260**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted via an Amendment on RIMS to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit a Final Report on RIMS for your study/research project to the ethics office once the project has concluded. Should you require more time than the allotted 12 months to complete this research, please apply for an extension by submitting a Continuation/Report on RIMS. Thank you for submitting your proposal for ethical clearance. We wish you success with

your research.

Yours sincerely, **Dr Adri Du Plessis**

Chairperson: General/Human Research Ethics Committee

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South Africa



Appendix B: Editors' report

Dr Jabulani Sibanda

Senior Lecturer: English Education

School of Education

Tel: (053) 491-0142

Email: Jabulani.Sibanda@spu.ac.za

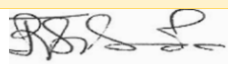
Alternate e-mail: jabusbnd@gmail.com

Website: www.spu.ac.za

Cell: 0845282087

July 2024

LANGUAGE EDITING CERTIFICATE

LANGUAGE EDITING DECLARATION	I confirm that I have proofread and edited the Dissertation detailed below, using the Windows 'Tracking' System to reflect my comments and suggested corrections for the author(s) to action.	
DETAILS OF WORK COMPLETED	Language Editing	
	Document Type: Dissertation	
	Title: The teaching of Grade 7 Mathematics through the use of multiple means of representation	
CLIENT'S DETAILS	Author: Irene Mpho Mmotsi	
	Student number: 2011159460	
	Affiliation: University of the Free State	
EDITOR'S DETAILS	Dr Jabulani Sibanda PhD English Education	SARS Tax number 3153156165
<p>Although the greatest care was taken in editing this document, the final responsibility for the product rests with the author(s).</p>		
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Appendix C: Turnitin report

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Appendix D: Title registration



16 October 2023

APPLICATION FOR TITLE REGISTRATION

Applicant: Mmotsi, IM

Student Number: 2011159460

Discipline: Subject Education in Mathematics

Study Code: Masters (EDMA8900)

Dear Ms Mmotsi

Your registered title is as follows: *"THE TEACHING OF GRADE 7 MATHEMATICS THROUGH THE USE OF MULTIPLE MEANS OF REPRESENTATION"*

All of the best with your studies.

Yours sincerely,

A handwritten signature in blue ink that reads "Patrick Mafora".

A handwritten signature in blue ink that reads "Duvenhage".

Prof Patrick Mafora Ms

CS Duvenhage

Chair: CTR committee Secretary: CTR committee

Appendix E: Transcripts

Interviewee: Educator A

Interviewer: Irene Mpho Mmotsi

Date of interview: 04/03/2024

Location of interview: School A

Researcher: Morning mam. Please note that your name or the name of the school will not be published in this research.

Educator A: Ok Ma'am

Researcher: Am going to ask you few questions based on what I have observed in your classroom and please, when you answer the question, elaborate. Make sure you explain every answer. Am going to start with simple questions. Please tell me your age.

Educator A: 33

Researcher: What is your qualification?

Educator: I have a B.Sc in physics and mathematics and then PGCE in Senior Phase and FET

Researcher: What are your PGCE majors

Researcher: Physical Sciences and Mathematics

Researcher: How long have you been teaching?

Educator A: it's been 6 years

Researcher: How long have you been teaching mathematics?

Educator A: 6 years

Researcher: Which textbooks are you using when preparing for your lesson?

Educator A: For grade 7?

Researcher: Yes ma'am

Educator A: I use Premier and Platinum

Researcher: Why do you specifically use Premier and Platinum?

Educator A: Because they have information that I need and different methods. These books provide different cognitive levels. I also use DBE workbooks.

Researcher: What other sources do you use besides textbooks?

Educator A: overhead projector

Researcher: What do you do with the overhead projector?

Educator A: I present a lesson using an overhead projector

Researcher: How? If I may ask.

Educator A: I use worksheets using the projector. We usually use the chalk and board method. On that day, I will be using the overhead projector to present my lesson from examples to activities and everything.

Researcher: Besides the projector, what else do you use?

Educator A: Teaching aids and concrete evidence.

Researcher: How do you select the teaching aids for your lesson?

Educator A: I select teaching aids that are aligned with the topic. Maybe I was doing common fractions so I use fraction strips because they are aligned with the common fractions

Researcher: How do learners respond to the representation that you have used?

