EXPLORING GRADE FIVE LEARNERS' PERCEPTIONS ON THE USE OF TECHNOLOGY WHEN LEARNING FRACTIONS IN ONE GRADE FIVE CLASS IN THE ILEMBE DISTRICT OF KWAZULU-NATAL, SOUTH AFRICA

By

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Declaration

I, Shamilla Hajaree, declare that

1) The research study in this thesis, except where otherwise indicated, is my original work.

2) This thesis has not been submitted for any degree or examination to any other university.

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16/12/2020

As the candidate's supervisor, I agree to the submission of this thesis.

Signed……………………J Naidoo……………………………

21/12/2020

Figures used in the study

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Abbreviations and Acronyms

CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
DoE	Department of Education
DSD	Department of Social Development
DWCPD	Department of Women, Learners & People with Disabilities
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
IEA	International Association for the Evaluation of Educational Achievement
LOLT	Language of Learning and Teaching
NCS	National Curriculum Statements
OBE	Outcomes Based Education
OECD	Organisation for Economic Cooperation and Development
PC	Personal Computer
PISA	Programme for International Student Assessment
SASA	South African Schools Act
TALIS	Teaching and Learning International Survey
TIMSS	Trends in International Maths and Science Study
WEF	World Economic Forum
ZPD	Zone of Proximal Development
ZPL	Zone of Proximal Learning

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Abstract

Teaching and learning that incorporates the use of a digital device is becoming popular at institutions of learning all around the globe. This research study examined the perceptions of one class of Grade 5 learners on the use of technology when learning fractions in mathematics. The socio-constructivist theory was used as a framework to frame this study. The study employed the qualitative research approach so as to generate rich, descriptive data. The qualitative research approach was ideally suited to this research study, since the involvement and experiences of the participants formed the core structure of the research itself. Answers to the research questions, analysis of data and conclusions drawn at the end of the study were all constructed from the interpretations and experiences of the learners who participated in the study. By linking this study to the interpretive paradigm I was able to further probe into the perceptions of the participants by asking a series of questions based in a focus group interview schedule. From the focus group interviews and observations it became apparent that the use of technology had a positive impact on the learning of fractions. Learners seemed to be unanimous in their conclusion that the intervention of technology had prompted learners to become more interested in the task and their engagement in the activities was deeper, thus making fractions seem easier and more accessible. As we embrace the infiltration of the fourth industrial revolution, it is imperative that teaching styles at schools are transformed to incorporate an innovative, technological dimension to the learning process.

Chapter One: Introduction

1.1. Context and rationale of the study

Canavan (2018) described teaching as a collection of skills and abilities, which when applied correctly can have a huge impact on learning. It seems obvious to say but technology should be a tool to help in teaching and learning. From direct instruction, facilitating discussions to hands-off guidance allowing independent or collaborative learning, employing various tactics at the right time is the key to effective teaching and learning. Therefore, integrating these pedagogies with technology is the key to successful teaching and is essential in preparing learners for the future.

Furthermore, Mushipe and Ogbonnaya (2019) stress that most learners do not enjoy learning mathematics because they find it uninteresting and boring. Many research studies are of the view that information and communications technology (ICT) can support mathematics teaching and learning and make the learners' mathematics learning more meaningful and joyful. The integration of technology into mathematics teaching and learning may, for example, help learners to visualise how any changes in one variable affects others thereby enhancing their learning experience compared to just manipulation of formulae to get the answer. ICT can stimulate, motivate and spark learners' appetites for learning and helps to enhance academic achievement. This can be demonstrated in their increased commitment to the learning task, increased independence and motivation for self-directed study, their enhanced enjoyment, interest and sense of achievement in learning when using ICT, and their enhanced self-esteem. ICT might offer learners tools for knowledge construction, reflecting, knowledge sharing and collaboration. These will lead to improved learning and achievement.

The Department of Education in South Africa (2004) is of the opinion that the developments in ICT create access to opportunities, redress inequalities, improve the quality of learning and teaching, and deliver lifelong learning. Experience worldwide suggests that ICT plays an important role in the transformation of education and training. Educational reforms are enhanced by enabling teachers and learners to move away from traditional approaches to teaching and learning. Furthermore, the use of ICT encourages a teaching and learning milieu which recognises that people operate differently, have different learning styles and have culturally diverse perspectives. Technology embraces inclusive education by providing opportunities, alternate methods of instruction and flexible assessments for learners who experience barriers to learning. Our education system must create graduates who use information effectively and keep abreast of technological advances.

In line with this, the focus of this research study was on the way in which the use of technology will allow learners in one Grade 5 class to better visualise and understand fractions in mathematics. Visual models are a central component in teaching fractions at all stages of conceptual development, rational-number thinking, procedural and operational problem solving (Petit et al., 2015). The Grade 5 mathematics curriculum at public schools in South Africa constitutes five content areas, namely, Numbers, Operations and Relationships; Patterns, Functions and Algebra; Space and Shape (Geometry); Measurement and Data Handling. Each content area contributes towards the acquisition of specific skills. Fractions, a topic which forms a part of the Numbers, Operations and Relationships content area, comprises describing and ordering fractions, calculations with fractions, solving problems involving fractions, and equivalent forms.

This research study was conducted at a primary school in the town of KwaDukuza in the Ilembe district on the north coast of KwaZulu-Natal, South Africa. The choice of the research site was based primarily on the fact that the researcher is a mathematics educator at this school and access to the location in order to conduct the investigation, was convenient. This school has a learner enrolment of approximately 1 000, with about 500 learners in the intermediate phase. The intermediate phase comprises of all learners from Grades 4 to 6. The learner population is made up of learners from diverse religious, cultural and socio-economic backgrounds. The school embraces the principles of inclusive education to an extent that immigrant learners, learners with special needs, gifted learners, learners who speak different languages and learners from different racial denominations form the learner population. The school provides a holistic development of learners by offering opportunities for learners to engage in various codes of sport and engaging learners in extra and co-curricular activities. The research study was conducted in one Grade 5 class at this school.

1.2. The learning of fractions

The importance of the knowledge of fractions in mathematical learning, coupled with the difficulties learners have with them, has prompted researchers to focus on this particular area of mathematics (Tsai & Li, 2017). Learning about fractions requires learners to recognise that many properties of whole numbers are not true of numbers in general and also to recognise that the one property that unites all real numbers is that they possess magnitudes that can be ordered on number lines. The difficulty of attaining this understanding makes the acquisition of knowledge about fractions an important issue educationally, as well as theoretically (Siegler, Fazio, Bailey & Zhou, 2013). A strong understanding of fraction concepts and procedures is a necessity in elementary grades before moving on to other rational number concepts in later grade levels. Fractional understanding in learners is a topic that deserves and requires more study for the benefit of teachers at all levels as well as learners (Wilkerson et al, 2015). Learners have trouble understanding and representing fraction relationships, and they commonly view the numerator and denominator as two separate numbers (Bruce, Chang, Flynn & Yearley, 2013). This research study attempted to use technology in mathematics lessons with the aim of adding a different dimension to the learning of fractions and to make fractions a topic that is more engaging for learners.

Research on the learning of fractions with the use of technology has been conducted internationally in countries such as: Australia by Mildenhall (2013), America by Hensberry, Moore and Perkins (2015), and Turkey by Gizem, Gokkurt and Zehra (2018). While technology has been introduced in the education system in most African countries, the expansion and its adoption remain slow due to a lack of effective ICT policies and a long-run supporting ICT infrastructure (e.g., electricity, Internet, software, and hardware devices), teacher capacity, and financial resources (Barakabitze, 2019).

These observations persuaded the researcher to supplement traditional teaching methods by incorporating technology as a tool to enhance understanding and visualisation when learning fractions.

1.3. The problem statement

According to Mushipe and Ogbonnaya (2019), the improvement of mathematics education in particular is one of the major priorities of the South African government. Of particular note are the growing calls to improve the teaching and learning of mathematics in South African schools through implementation of more innovative methods of teaching, especially the integration of ICT into teaching and learning. This is particularly important in light of the unsatisfactory learners' achievement in mathematics in the country over the years. For example, from 2012 to 2015 the percentage of students who scored at least 40% in mathematics in the grade 12 examination was 35.7%, 40.5%, 35.1% and 31.9% respectively in the National Senior Certificate Diagnostic Report of 2015. The report also shows that in 2015 only 3% of the candidates achieved a distinction (80% and above). This situation does not resonate with the developmental initiatives of the government to address the skills shortage in science, engineering and technology in the country nor does it enhance South Africa's competitiveness in the global economy.

This research was prompted by the observation that a gap exists with regards to the use of technology at Cato Primary school during mathematics curriculum delivery. While the use of technology seems to be prevalent in lesson planning and the recording of marks, the use of technology in the actual practical and theoretical lesson delivery remains subdued (Dube, Nhamo & Magonde, 2018). Furthermore, it was observed that the grade 5 learners at the school experienced many challenges in dealing with fractions as a part of the mathematics curriculum. Abdullah, Julius, Yann, Mokhtar and Abd Rahman (2018) propose that when learners exhibit misconceptions in fractions, teachers need to adapt their lessons to correct learners' misconceptions and guide their mathematical thinking in order to improve understanding. Learners around the world face difficulties in learning fractions. Even in countries such as China and Japan where the majority of their learners achieve good conceptual learning, fractions are still considered difficult for them. Fractions is a topic which is difficult to teach and difficult to learn and thus those notions present ongoing pedagogical challenges to mathematics education. In line with these observations, this research study sought to address this gap by exploring the underpinnings of the ways in which Grade 5 learners use technology to understand the concept of fractions in mathematics.

1.4. Introducing the key research questions

Research by Cinquin and Sauzeon (2019) indicates that for decades now, as the issue of social progress has come to the fore, the drive to improve access to education has been behind the growth in research into e-learning. Indeed, technology is expected to be one of the critical tools for improving access to education and ultimately aiding social inclusion. According to Attard (2018), many schools invest in mobile technologies or actively promote their use through Bring Your Own Device (BYOD) programmes with the expectation that the use of such devices will improve learner engagement and, as a result, improve learning outcomes. This research study explores learner perceptions of whether and how the use of technology within mathematics classrooms does indeed improve engagement with mathematics. Issues relating to the engagement and use of technology were explored within the context of the classroom, where learners are now considered to be 'digital natives', and ICTs are an integral and ubiquitous part of their daily lives.

The objectives of this study were to explore the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics; to identify the ways in which Grade 5 learners use technology when learning fractions in mathematics and to investigate why Grade 5 learners use technology in the way that they do when learning fractions in mathematics. The key research questions to be answered in this study were as follows:

i. What are Grade 5 learners' perceptions on the use of technology when learning fractions in mathematics?
ii. How do Grade 5 learners use technology when learning fractions in mathematics?
iii. Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics?

1.5. Social constructivism and diverse influences

The theoretical frameworks that underpinned this study were the theory of diverse influences and the socio-constructivist theory. A theoretical framework is considered an important component of research because it maps the way for the researcher to conduct an appropriate research as it provides theoretical underpinnings, which enable the researcher to formulate the research problem, ask appropriate research questions and provide a guide in choosing the research design. It also helps in the interpretation of the collected data and in drawing conclusions from such data for a particular study. This research study explored the learning of fractions in a Grade 5 class. The research was conducted in a classroom where teachers and learners from diverse social and cultural backgrounds interact with each other on a daily basis.

Valero (2010) has drawn our attention to the complexity of the networks of communities, interest groups and practices relevant to mathematics education and to the need for research to address this multiplicity of social practices and the connections between them. We are thus aware of the importance of studying the various communities and practices in which students and teachers participate, both within the classroom and beyond. We recognise the influence of policy and institutional structures and constraints at local, national and international levels. This increasing attention to social aspects of learning has been accompanied by a growth in research foregrounding issues of social justice. Differing levels of achievement in mathematics in particular as well as in education as a whole have been associated with membership of various social groups and the effects of factors such as gender, ethnicity, class and linguistic background on the achievement of students in school mathematics (Morgan, 2014). As a researcher, I was able to conduct an in-depth investigation into the diverse nature of the issues that influence the learning of fractions at school. This formed the basis of the theory of diverse influences.

Social constructivism was developed by post-revolutionary Soviet psychologist Lev Vygotsky. He argued that all cognitive functions originate in (and must therefore be explained as products of) social interactions and that learning did not simply comprise the assimilation and accommodation of new knowledge by learners; it was the process by which learners were integrated into a knowledge community. Vygotsky's theory stresses that social interactions are critical and that knowledge is constructed via the interactions with the environment and the other people. In line with the theory of socio-constructivism, a part of this research involved learners engaging with each other in smaller groups. Each group of learners was able to participate in activities and discussions around tasks provided in a worksheet. It was envisaged that this type of social interaction would assist in the alleviation of misconceptions and prompt learners to reflect on their learning of fractions. This study endeavoured to delve deeply into the social factors that influence mathematics learning, and further explore the affective relationships of learners at school and at home.

1.6. The scope of this study

Technology has the potential to make complex and abstract mathematical ideas more accessible to learners, especially those who have difficulties with challenging concepts (Kaplan & Alon, 2013). This research study attempted to explore the learning of fractions with the use of technology amongst one class of Grade 5 learners. The research method that was chosen for this study was an interpretive survey approach that was analysed using qualitative methods. In the vast majority of studies, according Draper and Swift (2011), it is simply not possible to collect data from every member of a particular population. An early step in designing a research study is therefore to decide who and how many people to recruit. Furthermore, Tracy (2019) describes a sampling plan as the design for how to specifically choose sources for your data. However, sampling can also refer to choosing specific locations, times of days, various events, and activities to observe in fieldwork. Good qualitative researchers, at the very least, engage in purposeful sampling, which means that they purposefully choose data that fits the parameters of the project's research questions, goals and purposes. The researcher also applies certain exclusion and inclusion criteria to ensure accuracy in order to determine who will participate in the study (Strydom, 2011). This study entailed the collection of data from participants who fitted the sampling profile. All 48 learners of this Grade 5 class participated in the intervention and teaching process, but only those learners who signed the consent forms and whose parents signed the consent forms, were included in the study sample.

At the end of data collection, responses to all research instruments were analysed and interpreted. The development of themes is a common feature of qualitative data analysis, involving the systematic search for patterns to generate full descriptions capable of shedding light on the phenomenon under investigation. It can also be helpful to re-listen to all or parts of the audio recording (Gale et al., 2013). Once the transcripts had been read and re-read, it was possible to identify key issues that run throughout the collection of data. Thereafter, the research questions were linked to the emergent themes so as to tie in the information that had been generated with the study under investigation.