Educator A: It was positive because they were involved in the topic. They were also presenting their answers or how did they get the answer.

Researcher: Do you think using representation was helping them to understand better?

Educator A: Yes. We have learners that have barriers to learning, we use something that they can touch or see.

Researcher: What motivates you to use more than representations?

Educator A: During the lesson, you have to use prior knowledge of learners before you can continue with the lesson and then you have to do enrichment or remedial so you have to use different topics. What motivates me to use more than one representation- I want to remind my learners of the prior knowledge and what they doing at that time.

Researcher: Do you think using multiple means of representation helps learners to understand better?

Educator A: yes. Like I said, we have different types of learners, that's why we use- maybe teaching aids or maybe remedial activity. Or normally do remedial activity during the

lesson but normally I have maybe activity. If I see that learners are struggling, then I have to remediate. When they are using concrete evidence they become excited or more understanding.

Researcher: You mention something about learners with barriers, how do you assist those learners in your classroom?

Educator A: I start within the class, during the lesson if I still have time, I give them remedial activities. Maybe I will be doing problem-solving if I see that they do not understand, I read the question for learners and solve the problem together. Have extra class for such learners.

Researcher: The last question as an educator did you learn anything from using the multiple means of representation in your lesson?

Educator A: Yes. We have different learners. Some learners learn more when using overhead projector and they understand better, but some learners understand better when using counters.

Researcher: Thank you very much mam for your time and allowing me to come and observe your lesson. This is the end of the interview. Thank you very much

Educator A: Thank you ma'am

Interviewee: Educator B

Interviewer: Irene Mpho Mmotsi

Date of interview: 04/03/2024

Location of interview: School B

Researcher: Morning ma'am. Am going to ask you few questions, please answer the questions with honesty

Educator B: Ok ma'am

Researcher: Can you please tell me your age?

Educator B: Am 32

Researcher: Number of years you have been teaching?

Educator B: I have been teaching since 2018 therefore it's been 6 years

Researcher: Number of years teaching mathematics?

Educator B: It's six years

Researcher: So, tell me which textbooks are using to prepare for your lessons?

Educator B: Spot on and Platinum

Researcher: Why specifically Spot on and Platinum

Educator B: ...uuuh Spot on I love activities, just everything about it is easy for me as well as examples.

Researcher: What other resources do you use besides the textbooks?

Educator B: I also have DBE workbooks and sometimes I use YouTube

Researcher: Why YouTube? What is it that you get from YouTube that you do not get from other resources?

Educator B: How they explain and everything is there.

Researcher: How do you select your teaching aids for your lessons?

Educator B: Mmmmh I don't know how to answer

Researcher: During your first lesson, you were representing shapes and you used different shapes. How did you select them?

Educator B: I took all the 3-D shape that I have.

Researcher: What were the responses of learners to the representation that you used? Let's start with the first lesson where you used 3-D shapes.

Educator B: The response is positive; they were able to see. I was just not telling me. They were able to see unlike when you were telling them.

Researcher: In the second lesson you did ratio, you used money and counters. What was the response toward that whole exercise?

Educator B: It was also positive. Because when you are talking about money, if you are reading money so so so and so, it's something they do not know but if you come with the money to the class, it becomes easier for them to understand. Even when sharing money, if we are not going to share equally meaning we are sharing with ratios.

Researcher: What motivates you to use more than one representation?

Educator B: So that learners can see that we do mathematics every day in our lives. With the counters they have been using the counters all along, why don't we come with money because they always have money with them?

Researcher: Do you think using multiple means representation help learners to understand better?

Educator B: Learners learn through playing. If you come with formal lesson others are not listening so if you use manipulative, it grabs learners' attention and they are able to concentrate.

Researcher: As an educator, did you learn anything from using the multiple means of representations?

Educator B: The last time I went to a workshop and in this workshop, they were using abacus to add and subtract numbers. It was something I was not aware of. That taught me that representation is very important in the lesson. Representation helps learners to understand better because they can see and touch objects. Learners also learn when they create their own objects and explaining these objects to other learners. Learners learn more through playing unlike when a teacher come present the lesson in English throughout the lesson, there will be some learners that will not understand a thing.