Noble and Smith (2014) argue that qualitative research is frequently criticised for lacking scientific rigour with poor justification of the methods adopted, lack of transparency in the analytical procedures and the findings being merely a collection of personal opinions subject to researcher bias. Similarly, Carcary (2015) notes that the essence of reliability for qualitative research lies with consistency. A margin of variability for results is tolerated in qualitative research provided the methodology and epistemological logistics consistently yield data that are ontologically similar but may differ in richness and ambience within similar dimensions. Qualitative researchers aim to design and incorporate methodological strategies to ensure the trustworthiness of the findings (Noble & Smith, 2014). The use of more than one data collection instrument (worksheets and focus group interview schedule), resulting in triangulation of data, can contribute positively to the trustworthiness of the findings during this research study.

Validity in qualitative research means “appropriateness” of the tools, processes and data. Whether the research question is valid for the desired outcome, the choice of methodology is appropriate for answering the research question, the design is valid for the methodology, the sampling and data analysis is appropriate, and finally the results and conclusions are valid for the sample and context (Waterman, 2013). The use of audio recording devices to record information verbatim enhanced the possibility of an accurate transcription of information-rich data.

Every step of the research logistics (from theory formation, design of study, sampling, data acquisition and analysis to results and conclusions) has to be validated if it is transparent or systematic enough. In this manner, both the research process and results can be assured of high rigour and robustness (Leung, 2015).

1.7. The contribution of this study to mathematics education

Many teachers have become apathetic and teaching is viewed as a tedious and mundane activity. One of the ways in which to challenge and change this mindset of teachers is highlighted by Dogan and Arici (2019) who foreground that today it is necessary to implement activities that will facilitate the learning of individuals, improve their thinking skills, and enable them to look at different aspects of an event or situation in the teaching-learning environment. In the education system, plans should be made to ensure the growth of the learners according to the changing world conditions, to establish connections among the disciplines and to transfer these connections in the field to the learners.

According to Segumpan and Tani (2018), the introduction of visuals into the mathematics lesson develops greater understanding of the mathematical concept of fractions. In comparison to learning concepts through lecture-discussions, learners learn better through viewing and understanding concepts with the aid of technology and supplemented by activities in the class that cater for more interaction. In line with this, Hwa (2018) reiterates that technological applications have become more common in today's education, stimulating innovative approaches in teaching and learning.

This study addressed pertinent issues regarding learners that could be used as future considerations when policy changes are being made. Policy makers could extract information from the study that may prove useful when undertaking a critical evaluation of the current policies and implementing changes. This study and the subsequent recommendations have their origins in the experiences of learners and the contextual factors that influence their learning of fractions. The focus on learners' experiences is an area that is bound to draw the attention of education leaders to this study. The subject is of considerable significance in light of ongoing discussion and debates about mathematics learning at national and international level. The inclusion of technology into the learning of mathematics can be used to promote greater understanding and clarify concepts for learners. Technology as a learning tool provides an additional means of communication, which may allow increased access to mathematics learning. Moreover, digital technology serves to expand the learning experience by equipping learners with 21st century skills.

Limitations or boundaries are anticipated to arise in this research design, since the sample size was small and the participants were learners from diverse academic, racial and socio-economic backgrounds.

1.8. Overview of the study

This research study has been produced by putting together a series of seven chapters, a list of references and pertinent appendices. The chapters in the study are ordered in the following manner:

Chapter one offers the motivation and rationale for the study. This chapter also introduces the key research questions and provides a brief outline of what to expect in the chapters to follow.

Chapter two offers a review of relevant literature for the study. The teaching and learning of mathematics is interrogated, together with a discussion of the use of technology, visual manipulatives and cooperative learning of fractions in mathematics.

Chapter three presents the theories that frame this research study. The relevance of socio-constructivist theory, the anchored instruction theory, the cognitive flexibility theory and the theory of diverse influences to this study is discussed in detail. This chapter provides a description and explanation of the principles of the theories and their impact on the study.

Chapter four presents the research design and methodology employed during this research study. The interpretivist paradigm and qualitative methodology, together with the context of the study and sampling strategies are discussed. The design and techniques of data collection are presented.

Chapter five provides a presentation and discussion of the findings arising from the study. The chapter begins with a description of the responses extracted from participants in the task-based worksheets. A brief account of the background to the focus group interviews is presented, after which the impact of technology on the learning of fractions and findings from the focus group interviews are discussed.

Chapter six aims to explore the emerging themes from the research study. This chapter responds to the key research questions, followed by a discussion of how technology makes fractions simpler to understand. Furthermore, the chapter identifies the link between the theoretical framing and the emergent themes.

Chapter seven is the final chapter in the study, which presents the concluding thoughts, new knowledge that this study brings to the field, recommendations and limitations that became apparent within this study. A summary of the main findings are presented.

1.9. Conclusion

The focus of this chapter was on the context and rationale of the study. An overview of the chapters that follow, together with a brief expression of the main ideas, bring up the conclusion to the chapter. Chapter two captures the pivotal issues surrounding the review of the literature that informed the study.

Chapter Two: Literature Review

2.1. Introduction

The previous chapter presented the background and rationale for this research study. The focus of this research study is: the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics. In light of this, the literature reviewed in this chapter offers a theoretical overview of studies related to this research focus. The chapter consists of two parts. The first part examines the learning of mathematics from a global perspective (in other countries), as well as mathematics teaching and learning within a South African context. An outline of the Curriculum and Assessment Policy Statements (CAPS) curriculum and a summary of contextualised mathematics learning conclude part one of the literature review.

Part two of the literature review explores the teaching and learning of fractions in mathematics, as well as the impact of the use of visual manipulatives and diagrams, and the use of cooperative learning or group work, on fraction learning. A discussion on the use of technology when learning fractions follows. The chapter concludes with a summary of the implications of the literature review for the study.

2.2. A global perspective of mathematics

Mathematics is a subject that is very important with its widespread usage in our everyday lives. The subject of mathematics is taught in schools with the aim of equipping learners with mathematical knowledge to develop their problem-solving skills, communication skills, as well as critical and systematic thinking skills (Lin & Rosli, 2017). Mathematics is an inherently abstract subject. It is unique in the curriculum, as it is inherently conceptual (Pope & Majorga, 2019). Riley (2017) states that there has been a worldwide decline in interest and achievement in mathematics amongst young people. Schools have the potential to address these concerns through innovative teaching that challenges and complements traditional approaches.

Mathematics, according to Joshi (2017), is a scientific and behavioural discipline which every country has integrated as a compulsory subject in school education. ICT supports mathematics for composing, revising, editing, publishing, calculating, making connections, visualising data, synthesising and problem solving. Varieties of notations, formulae, symbols, 2D and 3D figures, transformation of objects and graphs are available in mathematics which are really difficult to demonstrate on a blackboard/whiteboard. By using ICT- related applications, tools and software such topics can be taught expressively. It is also highly beneficial for learners to be stimulated and involved in learning, to have confidence in their mathematical capabilities. From the above description it can be concluded that ICT supports mathematics teachers in improving their designs of lessons to facilitate successful teaching and learning. Similarly, the part-whole concept was difficult to demonstrate to learners with the limited resources that were available. The use of technology in this research study impacted positively on the learners, who were able to visualise the concepts pertaining to fractions in mathematics.

Furthermore, Pope and Mayorga (2019) indicate that mathematics is concerned with patterns, relationships and structure. By encouraging learners to notice patterns and relationships and drawing learners' attention to inherent structural relationships, they will develop a rich interconnected understanding of mathematics that will provide firm foundations for future learning. Mathematics learning cannot and should not be confined to the classroom. Learners should be encouraged to link their mathematics learning to their daily activities, such as looking out for shapes and patterns on the playground or identifying measurements of mass when eating a chocolate, or notice the volume and capacity of a juice bottle. Linking classroom mathematics to everyday situations such as eating a chocolate or drinking juices and soft drinks, is an innovative way to pique learners' interest in investigating those aspects of mathematics that they usually find challenging. This type of learning appeals to learners who become enthusiastic about the learning exercise.

Across various countries, different levels of mathematics achievement and diverse solutions with different degrees of success are available. Haase and Krinzinger (2019) note that internationally, socio-economic, cultural, linguistic and religious diversity calls for accommodations between the need to implement a minimum curriculum and improve achievement and acknowledge diversity at the same time. This is in line with the theory of diverse influences, which is one of the theories that frame this research study.

2.2.1. Mathematics teaching and learning in other countries

In the United States, Jordan, Rinne and Hansen (2019) indicate that the two crucial areas of mathematics education that have proven to be challenging for learners are: core number competencies in the early grades and fractions in the intermediate grades. Failure to acquire knowledge in these areas may have a long-term impact on mathematical development. Potential difficulties with whole numbers and fractions have been detected. Results from recent intervention studies indicate that these skills can be improved in many learners with or at risk for mathematics learning disabilities. Since this study investigated the perceptions of Grade 5 learners on the learning of fractions, it was relevant to link the study to the issue of the challenges faced by learners when learning fractions in the intermediate grades in the United States. According to Wilkins & Norton (2018), fractions continue to pose a critical challenge for learners and their teachers alike. Mathematics education research indicates that the challenge with fractions may stem from the limitations of part-whole concepts of fractions, which is the central focus of fractions curriculum and instruction in the USA. Learners' development of more sophisticated concepts of fractions, beyond the part-whole concept, lays the groundwork for the later study of important mathematical topics, such as algebra, ratios, and proportions. In a part-whole conception, learners interpret fractions as a comparison of two numbers: the number of equal parts in the whole and the number of parts taken out of the whole to make the fraction. The limitations that arise from such interpretations are many, and can be overcome by using visuals and technology to demonstrate the concept.

Likewise, Gracia-Bafalluy and Puyuelo-San Clemente (2019) describe and discuss the current situation of mathematics education in the countries of southern Mediterranean Europe: France, Greece, Italy, Portugal and Spain. Most of these countries feature decentralised education policies and include regions and school centres with autonomy to describe guidelines, materials and resources. According to Gracia-Bafalluy and Puyuelo-San Clemente (2019), the European Union has established some common guidelines and a guide to mathematics, among other subjects. They allow these countries to share some definitions and common concepts, together with some suggestions for procedures related to identification, assessment and intervention when mathematics difficulties are observed in the classroom.

The developmental situation of Chile and Uruguay in terms of mathematics learning includes difficulties arising as a result of a deficiency in this subject. Statistics for mathematics provided by a number of international studies indicate that both countries present similar levels of performance and are subject to the mediating effects of socio-economic and gender variables. Additionally, Rodríguez, Cuadro and Ruiz (2019) indicate that the segregation factor present in the two countries makes learners with specific learning difficulties more vulnerable, and each country manifests differing levels of development in terms of the presence of education policies that respond effectively to these groups. Chile has subscribed to the new diagnosis and intervention trends of preventive models, however there are still some obstacles to their successful application in the field of school education. Uruguay, in turn, is striving towards a solution to the problem of education and presenting some promising initiatives.

According to Hwang, Utami, Purba and Chen (2019), authentic contexts contain rich resources wherein learners can use authentic objects as aid in advanced educational technology-assisted mathematics learning. The Ubiquitous-Fraction (U-Fraction) is a mobile application that helps students to learn fractions in authentic contexts and that integrates fraction concepts into daily contexts. In Taiwan the learning achievements of learners who used U-Fraction (experimental group) was compared with those of learners who used a web-based tool and the traditional learning mode (control groups). An analysis of the results demonstrated that the experimental group significantly outperformed the control groups in terms of learning achievements. In terms of learning behaviours, fraction concept/comparison learning and fraction addition/subtraction learning were most significantly correlated with learning achievement. It indicated that fractions can be learned better in an authentic environment. Furthermore, it was found that participants had positive perceptions toward U-Fraction and that they enjoyed using the technological feature to solve fraction problems in their surroundings.

Ramaa (2019) maintains that there are many key factors that influence school education in the Indian context. India is unique with respect to its geographical, cultural and linguistic diversity. Despite these variations there is a common framework at the national level for education from school Grades 1 to 12. There have been initiatives taken in the post-independence period in India for improving the quality of education in general and the education of learners with special needs in particular. Scarcity in the numbers of professionals and teachers who have expertise in the field is another important factor. Some important initiatives have been taken to conduct research in the area of teaching and learning difficulties. In an effort to improve the mathematics results in the Indian context, Rao and Saha (2019) observe that blended learning, which combines computer-assisted learning with traditional classroom learning, is one of the leading trends in education. Literature shows that blended learning often helps the learners to achieve better learning outcomes. *RemedialTutor* is a computer-assisted learning platform that focuses on the performance improvement of learners who have difficulty in understanding mathematical problems. This learning platform performs several tasks on demand; for example, providing the meaning of unknown words, sentence simplification, identification of questionable sentences, extraction of summarised content on a specific topic, preparation of question papers and automatic evaluation, identification of less confident sections, etc. The system is provided to the learners as a supplement to the traditional classroom activities and resources. During a comparative study, it was found that the group who used this system during their examination preparation performed better than the group of learners who relied only on their regular resources. This research study was conducted at a school in South Africa, where the education system is similar to that of India. The Department of Basic Education is responsible for drawing up a national curriculum, which is implemented at all schools in the country. Cultural and linguistic diversity form an integral part of schools in South Africa, including the school where this study was conducted.

Researchers da Silva, Noguiera, Rizzo and Silveira (2019) indicate that in Brazil the mean level of proficiency in mathematics, presented by learners aged between 9 and 12 years, is low. This situation is more serious when it comes to learning some topics that are not common in their daily activities, like rational numbers in their fractional representation. FracPotion is a 2D educational game that was created for elementary school learners. It is expected to evaluate whether students find the game funny and whether they can better identify, practice and understand educational content about fractions. Fractions tend to represent an extremely abstract concept, mainly when local culture does not make regular use of this kind of representation in common situations – which is the case for Brazilian culture, which have adopted the floating point decimal representation in detriment of the fractional one. Tools that help to stimulate learners to keep the motivational aspect when learning such subjects are potentially useful to these processes. Regarding the group to which this game was applied, the players/learners showed interest in the game's subject and they reported to have enjoyed the learning process supported by the game, indicating that the preliminary results were positive.

2.2.2. Mathematics teaching and learning in South Africa

Shortly after the fall of apartheid in 1994, the South African Schools Act (SASA) of 1996 was enacted to dismantle all inequities of the apartheid educational system. The SASA was intended to create an identical and democratic educational system that was in no way racist, sexist, or biased against any particular group because society viewed them as inferior. The educational reforms enacted post-apartheid were theoretically designed to desegregate schools and allow equal education for all. Equal funding for education was also a large portion of the implementation of these reforms (Waller & Kori, 2017).

Furthermore, mathematics education in South Africa is monitored and measured by the Trends in International Mathematics and Science Study (TIMSS), which is a four-year study conducted by the International Association for the Evaluation of Educational Achievement (IEA). The objective of TIMSS is to measure the quality of mathematics and science education on an international scale. TIMSS is one of the most established studies of educational quality worldwide, providing information on learners, their schools and home environments; and how these relate to mathematics and science achievement. In South Africa, the HSRC conducts the TIMSS research in collaboration with the Department of Basic Education and the IEA. TIMSS has an attachment to curriculum content therefore the results of TIMSS serve as crucial information for the participating countries to develop strategies and attempts to improve the quality of mathematics and science learning (Wijaya, 2017).

The mathematics achievement of South African learners ranked among the lowest in several international comparative assessments, for example, in the TIMSS 2002, TIMSS 2011 as well as the World Economic Forum (WEF) 2014. The TIMSS 2015 found that the average mathematics score of South African learners was 376 out of a possible 1 000 (Martin, Mullis, & Hooper, 2016). Out of the 48 countries which participated in TIMSS 2015 South Africa ranked second last, only outperforming Kuwait (Mullis et al., 2016). Furthermore, only 1% of

South African Grade 5 learners performed at the advanced international benchmark level (achieving above 625) and only 4% at the high international benchmark level (achieving 550 to 625) (Reddy et al., 2016). In addition to this, Wijaya (2017) notes that of the 13 test items in TIMSS 2015, eight items addressed basic concepts of fractions and five items were about operations of fractions.

According to data from the TIMSS 2015, which was conducted by the International association for the Evaluation of Educational Achievement (IEA), 48 countries participated in the TIMSS at the Grade 4 or 5 levels, including South Africa. From the population of 15 783 South African schools that offered Grade 5 classes in 2013, the IEA selected a stratified random sample of 300 schools, of which 297 schools participated in the TIMSS 2015. The sample was stratified by province, type of school (public or independent) and language of instruction (Afrikaans, English or dual medium). A random selection process of intact classes (as opposed to the selection of individual learners) was applied for each sampled school. A sample of 10 932 Grade 5 learners from South Africa participated in the TIMSS 2015 (Visser, Juan & Hannan, 2019).

Moreover, according to the Minister of Basic Education (2019), South Africa was one of 48 countries which took part in the Organisation for Economic Co-operation and Development (OECD) Teaching and Learning International Survey (TALIS), recently. It was the first time South Africa participated, and involved 2046 teachers and 169 school principals. The survey found that in South Africa:

- Principals reported "significant material resource shortages" hindering teaching such as library materials (70%) and technology (65%).
- One out of three principals (34%) report that acts of intimidation or bullying among their learners occur at least weekly in their schools, which is more than double the OECD average (14%).
- One out of four principals report weekly incidents relative to the use or possession of drugs and/or alcohol at school (South Africa – 27%; OECD average – 1%).
- Vandalism and theft (South Africa – 21%; OECD average – 3%).
- Pupils had diverse linguistic backgrounds with six out of 10 teachers working in schools where more than 10% of learners were not being educated in their mother

tongue (Motshekga, as cited in Gous, 2019, p 4).

The OECD's Le Donne (2019) reports that it's a signal that SA probably ranks among the poorest countries, but it can also be the case that there is high social segregation with these learners concentrated in some of the schools. But still 70% of teachers work in schools with at least 30% of learners who qualify as relatively poor.

Waller and Kori (2017) maintain that South Africa's struggling mathematics programme can be attributed to the lack of adequate teacher preparation and the previous racial separation that put entire generations of learners at a disadvantage. While South Africa has mathematics and mathematics literacy requirements, learners are only required to complete through to a ninth-grade education, ultimately creating a very high dropout rate in Grade 10. Curriculum reform and programmes to impact mathematics teaching and learning have been established to assist with the transformation of the state of mathematics education.

The Minister of Basic Education in South Africa (2019) declared that the present formal teaching and learning curriculum being implemented in South African schools reflects the culmination of efforts over a period of 25 years to transform the curriculum bestowed on South African formal education by apartheid. From the start of democracy in 1992, South Africa has built the current curriculum on the values that inspired the Constitution (Act 108 of 1996). The current (2019) curriculum being implemented at schools in South Africa is known as CAPS.

2.2.2.1. The South African Curriculum and Assessment Policy Statements

The Minister of Basic Education in South Africa introduced the new curriculum by stating that an important development in the post-apartheid era was a departure from apartheid education through an outcomes-based curriculum reform. Curriculum 2005 was launched in 1997, and it was the government's flagship education plan, which it promised to implement from Grades 1 to 12 by the year 2005. According to Motshekga (as cited in CAPS 2011), this curriculum was developed to overhaul completely the apartheid education system, and to rid South Africa of its legacy. It marked a dramatic shift from content-based teaching and learning to a learner-centred, outcomes-based approach. The key principles on which Curriculum 2005 was based are: integration, holistic development, relevance, participation and ownership, accountability and transparency, learner-orientation, flexibility, critical thinking, progression, an anti-biased approach, inclusion of learners with special educational needs, quality standards, and international comparability (National Department of Education, 1997). Outcome Based Education (OBE), introduced as part of Curriculum 2005, therefore represented the first substantive, sharp break with apartheid education (Vithal & Volmink, 2005). Through an outcomes-based approach, the government wanted learners to move away from rote learning, where learners simply memorise what they have been taught, to a system that teaches them to think critically (Khuzwayo & Mncube, 2017).

One of the aims of the South African Constitution is to establish a society based on democratic values, social justice and fundamental human rights. Education and the curriculum have an important role to play in realising these aims. However, Motshekga (as cited in CAPS 2011) noted that the experience of implementing OBE as a part of Curriculum 2005 prompted a review in 2000. The OBE system was difficult for teachers to comprehend, mainly due to abstract terminology and poor and inadequate training by the Department of Education. Many schools struggled to implement OBE, which had 67 Specific Outcomes across eight Learning Areas, all of which were meant to be incorporated into Learning Programmes.

This led to the first curriculum revision: the Revised National Curriculum Statement (RNCS) Grades R-9 and the National Curriculum Statement (NCS) Grades 10-12 (2002). Ongoing implementation challenges resulted in another review in 2009 and the RNCS (2002) and the NCS (Grades 10-12), were revised to establish CAPS. From 2012 the two National Curriculum Statements, for Grades R-9 and Grades 10-12 respectively, are combined in a single document and is simply known as the NCS Grades R-12. The NCS for Grades R-12 builds on the previous curriculum but also updates it and aims to provide clearer specification of what is to be taught and learnt on a term-by-term basis. The NCS Grades R-12 represents a policy statement for learning and teaching in South African schools and comprises the following:

- CAPS for all approved subjects.
- National policy pertaining to the programme and promotion requirements of the NCS Grades R-12.

- National Protocol for Assessment Grades R-12 (Motshekga, 2011, p. 3).

CAPS is a single, comprehensive and concise policy document that has replaced the former Learning Area Statements, Learning Programme guidelines and Subject Assessment guidelines for all subjects listed in the NCS from Grades R to 12 (Department of Basic Education, 2011). CAPS, an amendment to the NCS, is currently being implemented at public schools from Grades R to 12, so that the curriculum is more accessible to learners. With the introduction of CAPS, every subject in each grade has a comprehensive and concise policy document that provides details on what educators need to teach and assess on a grade-by-grade and subject-by-subject basis. This curriculum review aims to lessen the administrative load on educators and ensure they have clear guidance and consistency when they are teaching. CAPS builds on the previous (NCS) curriculum by providing clearer specifications on what is to be taught and learnt in each grade on a term-by-term basis in all schools. It describes the number of subjects to be offered to learners in each grade and the promotion requirements to be obtained (Motshegka, as cited in CAPS 2011, pps. 3-4).

The CAPS curriculum prescribes various topics and the content areas to be covered in each grade, with time allocated specifics together with the weighting of the content areas in each phase, outcomes and relevant assessment examples. Mathematics is taught at foundation (Grade 1–3), intermediate (Grade 4–6), senior (Grade 7–9) and further education and training (Grade 10–12) phases. Although teachers were free to teach the previous curricula as they saw fit, CAPS is prescriptive and demands uniformity in implementation across the country (Jojo, 2019).

This curriculum aims to ensure that learners acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives, (Motshegka, as cited in CAPS 2011, p. 4).

However, Govender and Hugo (2018) argue that numerous transitions in South Africa's basic education curriculum development have been criticised for failing to meet stakeholders' expectations. Questions have arisen as to whether the latest CAPS curriculum is functioning effectively in classrooms and whether it will improve the quality of education and transform the country's schools.

2.2.2.2. Contextualised mathematics learning

Classrooms represent an integration of the social into the learning process, as well as, a globally extensive institutionalised site for the promotion of learning. In the context of classroom learning, multiple participants are involved each with different levels and kinds of knowledge and experience (Chan, Clarke & Cao, 2018). Inclusive education is an education service system that includes learners with special needs to learn together with their peers in the regular school (Ikhwanudin & Suryadi, 2018).

Conventional classrooms in South Africa are characterised by being inclusive, catering for a range of learning challenges (DoE, 2001). These classrooms are mostly overcrowded, regarded as being competitive, and often academically benefit only learners who can work independently, take responsibility for their own progress and set clear achievement goals (Spangenberg, 2017). The TIMSS report for the 2015 study, led Reddy et al. (2016) to argue that education and learning are shaped by home, school and community environments with all of these exerting influences of different strengths and different directions. Some learner factors that seemed to influence the TIMSS scores obtained were confidence in mathematics, gender, experience of bullying, frequency of absence from school, education levels of parents and home resources. School factors such as school location, school safety, and amount of importance placed on achievement were also identified as factors of influence on the mathematics results (Umugiraneza, Bansilal & North, 2017).

Ikhwanudin and Suryadi (2018) maintain that the spirit of implementing inclusive education is to provide the widest possible opportunity or access to all learners in order to obtain a good quality of education and to meet their individual needs without discrimination. Schools that implement inclusive education systems have the opportunity to receive all learners with their specific needs. Especially for learning mathematics, inclusive schools will likely receive two types of learners, i.e. those who have difficulty in learning mathematics, and those who don't.

Mathematics performance at school level in South Africa is poor, which could be a result of learners with different learning challenges being accommodated in the same classroom (Spangenberg, 2017). The underperformance, according to Jojo (2019), is visible mostly in the public sector schools that form about 80% of schooling in the country. South Africa's mathematics educational outcomes can be associated with the aggravation of the excess supply of unskilled labour and worsening income inequality in the country. The public sector schools in South Africa are divided into those where learners are expected to pay school fees and those where learners do not pay any. Table 1 depicts the differences in learner performance in mathematics between public schools and independent schools in South Africa for the years 2011 and 2015.

Table 1: Performance by South African school type - TIMSS 2011 and 2015 (with a centre point of 500) adapted from Reddy et al. (2016, p. 7)

Type of School	**TIMSS 2011**	**TIMSS 2015**
Public non fee paying schools	324	341
Public fee paying schools	397	423
Independent schools	474	477

Naude and Meier (2019) propose that since mathematics is an area of education that causes the greatest concern for the South African education community, government focus should be on elements in the physical learning environment that influence the quality of education in the early years of schooling, which should be addressed urgently. With South African learners achieving low rankings in mathematics and science, according to the National Centre for Education Statistics and TIMSS SA (2015), the necessary question is whether there are avenues that still need to be explored in order to improve the poor mathematical performance of the country's primary school learners. As the results from the TIMSS and TIMSS SA (2015) indicate, the problems with the learning and teaching of mathematics in South Africa start in the early years of schooling and this is likely to have a snowball effect that culminates at the end of learners' schooling careers.

The Quality Improvement, Development, Support and Upliftment Programme (Department of Basic Education, Republic of South Africa, 2008) states that a major determinant for underachievement at the majority of schools in South Africa is a lack of the most basic resources (for example, textbooks and other educational equipment), which are essential for the creation of a quality learning environment. The lack of a proper physical learning environment still seems to be an unresolved and critical issue in South African schools.

Robertson and Graven (2019) illuminate the challenges that are confronting teachers and learners at the literacy/numeracy interface. Learners who have not developed sufficient English language proficiency to be learning mathematics through English are being taught in English, because of socio-politically and economically driven perceptions. Poor academic achievement and incomplete understanding are some of the consequences that stem from learners' diminished access to their home language.

Similarly, Juan and Visser (2017) also claim that determinants of educational achievement extend beyond the school environment to include the home environment. Both environments provide tangible and intangible resources to learners that can influence mathematics achievement. South Africa provides a context where inequalities in socio-economic status are vast, thus the environments vary from where learners draw resources vary. Findings reveal that both the school and home environments play important roles in learners' achievement, with the strongest associations exhibited with: speaking the language of the test at home.

Another contextual factor that impacts on mathematics learning is that learners are more willing to interact with mathematics activities if they feel their teachers assist them emotionally, and motivate them to communicate their experiences with the content, while their peers support them academically. Furthermore, it was established that learners' perceptions of their classroom social environment and teacher-learner relationships were intertwined with their motivation and engagement (Spangenberg, 2017). The changes in their learning as an output are the result of their personal characteristics as well as their particular ways of interacting with each other as part of their different existing relationships and associations inside and outside of the classroom (Chan et al., 2018).

The Department of Education (2001) believes that as an emerging economy, South Africa may potentially generate effective solutions for global behavioural challenges. South Africa envisages a growing inclusive economy being given voice in a single, democratic educational system. The DoE is devoted to provide all learners, despite their learning challenges, access to the same quality of learning and teaching, equal educational opportunities and improved quality of life. However, despite policies, such as White Paper 6 on Inclusive Education (DoE, 2001), to address responsibilities towards learners with learning challenges, a review of the strategic plans of the provincial departments of the DoE discloses inadequate provision to assist learners with learning challenges (Department of Social Development (DSD), Department of Women, Learners & People with Disabilities (DWCPD) & UNICEF, 2012). Besides South Africa's historical legacy of apartheid, there is still inadequate access of services to learners with learning challenges in most ordinary public schools, and these schools are not well-resourced to assist learners with learning difficulties (Spangenberg, 2017).