Researcher: What I observed from your lesson, you choose few learners from each group to come present in front of the classroom. Why?

Educator B: mmmmh it helps to build self-confidence. If a learner is presenting in front of the class, it is easier to correct that learner and you might find that other learners in class have the same problems or misconnects but cannot voice out. When they are corrected while they are in front of the classroom, it minimizes the chances of misconnects.

Researcher: Ma'am thank you very much for your time. I appreciate it a lot- and this is the end of the interview

Interviewee: Educator C

Interviewer: Irene Mpho Mmotsi

Date of interview: 04/03/2024

Location of interview: School C

Researcher: Good Morning ma'am. How are you?

Educator C: Am good mam. How are you?

Researcher: Am good. Please note that your name or the name of the school will not be published. A fake name will be used. Can you please tell me how old you are?

Educator C: 50 years

Researcher: Can you tell me about your qualification?

Educator C: It's SPTD (Senior Primary Teacher Diploma)

Researcher: How long have you been teaching?

Educator C: 19 years

Researcher: Wow 19? Please tell me the number of years teaching Mathematics?

Educator C: Since 2007, which makes it to be 17 years

Researcher: Number of years teaching grade 7?

Educator C: 19 years.

Researcher: So, you have been teaching grade 7 ever since you started teaching

Educator C: Yes

Researcher: Which textbooks are you using for preparing lessons?

Educator C: Am using the Math Today and also the DBE book and classroom

Researcher: So, you are using three textbooks?

Educator C: Yes

Researcher: So, why specifically these three textbooks?

Educator C: They are using different methods of teaching.

Researcher: How are they different?

Educator C: I usually use Math Today if I don't understand or if Math Today does not explain the concept, then I use the classroom mathematics

Researcher: So, you use the Classroom mathematics for referring?

Educator C: Yes

Researcher: What other sources do you use besides textbooks?

Educator C: I use manipulative objects. If I don't have counters, I just buy something that we can use in the classroom so that they can see or touch it.

Researcher: Do you have math Lab?

Educator C: Yes, we do use the Math lab although it does not have a software. Therefore, we cannot use the projector.

Researcher: How do you select teaching aids for your lesson?

Educator C: I select my teaching aids according to my topic.

Researcher: Can you please make an example with one topic?

Educator C: Let me see... when I do fractions, I come with orange apple and also the counter.

Researcher: What is the response of learners toward the representations that you used? For example, in your first lesson, you used apples, sweets, and counters to do fractions.

Educator C: They respond very well because I think they prefer to touch. If they are touching something and you want them to calculate in fractions, they can be able to calculate it using the counters. If you want them to divide, they are going to use apples into halves, quarter.

Researcher: What motivates you to use more than representation?

Educator C: They understand differently hence am using the different methods

Researcher: Can you make an example?

Educator C: In the class we have those learners that understand quickly and we have the slow learners so most of the time the slow learners need to touch so that they are able to understand the topic most of the time.

Researcher: In your lesson, you used an apple, sweets and counters. Which learners do you think are accommodated using these presentations?

Educator C: Apples accommodate those who do not understand, the slow learners. The sweets accommodate learners who understand quickly they are able to sort the sweets according to their colors and be able to write the sweets in form of fractions and also be able to add them.

Researcher: Do you think using multiple means of representation helps learners to understand better?

Educator C: If representations are not used, there will be few learners who understand but when you are using different methods or different techniques, they understand better. Like I said before, if they touch things they understand better than when you are writing the problem on the chalkboard.

Researcher: As an educator did you learn anything from using the multiple means of representation in your lesson?

Educator C: Yes, but it is going to depend on learners. Sometimes I don't use different methods, I only use one method because of that group. They differ especially grade 7 learners of 2024. You have to use different methods, otherwise you are going to stuck.

Researcher: What makes them to be different compared to other learners?

Educator C: They are very slow. I think they are learners of 2020. They did not attend school very well, hence they struggling.

Researcher: Which part do you think they struggle the most with in mathematics?

Educator C: Financial mathematics and problem solving. Division and multiplication.

Researcher: Thank you very much ma'am for your time. This is the end of the interview

Educator C: Thanks ma'am

Appendix F: Semi-structured interview with educators

1. Educators profile

Surname & initial: _____

Age: _____

Gender: _____

Race: _____

Qualification: _____

Number of years teaching: _____

Number of years teaching mathematics: _____

Number of years teaching Grade 7: _____

2. Learning and Teaching Support Material (LTSM)

Which textbooks do you use when preparing for lessons?