Umugiraneza et al. (2017) claim that a positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject and, in a similar way, a negative attitude towards mathematics relates to a negative emotional disposition. These emotional dispositions have an impact on an individual's behaviour, as one is likely to achieve better in a subject that one enjoys, has confidence in or finds useful. The results in the South African part of the TIMSS study illustrated that a positive attitude and achievement were related, as those learners who reported that they were confident about mathematics scored on average 89 points higher than those who were not confident (Reddy et al., 2016).

2.3. Teaching and learning fractions in mathematics

In addition to the mathematical knowledge and skills needed in the 21st century, mathematics education and performance in the subject determines access to jobs and further or higher education studies in a range of areas, from the natural and physical sciences to economics and technology. Thus, mathematics is regarded as a gateway subject, a requirement for admission to learning a large number of these high-status, high-paying professions (Jojo, 2019).

Mathematics is often considered to be the most difficult subject, boring and unrelated to everyday life (Amalia, Saiman, Sofiyan & Mursalin, 2018). The concept of fractions is one of the aspects of mathematics that many learners find to be difficult. Furthermore, Fennell and Karp (2017) reiterate that proficiency with fractions serves as a prerequisite for learner success in higher level mathematics, as well as serving as a gateway to many occupations and varied contexts beyond the mathematics classroom. Fractional concept is not a simple concept. The uniqueness of fractions, different from the original and integer numbers, sometimes makes it difficult for learners to understand, and makes it difficult to introduce to learners (Kurniawan, Sutawidjaja, As'ari & Muksar, 2018).

It is widely assumed that fractions were invented to aid accurate measurement in cases where the commonly used standard unit of measurement could not provide an exact description of a quantity (DBE, 2019). Mathematically, the fraction concept is very important to the understanding of decimals, because the place value parts after the decimal comma are fractions for example, the expanded notation for the number 23, 47 is 20 + 3 + 4/10 + 7/100. Simon, Placa, Avitzur and Kara (2018) indicate that promoting a deep understanding of fraction concepts continues to be a challenge for mathematics education. Research has demonstrated that learners whose concept of fractions is limited to part-whole have difficulty with advanced fraction concepts. To assist in overcoming these challenges, researchers have developed some effective learning strategies to improve learners' understanding of fractions. Recent research on interventions to support learners in their learning of fractions, report that they have been successful in promoting learners' understanding of fractions using mnemonic devices for teaching addition and subtraction of fractions, manipulatives with pictures to solve problems involving fractions and cue cards (Amalia et al., 2018).

Fraction sense is developed through instructional opportunities involving fraction equivalence and magnitude, comparing and ordering fractions, using fraction benchmarks, and computational estimation. Such foundations are then extended to operations involving fractions and decimals and applications involving proportional reasoning (Fennell & Karp, 2017). The complexity of the characteristics and the understanding of the concept of fractions cannot be understood in a relatively short time. Understanding the concept of fractions starts with the use of real objects to obtain something abstract, thereafter there are manipulatives, representations and fragments of the real or concrete object. Finally, the concept is represented as a symbol or mathematical notation (Kurniawan et al., 2018).

A study conducted by Soylu and Soylu (2005) shows that fifth-graders have misconceptions about the ordering, addition, subtraction and multiplication in fractions. At the end of the study, it was determined that especially when the learners were collecting and multiplying with fractions, they operate the fractions by considering the numerator and denominator separately and applied the previously learned rules to the subsequent rules. In their study, Haser and Ubuz (2002) found that fifth-grade learners ignored the rule of separating objects into equal parts in the case of fraction definitions and indication, and for multiplication, addition and subtraction operations in fractions they maintains the operational habits that they had acquired in natural numbers. Likewise, in Stafylidou and Vosniadou's (2004) study, 37.5% of the fifth-graders considered fractions as two independent natural numbers (Aksoy & Yazlik, 2017).

Peltier and Vannest (2018) note that the concept of fractions and specifically comparing fractions with like numerators or denominators poses challenges for learners. Teachers emphasise multiple representations (e.g. fraction cubes, fraction circles, fraction bars, number lines) of the concepts. Learners are able to solve problems when working with manipulatives but struggle to solve problems in the abstract.

The CAPS curriculum aims to simplify the teaching and learning of fractions by stipulating that the initial focus on fractions should deal with understanding the concept of a fraction. Once learners have consolidated this they can move on to working with equivalence, then comparing and then calculating fractions.

2.3.1. The use of visual manipulatives and diagrams in mathematics

Mathematical understanding centres on learners first having concrete, practical experiences before it becomes an abstract subject in which they need an understanding of symbols and how they are connected (Borthwick, 2019). Pope and Mayorga (2019) concur with this by stating that mathematical understanding is best developed through rich practical experience. This includes using manipulatives and models to support learners' mathematical understanding, or drawing pictures to support their mental work. These can help learners to clarify their thinking, develop their reasoning and articulate their approach to learning. It is important for learners to use concrete materials to understand mathematics rather than just acquire it without understanding.

Manipulatives (also referred to as representations or mathematical models), are key mathematical resources needed to support the teaching and learning of mathematics. They are physical constructs that can be used to embody, illustrate and demonstrate some of the most important mathematical ideas. Researchers have highlighted the importance of using representations or manipulatives to support the learning of mathematics. Manipulatives demonstrate the move from physical representations of mathematics to using mental images and finally to more abstract mathematics (Borthwick, 2019). This research study incorporated the use of visual manipulatives in the form of diagrams and paper folding to assist learners in solving problems related to fractions in mathematics.

Furthermore, Willingham (2017) asserts that young learners think more concretely than older learners or adults. Learners depend on physically interacting with the world to make sense of it, and their capability to think abstractly is absent or, at best, present only in a crude form. In the concrete operational stage (from about age seven to 12), the learner uses concrete objects to support logical reasoning. The learners in this study were all between 11 and 12 years of age, thus placing them within the concrete operational stage of development. The technological intervention and visuals had a positive impact on their understanding and learning of fractions.

Similarly, Shin and Bryant (2016) observe that many learners demonstrate difficulty in developing a conceptual understanding of mathematical topics. Therefore, researchers recommend using visual models to support learners' learning the concepts and skills necessary to complete abstract and symbolic mathematical problems.

To make complex mathematics concepts accessible to learners, Rau & Matthews (2017) posit that teachers often rely on visual representations. Because no single representation can depict all aspects of a mathematics concept, instruction typically uses multiple representations. Much research shows that multiple representations can have immense benefits for learners' learning. Using fractions as an illustrative domain, this study discusses how the choice of visual representation may affect learner learning based on the conceptual aspects of the to-be-learned content emphasised by the representation.

Revina and Leung (2018) noted that both Indonesian and Dutch curricula emphasise the use of models in learning mathematics. These may include concrete objects, manipulatives, models, schematisation and tools. In the curricula, learners are expected to understand mathematical notation, symbols, tables, diagrams, and use media or tools to support evidence in problem solving, or in developing the mathematical language.

This research study was conducted among Grade 5 learners at a school in the province of KwaZulu-Natal in South Africa. The study explored the perceptions of learners on the use of technology when learning fractions, therefore the learning content being taught had to adhere to the guidelines of the CAPS curriculum. In this regard, the CAPS curriculum for Grade 5 is clear: "Learners are not expected to be able to give equivalent fractions in symbolic (number) form without having diagrams to which they can refer. It is recommended that fraction strips or fraction walls are provided when learners are formally assessed. Calculations as with other aspects of fractions should be developed either through problem contexts or with the use of apparatus or diagrams. If learners have worked with drawings, fraction sums can be done without learning a rule or method. E.g. what is ¼ of 24? Learners can simply draw 24 objects and then make 4 equal groups" (CAPS, 2012. p. 176). During this study learners were engaged in solving fraction problems in two task-based worksheets, and on both occasions they employed the use of manipulatives to arrive at the solutions to the questions.

2.3.1.1. Visual manipulatives and the learning of fractions

Manipulative materials are used to create an external representation that stands for a mathematical idea in order to eventually develop an internal representation (Day & Hurrell, 2017). Furthermore, and crucial to this research study, the theory that learners are concrete thinkers, and physical movement is central to thought, seem to predict that manipulatives will always lead to better understanding (Willingham, 2017).

Ulusoy and Incikabi (2019) observe that developing learners' abilities in using and selecting appropriate representations and making transformations between representations is an important issue in mathematics education. Among the mathematical concepts, fractions have always reported as a challenging issue for learners in the middle schools for a long time. Researchers have suggested the use of different representations in learning and teaching of fractions in order to enhance learners' conceptual understandings of fractions, since it is important to understand the effects of multiple representation-based environments in mathematics classrooms. Hence, researchers who seek and design alternative pedagogical instructions can be more aware of what kind of learning occurred in representation transformation processes.

Furthermore, Kwon and Capraro (2018) argue that using manipulatives when teaching is a constructivist educational approach. It is recommended to use manipulatives as teaching tools to teach mathematical concepts at every grade level. They further reiterate that concrete manipulatives, such as dried beans, pattern blocks, cubes, fraction strips and counters can be used in elementary mathematics classrooms.

2.3.1.2. Diagrams and the learning of fractions

According to the CAPS document for intermediate phase mathematics in South Africa, learners should develop the concept of fractions in a variety of ways. Learners should also work with apparatus and diagrams. As per the CAPS document for mathematics in the intermediate phase, different diagrams or apparatus develop different ways of thinking. Region or area models develop the concept of fractions as part of a whole. Examples of area models include circles cut into fraction pieces, rectangles or other geometric shapes divided into fraction pieces (paper folding), fractions using grid paper and geoboards. Length or measurement models can be used to develop the concept of fractions as part of a whole and if used in particular ways, they can also be used to develop fractions as a measure. Examples of length models include fraction strips, Cuisenaire rods and number lines. Set models develop the concept of fraction of a collection of objects (and can lay the basis for thinking about a fraction of a whole number (e.g. ½ of 12). Examples of set models include counters of any kind in different arrangements. Learners should not only work with one kind of model, because this can limit their understanding of fractions. Fractions in diagrams should include area models, length models and set models (DBE CAPS mathematics – intermediate phase, p. 160). Figure 1 shows the fraction three-quarters represented as a set model, as an area model and as a length or measurement model.

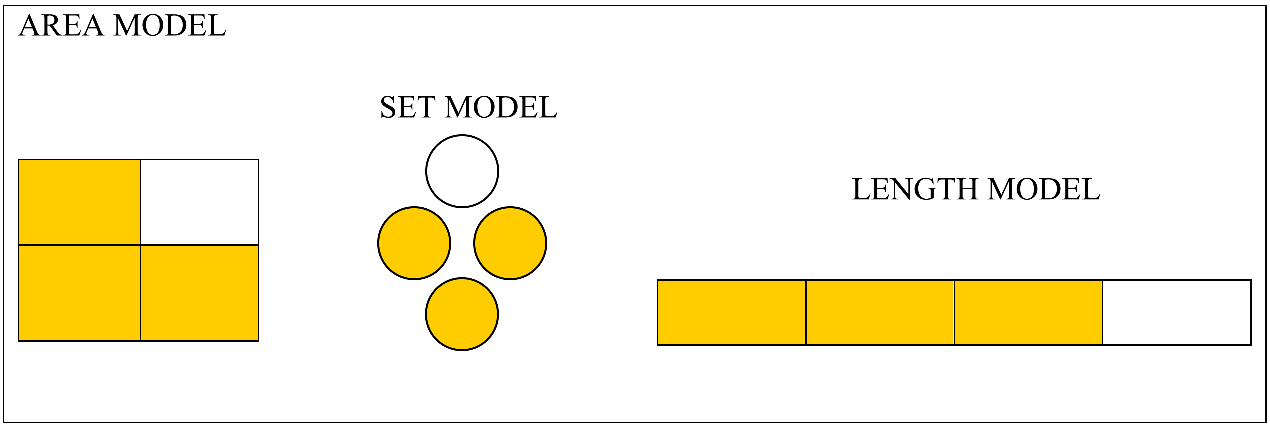


Figure 1. ¾ represented as an area model, set model and length model (Researcher's own construction)

Willingham (2017) claims that the utilisation of concrete materials enables the teacher and learners to break away from the traditional classroom setting and instructional style. It also allows the learners an effective way in which to represent their thinking in a manner which the teacher can then explore further. It enables the teacher to determine if there are any misconceptions in the learner's understanding of fractions. In addition to enhancing learners' abstract thinking ability, learners' use of manipulatives can also increase their level of interest and motivation, which is a critical factor influencing learners' success in mathematics. Therefore, learners' interest and motivation can grow if they perceive learning as enjoyable, important and stimulating (Kwon & Capraro, 2018).

The concept of fractions and specifically comparing fractions with like numerators or denominators poses challenges for learners. Teachers emphasise multiple representations (e.g. fraction cubes, fraction circles, fraction bars, number lines) of the concepts. Learners are able to solve problems when working with manipulatives but struggle to solve problems in the abstract (Peltier & Vannest, 2018).

Along similar lines, this research study involved the use of multiple representations in the task-based worksheets to assist learners in finding solutions to the given questions. One example of the drawings used in the task-based worksheets is the diagram in Figure 2.

<table>
<tr><td colspan="8">1 WHOLE</td></tr>
<tr><td colspan="4">½</td><td colspan="4">½</td></tr>
<tr><td colspan="2">¼</td><td colspan="2">¼</td><td colspan="2">¼</td><td colspan="2">¼</td></tr>
<tr><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td></tr>
</table>

Figure 2. Fraction diagram extracted from task-based worksheet
(Researcher's own construction)

2.3.2. Fractions and cooperative learning

According to the definition of Van Ryzin, Roseth and Biglan (2020) cooperative learning is a small-group instructional technique that establishes positive interdependence among students Cooperative learning is one of the few empirically supported instructional approaches that specifies the establishment of positive interdependence in small-group learning activities. Cooperative learning is an umbrella term that includes reciprocal teaching, peer tutoring, jigsaw, and other group-based activities in which teachers establish positive interdependence in small learning groups of two to four students. Chan and Idris (2017) elaborate that cooperative learning is a teaching strategy that encourages learners to assist each other in a small group to achieve a common goal. Through cooperative learning methods, each learner in the group is responsible for sharing opinions and working together to solve the mathematical problem.

Kovecses-Gosi (2018) emphasises that openness towards cooperation, the knowledge, the routines, the skills, the competences, the abilities needed for teamwork, and the attitudes needed for these are basic criteria in the workplace of the 21st century. Group work is an educational mode that promotes learning and socialisation among learners. Learners' active participation in the discussions around the group work structures and analytical discussions, together with the teacher's more defined feedback and avoidance of the traditional authoritative role, are examples of prerequisites for group work to be enacted in an inclusive manner (Frykedal & Chiriac, 2018).

In a similar vein Baloche and Brody (2017) indicate that in countries throughout the world, cooperative learning has earned its place as a respected pedagogy, one that has the potential to effect positively learner achievement, motivation for learning, intergroup relations, critical and creative thinking and problem-solving, and a host of other well-researched outcomes.

The question may arise how we should prepare the growing generation for cooperation if it is not emphasised enough in the school. Learners cannot work on the realisation of common problems and innovations as adults; nor can they be tolerant and acceptable with others if during learning in the school they do not meet such methods and strategies which improve those basic skills, abilities and competences (Kovecses-Gosi, 2018). It is therefore imperative that teachers embrace the idea of incorporating group work into the mathematics curriculum, so as to prepare learners for the challenges that they may encounter in the real world.

Skosana and Monyai (2013) emphasise that the South African government is aware that effective teaching can only take place in a supportive physical learning environment that provides learners with quality learning opportunities. One of the aims of this approach is to encourage interactive participation, collaboration by learners through communication and sharing of ideas, specifically in mathematics (Naude & Meier, 2019).

It is the view of Dugas (2017) that by teaching learners about social and emotional roles, and about positive and negative roles, cooperative learning provides avenues for talking about learning difficulties in a constructive way. It also gives all learners new ways to shine in class by helping them discover their unique roles that can contribute positively to the whole classroom group. By the same token Chan and Idris (2017) draw attention to the fact that as a learning process, cooperative learning requires learners to work and learn together. They are expected to be responsible not only towards their own learning, but also towards the learning of their friends. The practice of cooperative learning gives acknowledgements or rewards to make sure the learners have fun learning. In addition, cooperative learning motivates learners.

2.3.3. The use of technology in the classroom

To keep pace with the Fourth Industrial Revolution, which has integrated physical, digital and biological spheres in all aspects of life (World Economic Forum, 2016) it is necessary to nurture the next generation to become creative problem-solvers in the digital era. Every country/region requires creative problem-solvers who can contribute to every aspect of life in the digitalised world. Technology is a way to cultivate creativity and problem-solving skills in young people (Kong, 2019).

2.3.3.1. The use of technology globally

Svela, Nouri, Viberg and Zhang (2019) argue that the mobile learning body of knowledge is extensive and much is known about the technology impacts and affordances of mobile devices in educational settings. A particular focus has now shifted toward specific technologies in specific subjects. Mathematics is one such subject and tablets are one such technology that is gaining attention. The results from various academic technology and educational databases demonstrate that tablets are being predominantly deployed in various sub-disciplines such as Arithmetic, Computation, and Geometry. Pedagogical approaches lean heavily on game-based learning, environment interaction, and special needs support. Technological advantages include increased collaboration and mathematics engagement enabled by tablet mobility and a high potential for customisation of solutions. Developers, teachers, and researchers need to be informed of the successful use of technology deployments in mathematics.

Early adopters of technology in education started with computer rooms, and the overhead projector was quickly phased out by data projectors, interactive white boards and television sets. This certainly changed how we presented content and information to learners, but it is only in the last few years that technology access for every learner is becoming a norm (Canavan, 2018). Rasanen, Laurillard, Kaser and von Aster (2019) note that in developed countries learners and teachers have access to hundreds of thousands of learning applications and games. However, the digital divide is significant: some parts of the world still lack the basic requirements for participation in the digital revolution, such as electricity. Similarly Amalia et al. (2018) view teachers as learning agents who need to master and apply ICT in the learning of mathematics at school. Viewed as an integrated part of learning tools, technology can broaden the scope of course material that learners can learn and can expand their knowledge.

Learners with mathematics learning disabilities have a weak understanding of fraction concepts and skills, which are the foundations of algebra. Shin and Bryant (2016) point out that such learners might benefit from computer-assisted instruction that utilises evidence-based instructional components (cognitive strategies, feedback, virtual manipulatives). The implementation of technology in teaching fractions can help teachers to assess online materials, interactive media, software, games and so on (Amalia et al., 2018). The use of technology-based tools in the teaching and learning of fractions in this study illuminated a strategy that allowed learners to obtain clarity on the concepts associated with fractions.

Wassie and Zergaw (2019) maintain that nowadays, technology is influencing learners' learning style preference from the very beginning of their schooling. Learners prefer to see, to touch, and to comprehend what they learn. Scholars have also deduced that technological literacy is an essential skill of teaching with the power to motivate and create opportunities for learners to comprehend, construct and explore new approaches to problem-solving. GeoGebra is an interactive mathematics software created by Markus Hohenwarter in 2002 for teaching mathematics. From then on, GeoGebra has been developed by international communities in supporting the teaching and learning of simple to advanced courses in mathematics and related disciplines. The fluency of learners in using technology is an opportunity for educational institutions to bring technology integrated lessons into practice. Thus far, GeoGebra has been found to be a crucial tool in the teaching-learning of mathematics at secondary and tertiary education institutions. In the modern era where technology usage is a tradition of the generation, integrating the teaching and learning with mediums that could catch up and satisfy learners' interest is noteworthy. In line with this, the contributions of GeoGebra in the teaching and learning of mathematics is a tool that fosters learner interest and achievement in an environment where different learning styles are explored.

Furthermore, Akogwu, Abugu, Okeke and Umakalu (2019) elaborate that teaching and learning of mathematics should not be focused on purely theoretical approaches, but also a variety of learning approaches that involve the use of teaching aids confirmed to help stimulate learners' interest in Mathematics. By integrating dynamic mathematics software, like GeoGebra, teachers can be able to make graphical representations of mathematics concepts. As the concepts are introduced with pictorial representations, teachers and their students are able to make the connections between the pictures, the concepts, and the symbolic representation.

Learning with the aid of technology has proven to be an advantage for learners who have used the effective mathematics software called Hawgent. Wijaya, Ying and Purnama (2020) assert that teaching and learning under the influence of ICT has become an upsurge in the international education of research and practice. Due to this, there is a wide application of information technology that has a profound impact on mathematics education. Based on the multiple representations of mathematics, the effectiveness of Hawgent dynamic mathematics software was tested against traditional teaching methods on a sample of primary school learners in Bandung. The result of this study concludes that the understanding ability of those learners whose learning is supported by Hawgent are superior to those who are using the traditional teaching methods.

Along similar lines, Rasanen et al. (2019) stress that even though there is still a debate about the effectiveness of using educational technologies and the results have been inconclusive, the use of technology-enhanced learning in education is increasing inevitably as the technologies get cheaper. At the same time, the rise in controlled intervention studies of technology to support learners and adults with learning difficulties is offering new possibilities to understand the mechanisms of learning mathematics.

Teacher-designed learning in each mathematics topic will have an effect on learners' mastery of mathematical concepts. Therefore, teachers must prepare appropriate learning tools. One means to increase learner activity during learning is by using task-based activity worksheets. In keeping with the views of Amalia et al. (2018) that teacher-made task-based worksheets should be integrated with ICT, this study included the use of two task-based worksheets together with the use of technology in an endeavour to analyse the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics. Teachers must be able to design mathematical tasks using an attractive, varied display of images, stimulating curiosity and understanding of the material.

2.3.3.2. The use of technology within South African classrooms

Research by Vencie and Dhliwayo (2018) suggests that technology has become the by-word in education. In fact, it has permeated all facets of life to the extent that ignoring it in the classroom may result in products that are not fit for the global village. Most countries in Africa and globally, acknowledge that they cannot provide a 1:1 learner computer ratio. African countries have poverty and inconsistent internet as challenges in integration in education. Increased advancement towards technology integrated learning in their education systems may be speeded up by incorporating advanced computer hardware and connectivity.

Poor learner achievement in mathematics has been a great concern for the Department of Basic Education (DBE) in South Africa. The outcome of South African learners' participation in TIMSS is that a scientifically rigorous trend methodology shows that the educational system is improving. However, the pace of this change is too slow. The low hanging policy amenable interventions identified in the TIMSS analysis needs to be explored to facilitate faster improvement of educational achievement (Reddy, 2016).

These results indicated that only a handful of South African Grade 5 learners used their skills and knowledge in order to solve complex mathematical problems. One of the many strategies to improve the mathematics achievement of South African learners included the integration of Information Communication Technology in education. This could be due because some researchers found that using computers in mathematics education might increase learners' scores (Bulut & Cutumisu, 2018; Falck, Mang & Woessmann, 2018). Additionally, Saal (2017) found that 73.9% of South African learners were taught by teachers who were not using computers in mathematics instruction.

According to Larkin and Calder (2016), several recent curriculum reforms, both in South Africa and abroad, aim to address the shortfalls traditionally associated with mathematics education. This can be done through increased emphasis on higher-order thinking and collaborative skills, enhanced by harnessing the affordances of digital technology in conjunction with social constructivist pedagogies and contextual scenarios.

In his State of the Nation address on 7 February 2019, the President of the Republic of South Africa, Cyril Ramaphosa, stated the government would provide digital workbooks and textbooks to every school learner in South Africa by 2025 (De Villiers, 2019). This announcement begs the question of how effective the incorporation of ICT is in education.

The questionnaire responses from Grade 5 learners, their mathematics teachers and school principals, participating in the TIMSS 2015 research project, have been utilised to analyse the impact of the use of technology in mathematics teaching and learning. Findings from descriptive statistics showed that almost 90% of the learners were taught by teachers who did not have computers in their mathematics classrooms. Consequently, only 10% of learners were taught by teachers who utilised computers in the classroom (Saal, van Rhyneveld &

Graham, 2019).

Pope and Mayorga (2019) claim there is a plethora of websites and an increasing number of educational apps that can have a real impact on learners' learning and achievement. Schools are moving to more mobile and recent digital technologies such as tablet computers, laptops and netbooks, and even more recently, social media and collaborative platforms such as Google Drive/Classroom or Wikispaces. It can be challenging to navigate this vast digital ocean of resources and find the right one, which will allow teachers to exploit the potential of available technology to the benefit of learners' learning. After an investigation into the use of educational technology in South Africa and whether there was a relationship between the use of technology in mathematics and the mathematics achievement of Grade 5 learners, Saal, van Ryneveld and Graham (2019) reveal that the use of educational technology is related to the mathematics achievement of learners. One of the many strategies to improve the mathematics achievement of South African learners includes the integration of technology in education.

Along similar lines, in this study a compact projector, which is an example of mobile technology, was used to promote the learning of fractions in mathematics. Learners were allowed to watch a PowerPoint presentation and a video of a lesson on fractions. This was an interactive session whereby learners were given the opportunity to ask questions and the teacher was able to offer explanations as the lesson and visual presentation unfolded.

2.4. Implications of the literature review for this study

The literature review is a process that is fundamental to any research. It is the section of the study during which researchers find out what already exists in the area they propose to research. The review forms the foundation for the research proper, because researchers need to know about the contributions others have made to the knowledge pool in their topic (Hart, 2018).

This literature review explored the current knowledge, as well as theoretical contributions to this research study, which highlighted the learning of fractions in mathematics among Grade 5 learners. The chapter presented the findings of various scholars and their contributions towards the interpretation and illumination of concepts which are pertinent to this study.

2.5. Conclusion

The first part of this chapter began by providing an outline of mathematics teaching and learning in other countries and in South Africa. The CAPS curriculum was discussed and thereafter, the issue of contextualised mathematics learning was interrogated. Part two of the literature review went on to deal specifically with the teaching and learning of fractions, and how fraction learning is influenced by the use of visual manipulatives, diagrams and cooperative or group work. The use of technology in the classroom and more importantly for this study, the use of technology in learning fractions concluded this chapter. In chapter three I present the theoretical framework utilised in this study.

Chapter Three: Theoretical Framework

3.1. Introduction

In the previous chapter, the literature review underpinning the perceptions of Grade 5 learners on the use of technology when learning fractions, was introduced and discussed. In this chapter the focal point is the theoretical framework that guided the study.

Among the widespread definitions for a theoretical framework, we distil them to mean an explanation of the way things work. The source, size and power of those explanations vary, but they all link back to an attempt to understand some phenomena (Collins & Stockton, 2018). Theoretical frameworks, according to Hughes, Davis and Imenda (2019), tend to state the theory or theories that inform the formulation of the problem to be studied. The theoretical framework can make connections between the problem of the study, specific research questions, data collection and analysis techniques, as well as, how one will interpret her/ his findings.

According to Keleszade, Guneyli and Ozkul (2018) frameworks can guide implementation, facilitate the identification of determinants of implementation, guide the selection of implementation strategies, and inform all phases of research by helping to frame study questions and hypotheses, anchor background literature, clarify constructs to be measured, depict relationships to be tested, and contextualise results. Frameworks provide a common language, allowing for cumulative evidence to develop. Collins and Stockton (2018) concur by stating that a theoretical framework is at the intersection of existing knowledge and previously formed ideas about complex phenomena, the researcher's epistemological dispositions, and a lens and a methodically analytic approach. Working through these three components renders theory a valuable tool to the coherence and depth of a study.

The landscape of theories on teaching and learning is vast and dynamic. In a single day, learners may engage with behaviourism-inspired videos with mastery quizzes, connect on social media to a community of practice for advice on solving a homework question, use responses to help their construction of understanding of a topic, and post social media comments where they share their understanding and the resources that helped them

(Campbell, Craig & Collier-Read, 2019).

This chapter begins with a description and explanation of the backbone of the theoretical framework within which this research study was embedded, namely, the constructivist theory of learning. Several learning theories are usually classified as constructivists, for example: situated cognition, activity theory, experiential learning, anchored instruction, and socio-constructivist learning. Connectivism is also presented as a new and important theory which is linked to constructivism (Mattar, 2018).