What other sources do you use besides textbooks?

How do you select the teaching aid for your lesson?

3. The use multiple means of representation

What are the responses of learners to the representation you used?

What motivates you to use more than one representation?

Do you think using multiple means of representation during the lesson helps learners to understand better?

As an educator, did you learn anything from using multiple means of representation in your lesson?

Appendix G: Observation Schedule

Name of the school: _____

Surname and initials: _____

Date: _____

Start time: _____

End time: _____

Observation no: _____

Lesson topic: _____

1. What kind of representation is the educator using during the mathematic lesson?

Representation	Not used at all	Used but frequently	Frequently used	Used all the time
Concrete/virtual models Counter				
Computer software				
Symmetrical objects				
Fraction bars				
Counters				
Diagrams/pictures				
Area models				
Fractional chart				
Number line Sets				
Experience-based				

metaphors Games				
100 Real-life problems				

The interaction of the educator with learners in the classroom

Type	Not used at all	Not frequently used	Used frequently	Used all the time
Individual				
Small group				
Large group				
Pairs				

2. How do educators use the multiple means of representation in the lesson?

4

. Any other observations?

Appendix H1: Consent forms



Research study information leaflet and consent form.

Date

20 FEBRUARY 2024

Title of the research project

The teaching of grade 7 mathematics through the use of multiple means of representation

Principle investigator / researcher(s) name(s) and contact number(s): IRENE

MPHO MMOTSI 2011159460 082 833 6249

Faculty and Department:

FACULTY OF EDUCATION

DEPARTMENT OF MATHEMATICS

Study leader(s) name and contact number:

MPALAMI N

058 718 5340

What is the aim/ purpose of the study?

The proposed study aims at exploring how Grade 7 educators in Thabo-Mofutsanyana District use multiple means of representation to make mathematics accessible to all learners.

Who is doing the research?

My name is Irene Mpho Mmotsi, am currently studying Master of education in subject education majoring in Mathematics at the University of the Free State (QwaQwa campus). My study is about the teaching of Grade 7 Mathematics through the use of multiple means of representation. I will be observing how educators use different representation to teach the same topic. The aim of the study is to explore how Grade 7 educators in Thabo-Mofutsanyana District use multiple means of representation to make mathematics accessible to all learners.

Why are you invited to take part in this research project?

These participants are chosen because they are educators who are teaching grade 7 mathematics. They are all working in circuit 8 in Thabo Mofutanyana. Four participants were randomly selected because they are available and willing to take part in the study.

What is the nature of participation in this study?

When taking part in the study, the educator should expect the following:

- Educators workshopping on the use of multiple means of representation
- A maximum of two classroom observations of 30 minutes to 1hour Mathematics lesson.
- An in-depth interview after lesson.

Can the participant withdraw from the study? Participation is voluntary and there is no penalty or loss of benefit for non-participation. Being in this study is voluntary, and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time, and without giving a reason.

What are the potential benefits of taking part in this study?

The study might shed light to the Department of Education with regard to the extent to which, through the employment of multiple means of representations, teachers are accommodating all learners during instruction. The educator will use multiple means of representation during the lesson which will ensure mathematics is accessible to all learners.

What is the anticipated inconvenience of taking part in this study?

There are no risks of harm or side effects to the potential participants. The researcher will do the lesson observation during mathematics lesson not any time of the day. Therefore, the participant will not be inconvenienced. The interview will take place after the lesson during lunch break, and the educator can have lunch while doing the interview. This might cause some discomfort because the educator might be tired and want to take a break.

Will what I say be kept confidential?

Your name will not be recorded anywhere, and no one will be able to connect you to the answers you give. Your answers will be given a fictitious code number or a pseudonym, and you will be referred to in this way in the data, any publications, or other research

reporting methods such as conference proceedings. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report

How will the information be stored and ultimately destroyed?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet for future research or academic purposes. Electronic information will be stored in a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval, if applicable.

How will the participant be informed of the findings / results of the study?

If you would like to be informed of the final research findings, please contact Irene Mpho Mmotsi on (082) 833 6249 or email Irene.mmotsi@gmail.com. The findings are accessible for one year. Should you require any further information or want to contact the researcher about any aspect of this study, please contact (083) 750 4205, email: moloinkukile@gmail.com. Should you have concerns about the way in which the research has been conducted, you may contact Dr Mpalami, contact: (058) 718 5340, email: MpalamiN@ufs.ac.za

Thank you for taking the time to read this information sheet and for participating in this study.

Consent to participate in this study

I, the undersigned,

(participant's full names to be included), (the "Participant")

confirm that I voluntarily agree to participate in the research study referred to as the

_____ (the "Study") in relation to

_____ and which Study is being conducted by

_____ (Irene Mpho Mmotsi), (the "**Researcher**").

I, the undersigned Participant, further confirm that:

1. The researcher has explained the nature, procedure, potential benefits, and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);
5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study, and any related activities;
6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer, or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;
7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage;
8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

I, the Participant, agree to the recording of the observation and interviews.

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

Appendix H2: Consent forms for parents



Research Study Information Leaflet and Parental Consent Form

Date

20 February 2024

The teaching of grade 7 mathematics through the use of multiple means of representation.

Researcher's name(s) and contact number

IRENE MPHO MMOTSI

2011159460

082 833 6249

Faculty and department

Faculty of Education

Mathematics department

Study leader's name and contact number

Dr Mpalami Nkosinathi

058 718 5340

What is this research project all about?

The project is about how educators use different representations to teach the same topic in mathematics lessons to ensure that all learners understand the topic.

Why has your child been invited to take part in this research project?

The child has been selected to take part in the study because the educator will be using multiple means of representation in the chosen grade 7 class. Your child is part of the chosen class.

Who is doing the research?

My name is Irene Mpho Mmotsi. I am currently studying Master of education in subject education majoring in Mathematics at the University of the Free State (QwaQwa campus). My study is about the teaching of Grade 7 Mathematics through the use of multiple means of representation. I will be observing how educators use different representations to teach the same topic. The aim of the study is to explore how Grade 7 educators in Thabo-Mofutsanyana District use multiple means of representation to make mathematics accessible to all learners.

What will happen to your child in this study?

The researcher will sit at the back of the classroom, observing the lesson without any interaction with the learner or educator during the lesson. A video and pictures will be taken during the lesson

Can anything bad happen to your child?

Nothing bad can ever happen to the child. The lesson will be normal as usual.

Can anything good happen to your child?

Multiple means of representation can assist learners to understand any topic better. If educators use different representations in the classroom there is a high chance of mathematics performance improving. Hence, your child might perform better in mathematics.

Will anyone know your child is part of the study?

The name of the child will not be recorded anywhere and no one will be able to connect your child to pictures of books taken in the classroom. Hard copies of the study will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet for future research or academic purposes; electronic information will be stored on a password-protected computer.

Who can you talk to about the study?

For more information, feel free to contact the researcher or supervisor:

Researcher contact details: (082) 833 6249

Researcher email: Irene.mmotsi@gmail.com

Supervisor contact details: (058) 718 5340

Supervisor email: MpalamiN@ufs.ac.za

What if you do not want your child to do this?

The child can stop being in the study at any time without getting in trouble.

Please return this section

Name of child: _____

Name of Parent: _____

- Do you understand this research study and are you willing to let your child take part in it?
Yes No Has the researcher answered all your questions?
Yes No
- Do you understand the child can withdraw from the study at any time? Yes No
- I give the researcher permission to make use of the data gathered from my child's participation Yes No

Signature of Parent

Date

I, the undersigned Parent, further confirm that:

1. The researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);

5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;

6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer, or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;

7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and de-identified at such stage;

8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

I, the Parent, agree to the observation.

Full Name of Parent: _____

Signature of Parent: _____ Date: _____

Full Name(s) of Researcher(s):

Signature of Researcher: _____ Date: _____

Appendix H3: Consent form for principal



REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear *Principal*

I am doing research and would like to request permission to conduct our research at your school.