This research study is limited to what seems to be the most widely accepted version of constructivism in mathematics education: socio-constructivism. In order to better understand the perceptions of Grade 5 learners on the use of technology when learning fractions, the study is grounded on the principles of constructivism, through employing the combined lenses of social constructivism and connectivism. A brief description of the background of social constructivism is provided, followed by a discussion of the principles of social constructivist theory. Thereafter, I explore the tenets of social constructivist theory, which include anchored instruction, situated cognition, the zone of proximal development, scaffolding and connectivist theory. In addition to these theories, the theory of diverse influences and the use of technology occupy a significant part of the framework for this study.

3.2. The social constructivist theory

Towers, Takeuchi and Martin (2018) maintain that teachers and learners, working in concert with the learning environment (which includes parents and other social influences such as peers and the media) bring forth a world of mathematical significance together. Learners' relationships with mathematics are therefore not determined only by what happens inside classrooms but instead are dependent on a much broader contextual milieu in which learners are immersed. This milieu helps to shape not only what learners learn in school but also their emotional connections with the disciplines. To better understand how this broader contextual milieu might influence learners' emotional relationships with mathematics, this study makes reference to literature that examines learning from a social constructivist perspective.

Furthermore, Maunder and Crafter (2017) emphasise that together with the changes experienced in the field of education around the world, it is expected that the global focus will shift from teacher-centred education to learner-centred education. Furthermore, it is expected that attention will be paid to the needs of learners to ensure that they are implementing their learning in practice throughout the entire education process. In this context, as a learner-centred theory, social constructivist theory is prominent as it is essentially based on cooperative learning and displays the importance of learner's peers in the realisation of learning.

To better understand social constructivism, this study is rooted in the work of Lev Vygotsky (Shaikh, Karim & Asif, 2017). According to Vygotsky (1978), knowledge gets constructed by exchanging dialogues and interacting with others in a social setting. Furthermore, Vygotsky (1978) elevates social interaction in learning over individual cognitive learning and considers that much important learning by the student occurs through social interaction with their teacher and with their peers (Finnegan & Ginty, 2019). Vygotsky's approach to child development has had, and continues to have, a major impact on teaching and learning and on research in education. Researchers continue to research his ideas, as well as work to apply his insights in their studies of teaching and learning (Lerman, 2019). Likewise, this research study employs the socially interactive process of group work and collaborative learning among learners.

Socio-constructivist theories encompass both the individual and social aspects of learning, since learners grow up in a social environment on which they depend for their cognitive development. Socio-constructivism is the most widely accepted version of constructivism in mathematics education (Noorloos, Taylor, Bakker & Derry, 2017). Many of the processes by which educational phenomena are experienced and by which the products of the learning process are enacted are essentially social (Vygotsky, 1978). The institutions (e.g. schools) and the individuals (e.g. teachers) whose primary function is to promote learning, do so by means of social interaction (Chan et al., 2017).

The theoretical background of this research study relies, among others, on the social turn within learning theory and the emphasis on the fusion of the learning process into a socio-cultural environment (Francois, Mafra, Ricardo, Fantinato, & Vandendriessche, 2018). Social constructivist theory, as explained through the work of Lev Vygotsky, is the lens which gave this research a social and interactive approach. The roots of socio-cultural approaches are found in Vygotsky's (1978) work and there is a shared understanding of development as shaped by the contexts in which individuals are based, and the social and interactional relations that exist between them (Maunder & Crafter, 2017).

Socio-constructivism was intended to overcome a dichotomy that many scholars saw between the theoretical perspectives of cognitive constructivism on one hand and socio-cultural theories on the other (Noorloos et al., 2017). Learners, according to Vygotsky (1962), shape their own minds through their own actions within given socio-cultural settings. Significant here is that learners understand the tasks they face and believe that they have the capacity and intellectual tools to undertake them. Constructivist learning orientations seek to understand how learners create their knowledge constructs and what these mean for understanding influences on thought processes. The fluid nature of constructivist learning requires teachers to adopt the view that each learner will construct knowledge differently. Social constructivism posits that learner construction of knowledge is the product of social interaction, interpretation and understanding. Figure 3 illustrates the different ways in which social constructivism manifests itself in the classroom.

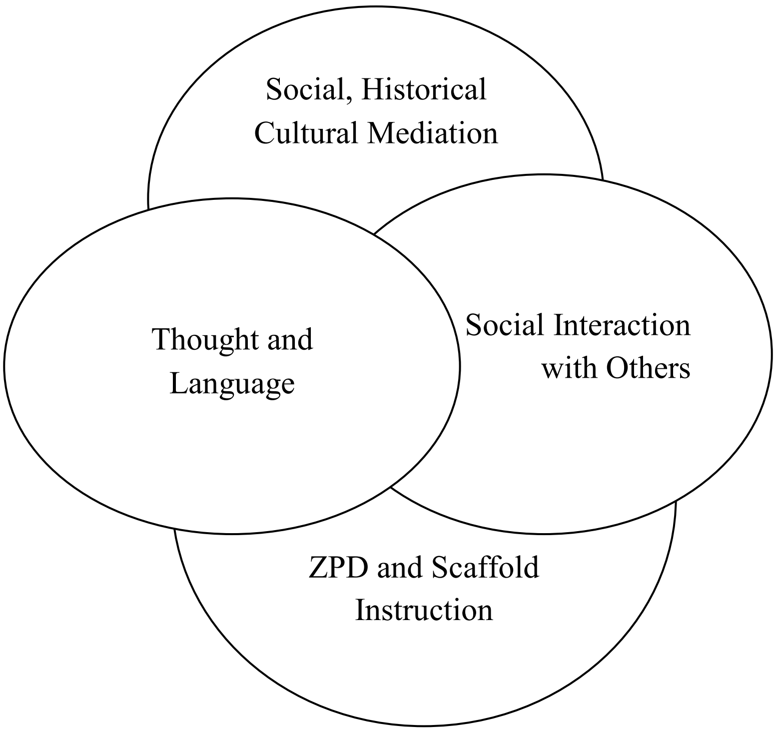


Figure 3. Vygotsky’s theory of social constructivism in the classroom
Adapted from Vygotsky (2002, p. 201)

According to Vygotsky (1978) it has been argued that socio-cultural theory not only provides a mechanism for understanding cognitive development in interaction, but also social and emotional learning through shared cultural school spaces with peers and teachers. Understanding or meaning-making is mediated through socialisation, interactions and guidance with others. Mediation is a central tenet of Vygotsky's work and speaks to a process whereby the individual and the social mutually shape each other (Maunder & Crafter, 2017).

Social constructivism does not remove the need for the teacher; rather it redirects teacher activity towards the provision of a safe environment in which learner knowledge construction and social mediation are paramount. Such orientations require teachers to understand the requirements and stages through which learners travel on their journey towards understanding, which in turn might successfully mediate into the socio-cultural space. In short, the process of scaffolding the learning journey is the key teacher requisite (Vygotsky, 1978).

This research study was conducted in a Grade 5 class, where the teacher and learners were engaged in instruction and discussion about issues surrounding the learning of fractions. The classroom is a social setting where social interaction is prevalent among learners and teachers, and among learners themselves. Therefore, this study aligns itself appropriately with socio-constructivist principles. Furthermore, in line with the tenets of Vygotsky (1978), the study adopted a blended approach to learning, whereby the traditional classroom activities were supplemented with computer-assisted learning.

3.2.1. Background to the social constructivist theory

Socio-constructivist theory elaborates on the learning theory of the Russian Lev Vygotsky (1978) and his concept of a zone of proximal learning (ZPL). The concept can be understood as the cognitive field of the pupil, which can be spotted at the fringe of the background knowledge and the out-of-school worldview (Francois et al., 2016). Many of the processes by which educational phenomena are experienced and by which the products of the learning process are enacted are essentially social (Vygotsky 1978). Villamizar (2017) posits that humans are essentially social beings. Since the time we are born, a variety of social interactions start to take place within our families, schools, communities and definitely, our own learning situations. Learners' learning was seen less in terms of an individual process and more as the sum of the relationships they develop with others (Macblain, 2018).

As a natural process, learning is a complex and dynamic experience in which learners, teachers, peers and a specific environment interact between each other in order to gain higher mental functioning (Villamizar, 2017). Moreover, Francois et al. (2016) propose that it is the zone of learning where the pupil will be able to connect insightfully to new knowledge because of the intrinsic relation between background knowledge and new inputs. Background and out-of-school knowledge are integrated in formal learning as a stepping-stone for acquiring new knowledge, new meanings and new mental frames.

Vygotsky (1978) believes that learners' cognitive development arises from their social interactions and through supported learning from others that encourage the construction of knowledge. Vygotsky was in fact less interested in the individual nature of learning in learners and more so in the cultural contexts within which learners grow up (Macblain, 2018).

3.2.2. Principles of the social constructivist theory

Social constructivist principles and ideas are among those most cited in both educational and psychological circles today, and many current scholars and reformers ground their work in social constructivist theories (Knapp, 2019). Researcher Barak (2017) points out that changes in our global world have shifted the skills demand from acquisition of structured knowledge to mastery of skills, often referred to as 21st century competencies. The attributes for teaching and learning in the 21st century include adapting to frequent changes and uncertain situations, collaborating and communicating in decentralised environments, generating data and managing information, and releasing control by encouraging exploration.

Existing research by Nguyen (2017) suggests that although human potential is theoretically limitless, the practical limits of human potential depend upon quality social interactions and residential environment. Vygotsky believes that it was cooperation and the pooling of ideas that promoted change and cognitive development. Vygotsky (1987) emphasises that learning occurs as a result of interaction between individuals and their social environment with media presence; and interaction has a large impact on learning (Korucu & Cakir, 2018). Mathematics learning flourishes in an environment that promotes group activities, conversation and interaction, creativity and communication. This suggests that in order for teaching and learning to be effective, the social dimension of learning must be recognised (Francois et al., 2016).

Together with assisting learning and development of learners within their ZPD, teachers should also promote in them the respect for each other's personality by paying respect to their level of competence, individuality, background and identity. In Vygotsky's view, the teacher does not control the class with rule and structure; rather, the teacher collaborates with the learners and provides support and direction (Nguyen, 2017).

The social constructivist theory frames this study as the teaching and learning of mathematics is a process that always considers the learner holistically. Researchers Francois et al. (2016) indicate that the learner is an agent who is active within a specific world context and all these aspects are mutually constitutive for the learning process. Learning is not perceived as the reception of factual knowledge or robust information. It is a social activity that takes place within a community, at first legitimately peripheral. Later on it increases gradually in engagement and complexity. Participation in social practices is the fundamental form of learning. It implies more than connecting the immediate context to the instruction.

Keleszade , Guneyli and Ozkul (2018) assert that together with the changes experienced in the field of education around the world, it is expected that the global focus will shift from teacher-centred education to learner-centred education; furthermore, attention will be paid to the needs of learners to ensure that they are implementing their learning in practice throughout the entire education process. In this context, as a learner-centred theory, social constructivist theory is prominent as it is essentially based on cooperative learning and displays the importance of a learner's peers in the realisation of learning.

This aim of this research study was to show how collaborative and cooperative activities can be performed in the context of learning fractions and how this can transform learners' thinking abilities. This was evident in this research study, especially during the activity which allowed learners to work in groups, thus, providing the opportunity for cooperation and social interaction among learners while learning.

3.2.3. The anchored instruction theory

Mattar (2018) posits that anchored instruction aims to overcome the problem of inert knowledge through immersion. The group anchors instruction in complex problem-solving environments, called macro contexts, which enable the exploration of a problem from many perspectives, serving as environments for cooperative learning and teacher-directed mediation. Anchors should provide opportunities for teacher guided discovery. Pellegrino and Brophy (2008) expand on the idea of anchored instruction by stating that this theory actually reflects an the ongoing dialectic among issues of theory, instructional design, research on learning and assessment, technology, teacher knowledge and professional development, and the realities of diverse learners in diverse instructional settings.

This research study was initiated based on the observation that grade 5 learners experience difficulties in the execution of tasks that involved fraction learning. In line with the observations of Mattar (2018), the learners in this study were given the opportunity to approach their challenges by using multiple learning resources that included manipulatives, worksheets, videos and a PowerPoint presentation. Learners were further engaged in cooperative learning in the form of group work. The anchored instruction theory was well suited to this research as the constitution of learners in the sample was representative of diverse learning ability. Furthermore, computer-assisted learning provided the teacher with the opportunity to explore how learners interact with technology when learning fractions in mathematics.

3.2.4. The cognitive flexibility theory

Braem and Egner (2018) indicate that cognitive flexibility refers to the ability to quickly reconfigure our mind, as when we switch between different tasks. Cognitive flexibility can be conditioned by simple incentives typically known to drive lower-level learning, such as stimulus–response associations. Cognitive flexibility can also become associated with, and triggered by, bottom-up contextual cues in our environment, including subliminal cues. Such a learning perspective on cognitive flexibility offers new directions and important implications for further research, theory, and applications

Research by Magalhaes, Carneiro, Limpo and Filipe (2020) has shown that cognitive flexibility plays a critical role in the learning and academic achievement of learners. The unique contribution of cognitive flexibility to academic achievement across schooling found that better performance on the flexibility score was associated with better academic outcomes after controlling for fluid intelligence, attention, inhibitory control, working memory, and planning. Thus, cognitive flexibility is a key component for school achievement. The learners in this research study were engaged in multi-modal learning, thus exhibiting characteristics that resonate with cognitive flexibility. The ability to switch from one way of learning to another meant that learners were flexible in their approach to processing information from various sources, thereby facilitating meaningful learning. In each of the stages of data collection, learners were exposed to different resources to enhance their understanding and interpretation of fraction problems. Learners embraced the different learning situations with flexibility which allowed them to adapt to new and innovative approaches to learning, such as the use of technology as a tool in learning fractions.

3.2.5. The zone of proximal development

Charles (2018) defines the ZPD as the range between the comfort zone and the fight-or-flight zone, where all learning takes place with the scaffolded and guided support of a teacher. Similarly, Eun (2017) describes the ZPD as an overarching concept that integrates the main tenets of Vygotsky's theory of human development. The conceptualisation of the ZPD begins with its social, cultural and historical context and traces its development as a spatial and temporal metaphor that reflects the socio-genetic root of all human mental functioning. This research study allowed learners to engage in motivation, collaboration, and peer and mentored scaffolding in order to elucidate the learners' skills and knowledge when solving problems associated with learning fractions.

Panhwar, Ansari and Ansari (2016) elaborate that the ZPD is a theoretical endeavour to understand the process of contradictory points between the internal possibilities and external needs that form the dynamic and driving energy for development. The idea of ZPD is associated with Vygotsky, who practised it as an assistance to expound the methods in which the social and the individual communicative learning processes take place. Vygotsky attempts to highlight that people fashion themselves from the outer world by engaging themselves with the connotations of the factors recognised in social undertakings.

Researchers Phillips, Sheffield and Moore (2016) view the ZPD as the distance between the actual developmental level and the level of potential development under adult guidance or in collaboration with more capable peers. At its core, the philosophy behind a social constructivist course is that knowledge is created when it is shared. The ZPD is the space between what a learner can do without help and where a learner needs support. Scaffolding is the temporary support that the learner obtains from other learners within a group or from the teacher so as to bridge this space (ZPD), in order to develop and extend the learning process. Therefore, this research study was well suited to be framed within Vygotsky's ZPD and scaffolding. Figure 4 depicts a visual summary of Vygotsky's ZPD

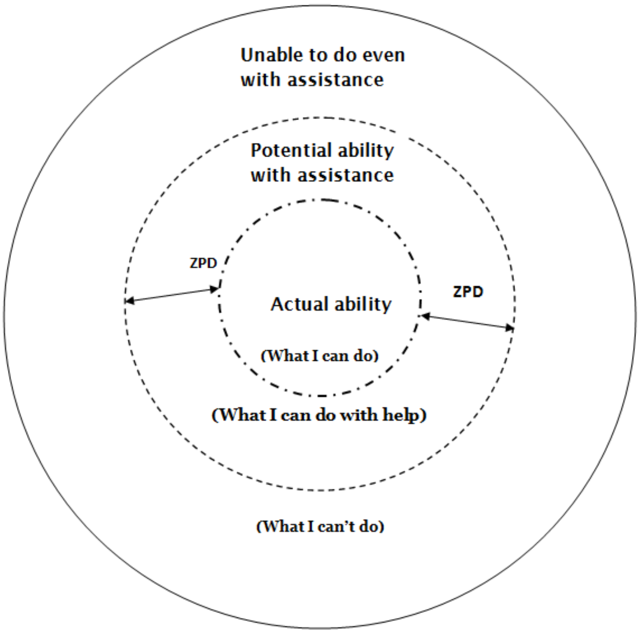


Figure 4. A visual summary of the ZPD
Adapted from Malik (2017, p.2)

Vygotsky's ZPD, according to Abbas (2017), is advantageous for teachers, for these levels indicate where the learner is at a given moment as well as where he/she is going in his or her process of learning. A teacher may plan the class instruction to provide practise in the ZPD for individual learners or for groups of learners. When learning new material or skills, learners sometimes need to be assisted with moving through the disequilibrium process that can occur when the new information contrasts with their existing frames of reference or ways of knowing (Clapper, 2015).

An essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the learner is interacting with people in his/her environment and in cooperation with his/her peers (Colter & Ulatowskib, 2017). Likewise Abbas (2017) maintains that cooperative learning activities can be planned with groups of learners at different levels leaving them to help each other to learn. Scaffolding is a procedure to help the learners to reach their ZPD. Having the learners work in pairs or groups is considered only the initial step in Vygotsky's theory of ZPD because grouping is the first step of encouraging learners to break social borders between them. The successful application of Vygotsky's ZPD requires an educational management and learning environment dedicated to these principles.

According to researchers Shaikh, Karim and Asif (2017), the social constructivist theory states that knowledge is co-constructed in the environment with others (Vygotsky 1978). Although learning occurs through collaboration, it is still an internal mechanism within the individual. Individual learning is actually a product of knowledge creation, and this happens when collaboration takes place and knowledge itself gets co created in the environment. Moreover, Vygotsky also argues that individual level learning happens in the ZPD or the space where intellectual growth is still ongoing. Vygotsky argues that learning is actually an expansion of the ZPD into the Zone of Actual Development. Along similar lines Eun (2017) notes that a critical feature of the ZPD, one that goes beyond a simple social interactional interpretation of human development, is its specific focus on joint activity. The participants involved in the ZPD are not merely two individuals who happen to be in the same place at the same time. They are engaged in a collaborative activity oriented toward fulfilling a specific goal. The zone itself is created on the basis of a need for collaboration and assistance in accomplishing a specific activity toward an established goal.

According to Vygotsky (1978), the ZPD is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. Human learning presupposes a specific social nature and a process by which learners grow into the intellectual life of those around them (Colter & Ulatowskib, 2017).

The ZPD is the area in which memorising, thinking, paying attention, problem solving and concept formation skills should be fostered (Villamizar, 2017). Similarly Clapper (2015) suggests that cooperative-based learning and the ZPD may be used to assist the learner with working through the disequilibrium process, including accommodating and assimilating the new skills and information into their own practice.

Furthermore, Villamizar (2017) observes that the ZPD contains two basic components: first, there is always a task or a problem that needs to be solved with the help of someone else who is considered the expert on the matter; and second, there is also a person, often called novice, who can do better if well-assisted. Although there have been a number of controversies about what type of participant can be named as the "expert", more and more researchers believe that experts can be not only teachers or high achiever learners, but also other peers, parents or administrators.

The ZPD emerges through participation and interaction, not only between individuals but also between individuals and tools (Abtahi, 2018). In line with this observation, this study used the Vygotskian concept of the ZPD to examine the learning experience and perceptions of Grade 5 learners as they attempted to solve fraction problems with the use of technology. The aim was to highlight how tools can facilitate the enactment of a ZPD, within which the tool provides the guidance. The research shows how learners' interpretation of the concept of fractions and their perceptions on the use of technology marked what they said and did.

3.2.6. Scaffolding as a part of social constructivism

The term 'scaffolding' comes from the work of Wood, Bruner and Ross (1976). The term 'scaffolding' was developed as a metaphor to describe the type of assistance offered by a teacher or peer to support learning. In the process of scaffolding, the teacher helps the student master a task or concept that the student is initially unable to grasp independently. The teacher offers assistance with only those skills that are beyond the student's capability (West, Swanson & Libscomb, 2017).

Armstrong (2019) describes scaffolding as a concept that is closely aligned with social interaction in the theory of social constructivism. By observing any group of learners making something or playing a game of some kind, we can observe how learners often seem to be natural scaffolders, making suggestions and asking questions – sometimes giving orders.

Wright (2018) opines that scaffolding had roots in Vygotsky's ZPD within his wider socio-cultural theory. Scaffolding was viewed as a process that provided temporary support to an individual learner. Researchers have broadened the scaffolding metaphor to include models of effective scaffolding, support offered by peers in collaborative situations and support within technology mediated environments.

Juma, Lehtomaki and Naukkarinen (2017) note that the basic assumption underlying scaffolding is that when learners are well supported in solving a problem, they will later manage to perform the task independently. Throughout the scaffolding process, there is a strategy of gradually withdrawing support so that learners can proceed to work independently. Likewise Colter and Ulatowskib (2017) claim that scaffolding may be viewed as a temporary form of assisted learning, involving explanation from the teacher and feedback from the learner, which aims to create independence in the learner. Like physical scaffolding, the supportive strategies are incrementally removed when they are no longer needed, and the instructor gradually shifts more responsibility to the learner in the learning process. As can be seen in Figure 5, scaffolding is a gradual process during which the role of the teacher fades as the learner gains confidence to perform tasks independently.

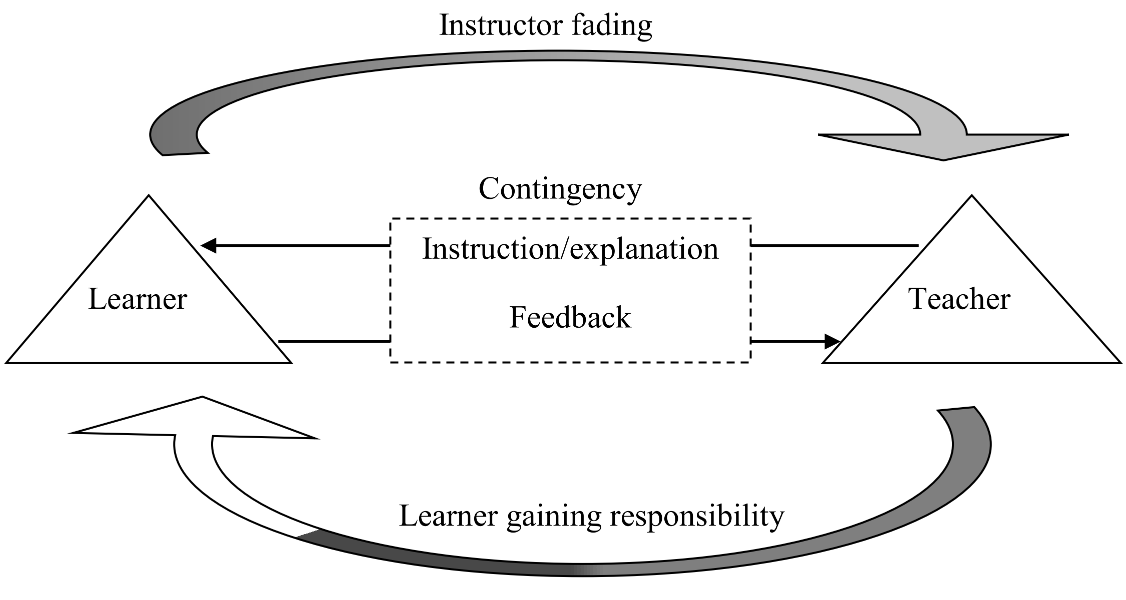


Figure 5. The Process of Scaffolding – the dynamic interaction between teacher and learner
Adapted from Malik (2017, p. 3)

This means the ZPD assumes that the present level or actual development of the learner is enhanced to a higher level of cognition through increased interactions, involvement and collaboration or direction from a more-skilled person (Juma, Lehtomäki & Naukkarinen, 2017). The guidelines for scaffolding include assessing learners' current knowledge and experience so as to develop projects that will push them to the ZPD, make connections to what learners already understand, to motivate them and to provide opportunities for feedback from peers. Some tasks will be beyond the peers' ability to provide scaffolding, so the teacher may step in to provide the scaffolding (Morgan & Skaggs, 2016).

West, Swanson and Libscomb (2017) explain that when teachers scaffold instruction, they typically break up a learning experience, concept, or skill into discrete parts, and then give students the assistance they need to learn each part. For example, teachers may give students an excerpt of a longer text to read, engage them in a discussion of the excerpt to improve their understanding of its purpose, and teach them the vocabulary they need to comprehend the text before assigning them the full reading. Morgan and Skaggs (2016) concur that scaffolding (i.e. assistance) is most effective when the support is matched to the needs of the learner. This puts them in a position to achieve success in an activity that they would not have been able to do alone. This also gives learners more control over their learning. Scaffolding is the process through which learning is mediated. It is commonly used to describe the interactions between the learner and teacher in exploring problems and co-constructing meaning (Armstrong & Tsokova, 2019).

Vygotsky is of the opinion that when a learner is in the ZPD for a particular task, providing the appropriate assistance would give the learner enough support to achieve the task (Morgan & Skaggs, 2016). Alongside the interaction between the learner and teacher, Vygotsky maintains that the interaction with other peers is an effective way of developing skills and strategies. Therefore, it is beneficial for teachers and educators to use cooperative learning tasks whereby less competent learners can develop their skills with help from their more skilful peers (Wilkinson & Jones, 2017).

Colter and Ulatowskib (2017) believe that socio-constructivist approaches can harness the facility for collaborative working, by making room for group activities in which learners are encouraged to work democratically and independently. Scaffolded learning is deployed to improve learners' comprehension of class material over time and through social interaction. It provides rigorous guidance in learner assignments at the beginning of the learning process since learners might be incapable of learning the material on their own.

In this research study, learners were separated into groups, in order to complete a task-based worksheet. Each group comprised of learners with diverse learning abilities. The interaction among the learners in the group included questioning each other and supporting each other in finding solutions to the questions posed in the worksheet. This created the opportunity for learners to break down any social barriers that they may have encountered, and provide the scaffolding to those learners who derived some benefit by engaging in this collaborative learning exercise.

3.2.6.1. Collaborative learning

Social constructivism refers to the Vygotskyian version of constructivism that includes collaboration with others as a key component (Phillips, Sheffield & Moore, 2016). Collaborative learning uses social interaction in constructing knowledge; it does not depend on ideas put forward by others previously but instead involves learning by interacting with each other as a group in order to solve problems. By interacting, individuals work together to maximise not only their own learning but also other group members' learning (Korucu & Cakir, 2018). Social constructivist approaches can harness this apparent facility for collaborative working and playing, by making room for group activities in which learners are encouraged to work democratically and independently. They also provide productive opportunities for experiencing and dealing with differences and conflict which can always occur among people working together (Armstrong, 2019).

According to Vygotsky (1978), learning in social circumstances involves knowledge construction which supports interaction, inquiry and discussion, and provides enhanced learning with active participation (Korucu & Cakir, 2018). The collaborative learning process manifested itself during this research study. The study involved dividing the learners in the class into small groups, where they engaged in discussions about fractions and attempted to find solutions to questions in the task-based worksheet. Some of the learners used paper folding and others used diagrams in order to assist them in attempting to solve the problems. This type of social interaction within the classroom emphasises why social constructivism, together with scaffolding and the ZPD, are the most suitable theories to frame this study.

Collaborative learning has a social constructivist philosophical background. It defines learning as constructing knowledge in a social environment (Korucu & Cakir, 2018). Scaffolding had roots in Vygotsky's ZPD within his wider socio-cultural theory. Scaffolding was viewed as a process that provided temporary support to an individual learner. Researchers have broadened the scaffolding metaphor to include models of effective scaffolding, support offered by peers in collaborative situations and support within technology mediated environments (Wright, 2018).