DATE:

27/09/2023

TITLE OF THE RESEARCH PROJECT

The teaching of grade 7 mathematics through the use of multiple means of representation.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Irene Mpho Mmotsi 2011159460 082 833 6249

FACULTY AND DEPARTMENT:

Education
Mathematics, Natural Science and Technology Education

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Nkosinathi Mpalami Contact number: 078 678 1125

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The proposed study aims at exploring how Grade 7 educators in Thabo-

Mofutsanyana District use multiple means of representation to make mathematics accessible to all learners.

WHO IS DOING THE RESEARCH?

My name is Irene Mpho Mmotsi. I am currently studying for a Master of Education majoring in Mathematics at the University of the Free State (QwaQwa campus). My study is about the teaching of Grade 7 Mathematics through the use of multiple means of representation. I will be observing how educators use different representation to teach the same topic. The aim of the study is to explore how Grade 7 educators in Thabo-Mofutsanyana District use multiple means of representation to make mathematics accessible to all learners.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This Study have received approval from the Research Ethics Committee of UFS.

Approval number: *UFS-HSD2023/2260*

WHY ARE YOUR INSTITUTION/ORGANISATION/COMPANY INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

- The focus of the Study is on grade 7 educator's mathematics teachers.
- The teachers in your school attended a workshop about Universal Design for learning principles.
- The aim is to explore how educators in grade 7 use multiple means of representation in mathematics lesson

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

- The participant's actual role in the study is to implement UDL principles in teaching grade 7 mathematics. Their lesson preparation and presentation must comply with UDL principles and guidelines.
- Observation and interviews will be used for data collection.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The study might shed light to the Department of Education with regard to the extent to which, through the employment of multiple means of representations, teachers are accommodating all learners during instruction. The educator used multiple means of representation during the lesson which will ensure mathematics is accessible to all learners.

[Click here to enter text.](#)

WHAT IS THE POTENTIAL RISKS TAKING PART IN THIS STUDY

There will be no risk or discomfort in participating in this Study. I will consult with the participants after school hours to avoid disturbing the classes. The participants are grade 7 mathematics educators. There will be no possible or reasonably foreseeable risks of harm or side effects to the potential participants. There will be no risk of others identifying the person's participation in the research. If injury or harm attributable to the Study occurs, the Researcher will refer the participants to the specific channel for support.

WILL THE INFORMATION BE KEPT CONFIDENTIAL?

The name of the school will not be recorded anywhere, and no one will be able to connect you to the answers the educators give. Their answers will be given a fictitious code number or a pseudonym, and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Identify who will have access to the data (transcriber/external coder) and how these individuals will maintain confidentiality (e.g. by signing a confidentiality agreement). Their answers may be reviewed by people responsible for making sure that research is done properly. These include the transcriber, external coder, and members of the Research Ethics Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Hard copies of answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet for future research or academic purposes. Electronic information will be stored in a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable

WILL THERE BE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There, will be no reward or payment allocated to participate in this Study. There will be no potential inconvenience and/or discomfort to the participant as I would have obtained the permission from the school principal and the participants. There will be no possible

or reasonably foreseeable risks of harm or side effects to the potential participants. There will be no risk from others and participation in the research. The researcher will explain to the participants that they may withdraw if they feel like they don't want to participate any further as their participation is voluntary. There will be no injury or harm attributable to the Study.

HOW WILL THE INSTITUTION / ORGANISATION / COMPANY BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

If you would like to be informed of the final research findings, please contact Irene Mpho Mmotsi on (082) 833 6249 or email Irene.mmotsi@gmail.com. The findings are accessible for one year. Should you require any further information or want to contact the researcher about any aspect of this study, please contact (083) 750 4205, email: moloinkukile@gmail.com. Should you have concerns about the way in which the research has been conducted, you may contact Dr Mpalami, contact: (058) 718 5340, email: MpalamiN@ufs.ac.za

Yours sincerely
Irene Mpho Mmotsi

Consent to the school principal

I, the undersigned,

(principal's full names to be included), confirm that I voluntarily agree for the school to participate in the research study referred to as the

_____ (the "Study") in relation to

_____ and
which Study is being conducted by

(Irene Mpho Mmotsi), (the “**Researcher**”).

I, the undersigned Participant, further confirm that:

1. the Researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);
5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;
6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer, or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;
7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage;
8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying

I, the school principal, agree to the recording of the observation and interviews.

Full Name of Principal: _____

Signature of Principal: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____