By encouraging learners to work collaboratively, learners learn from each other and develop self-esteem and a belief in themselves as creators, makers and problem solvers (Armstrong & Tsokova, 2019). Once the instructor has prepared the learner adequately well for them to appreciate the complex nature of scholarly inquiry, learners use what they have learned to move forward on their own (Colter and Ulatowskib, 2017). In order to tease out the complexity of the social aspects of learning, the basic structure of this research study was to strategically increase the complexity of the classroom activities under investigation, by varying the social unit of the classroom into individual, small group and whole class discussion. The interaction foci was dynamic, and moved from mainly focusing on minimising the directive role of the teacher, particularly in the support provided for learner collaborative activity, to gradually increasing the role that the teacher plays within the classroom, with the presentation of the technology enhanced lesson (Chan et al., 2017).

3.2.6.2. Activities associated with scaffolding

Scaffolding suggests a temporary and flexible system that can be quickly and easily assembled and disassembled once the learning task is accomplished, at which point the learner's ZPD is expanded and scaffolding is moved to the new edge of the learning frontier. (Morgan & Skaggs, 2016). When scaffolded instructions are provided during the first lessons, learning is more likely to occur not only because students feel affectively supported, but also because each scaffold guides the brain towards a comprehensive understanding of the input in use (Villamizar, 2017). Instructional scaffolding is a well-researched, commonly-practised educational technique whereby support is temporarily provided as an individual learns (Erdei, Springer & Whittinghill, 2017).

The social dynamics of a peer group differs to the expert-like authority of the instructor. The ethos of learning *with* peers and *by* peers may encourage a collective process which encourages the learners to reconsider their viewpoints. Also, rather than looking for cues of struggle in the learner, peers may offer more explicit forms of help because they might see it as aiding as one of their own rather than seeing it as a form of development towards independence (Malik, 2017). There are various activities which may be used as strategies to facilitate effective scaffolding. Some of the commonly used strategies are represented diagrammatically in Figure 6.

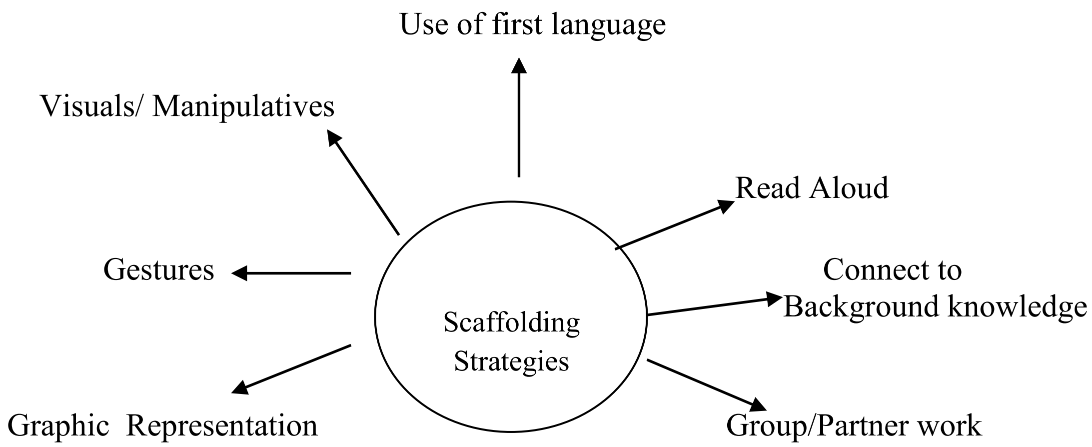


Figure 6. The researcher's representation of Scaffolding Strategies

High quality materials can be totally meaningless if they are not manipulated accordingly to reach students' ZPD and encourage social interaction. That's why, the kind of tasks and activities requested to students become the trigger factor to fuel higher mental processes (Villamizar, 2017). Grounded in socio-constructivist teaching and learning theory, scaffolding historically referred to support provided by a teacher to a student. However, in the modern learning environment, instructors have access to a wide range of tools and techniques with which to help them scaffold learners (Erdei, Springer & Whittinghill, 2017). In addition, teachers may also motivate peer-work in order to create the chances for them to exchange personal insights or strategies they employ to better reach the class goals and hopefully, sort out problems cooperatively (Villamizar, 2017). This research study employs the use of instructional scaffolding strategies to investigate the perceptions of Grade 5 learners on the use of technology when learning fractions. It was evident in this research that participation in the group activity allowed learners to develop self-confidence, and a knowledge base that would lend itself to successful learning. For example, the learners who experienced difficulty in solving the given questions were assisted by others in the group who were able to interpret and understand the content of the worksheet. The scaffolding of learners in the process of learning fractions in Grade 5 was further reinforced by the use of manipulatives to assist learners in solving problems in the task-based worksheets.

3.2.7. Connectivism as a part of social constructivism

The boom of online technologies into the learning environment, as well as the increasing amount of available information, has led to defining the idea of a new didactic theory - connectivism (known as the theory of digital age) (Homanova, Prextova & Klubal, 2018). Connectivism is a learning theory that is designed for the digital age. Learners in today's classrooms are digital natives who have unique learning styles (Rice, 2018). The emergence of the internet has provided access to the views and opinions of a wide range of individuals opening up opportunities for new forms of communication and knowledge formation. Previous ways of navigating and filtering available information are likely to prove ineffective in these new contexts. Connectivism is one of the most prominent of the network learning theories which have been developed for e-learning environments. There is unlikely to be a single theory that will explain learning in technological enabled networks (Goldie, 2016).

Connectivism, the latest didactic theory, focuses on the connectivity of sources, establishing relationships, interaction and sharing of knowledge in a constantly forming complex network (Homanova, Prextova & Klubal, 2018). As a recent and growing learning theory, connectivism argues that there are tremendous changes happening in the learning processes and it is not possible to build on the previous theories. Instead, a new conceptual framework should be built in an attempt to explain the emerging phenomena (AlDahdouh, Osorio & Caires, 2015). According to Mattar (2018), connectivism or distributed learning ought to be considered as an updated version of constructivism, understood as a general philosophy of education for the digital age. It is possible to position it as the development of constructivism in response to the current scenario of the intense use of technology in education, functioning though as a philosophy of education.

In this rapid change process, technology plays a leading role inside the classroom scenario. For instance, technology development is affecting, among others, tools developed around the classroom and significant changes in curriculum development. Tools development, the rapid development of technological tools such as the personal computer (PC), laptop, internet, smart phone and multi-media has involved the educators in a battle of keeping pace with its speed of progress (AlDahdouh, Osorio & Caires, 2015).

Connectivism is then proposed as a more adequate theory for a digital age, when action is needed without personal learning, using information outside our primary knowledge. Learning is no longer a process that is entirely under the control of the individual, an internal, individualistic activity: it is also outside ourselves, within other people, an organisation or a database, and these external connections which potentiate what we can learn are more important than our current state of knowing (Mattar, 2018).

This research study included the incorporation of technology into the mathematics curriculum while Grade 5 learners were engaged in learning fractions. This prompted the researcher to investigate the response of learners to the introduction of a new phenomenon into the teaching and learning process.

3.2.8. The use of technology as a part of connectivism

Education has always lived in tension between two functions: education as a matter of assuring continuity and as a matter of fostering creativity and change (Scherer, Siddiq & Tondeur, 2019). The integration of technology into education has not only provided teachers and learners with more resources but also introduced more dynamic and interactive learning strategies into the classroom. To ensure and enhance the effectiveness of technology-enhanced education, educators need to use technology in ways that best satisfy learners' learning needs (Nami & Vaezi, 2018).

Technology plays a significant role in how we learn and how we conduct our daily lives (Vululleh, 2018). The speed with which the evolution of technology has taken place is phenomenal. Today, school teachers in many countries around the world are working with digital natives who are growing up with new technologies as a non-remarkable feature of their life (Scherer, Siddiq & Tondeur, 2019). Much has been done around the concept of technology integration in schools and the impact or lack of impact on learner achievement (Perry, 2018).

In recent years, e-learning technology has changed the methods by which instructors teach and by which learners learn. For example, technology allows instructors and learners to share course materials in multiple ways, such as slideshows and videos. This method of learning promotes the utilisation of electronic technologies to access educational materials in non-traditional ways. It has the potential to improve instructional effectiveness for all learners by providing individualised, in-the-moment interactions among learners, their peers, and their instructors (Vululleh, 2018). This research study employed the use of technology as a form of scaffolding or support structure to promote the understanding of fractions in Grade 5.

The use of technology in education is of great importance for both the realisation of effective learning teaching processes and raising individuals possessing competences necessary for being a member of the 21st century society (Durak & Saritepeci, 2017). New developments in educational technologies are making it possible for teachers to bring technology into the classroom more than ever before (Bailey, 2019). Most of the literature on technology use in schools centres around availability and access to technology in the classroom setting. This study looks at the actual integration of technology through instructional delivery in the classroom (Perry, 2018).

A wide variety of new innovative technologies hold the promise of personalised and persistent learning options available to meet the needs of today’s teachers and learners (Bailey, 2019). Integrating technology early in education may allow the learner to become more aware of not only how to use the technology, but also may give the learner more confidence in the subject, especially mathematics (Murphy, 2016). It has become the designated aim of education to help learners to become digitally literate citizens who can cope with the complexities and dynamics in today's societies (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014).

However, enthusiasm for technology integration in the classroom is often tempered by concerns about costs, system requirements and privacy issues. These are general areas of constraint that administrators will need to first tackle in order to realise the promise that new forms of technology can potentially improve and optimise the learning environment. What remains clear is that people, both learners and adults, see value in learning with the assistance of technology. Is this based on technological determinism across society as a whole? Or is there evidence to suggest that technology incorporated into learning environments will enable more efficient and effective learning experiences? (Bailey, 2019).

Developing environments where new technologies are used, is important for delivering 21st century proficiencies and supporting knowledge sharing. Hence, the teacher-student-environment interaction is extremely important. In these environments, interactions can occur synchronously and asynchronously (Korucu & Cakir, 2018). Using technology in classrooms may increase learner engagement, increase motivation to learn and allow for better teacher-learner interaction. The use of technology can further support learner collaboration, assist in the accuracy of mathematical computation, and help learners feel more comfortable with learning mathematics and also allow for a deeper understanding of mathematical concepts (Murphy, 2016).

In many educational institutions, technology has been seen as one of the key drivers for the improvement of teaching and learning (Yang & Kwok, 2017). The positive effect of using technology throughout the curriculum can assist learners learning mathematics to higher-order thinking that can help learners even beyond the classroom (Murphy, 2016). Effective technology integration can help provide all learners with the ability to access the general education curriculum, offering them multiple means to complete their work with greater ease and independence in performing tasks that they were formerly unable to accomplish, or had great difficulty in accomplishing (Ahmad, 2015).

To this extent, the use of technology within the curriculum from elementary to high school is necessary for the betterment of learning mathematics. It is expectant that educators will continue to use technology in new ways in the classroom to help learners be prepared for today’s ever-changing technology driven society (Murphy, 2016). Hence, with effective integration of technology into the regular classroom, learners can have the provision of multiple means to complete their work, with greater independence in performing tasks that they were formerly unable to accomplish or could accomplish with great difficulty; through suitable enhancements or changed methods of interaction with the technology, needed to accomplish such tasks (Ahmad, 2015). The use of ICT is helpful in facilitating teaching and learning for both teachers and learners in the classroom.

To achieve successful integration of ICT in class, it requires efforts from teachers, learners and school administrators (Yang & Kwok, 2017). The implementation of technology into this research study was used as a tool to enhance the understanding of fractions among Grade 5 learners. Learners completed the first task-based worksheet after engaging in group work and making use of manipulatives. After participation in the lesson that reinforced fraction comprehension with the use of technology, learners were then asked to complete the second task-based worksheet, after which a series of focus group interviews were conducted with the learners.

3.3. Exploring the theory of diverse influences

In schools, learner populations are becoming more diverse because learners come from increasingly varied backgrounds and cultures, have different life experiences, and possess different innate and acquired characteristics. It is these differences among learners that have the potential both to enrich and to limit a learner's capacity to learn within a given school environment (Francois et al., 2017). Similarly, Chan, Clarke and Cao (2017), emphasise that classrooms represent a globally extensive institutionalised site for the promotion of learning. In the context of classroom learning, multiple participants are involved each with different levels and kinds of knowledge and experience. The changes in their learning as an output are the result of their personal characteristics as well as their particular ways of interacting with each other as part of their different existing relationships and associations inside and outside of the classroom. The only way for teachers to deal with educationally significant differences among learners is to make necessary adjustments when setting goals, planning lessons, organising groups, and when teaching and interacting with learners (Westwood, 2018).

Ashman and Conway (2018) propose that having a gifted learner within the same class as others who are considered to be slow learners creates a situation which teachers may find to be beyond their personal programming skills. The difficulties encountered in mixed-ability classrooms are closely related to matters of classroom organisation and control. When teachers are unable (or perhaps unwilling) to meet learners' diverse learning needs, they increase the risk of control problems that result when a class group reflects a broad range of learner characteristics – from those who are unable to cope with the learning task (slow learners) to those already able to do the task unassisted (above-average ability. Mixed-ability teaching may require the teacher to learn new organisational skills, including group work, learner self-regulation and classroom management.

Teachers have to investigate the background knowledge that learners actually bring to school how they can introduce their learning context in the teaching of mathematics at school. Blindness and ignorance concerning the local culture, local practices and knowledge may well explain the gap between success and failure, in a formal mathematics classroom. Learners attending classes need to be apprehended in their entirety, since learning is connected to their daily life experiences and new pedagogical materials will never be isolated from the other forms of local knowledge they are embedded in (Francois et al., 2017).

There are many factors which may influence the way in which teaching and learning takes place at schools. There are issues related to linguistic factors, cultural factors, traditional curricula, conventional assessment systems, inappropriate classroom sizes, passive learners, and disadvantaged learners, while adopting social constructivism in teaching and learning mathematics. The social domain includes linguistic factors, interpersonal interactions such as peer interaction, and the role of instruction of the teacher (Panthi & Belbase, 2017). There are many factors which may contribute to the diverse nature of learners present together in a classroom. Some of these factors which influence the diversity of learners are presented in Table 2.

Table 2: The researcher’s interpretation of Factors influencing Diversity and Inclusion in the Classroom

Thinking Styles	Language	Ethnicity	Gender
Values	Perspectives	Experiences	Race
Manners of Interacting	Nationality	Culture	Skills
Physical Abilities	Relationships	Religion	Age

Classrooms represent a globally extensive institutionalised site for the promotion of learning (Chan et al., 2017). Furthermore, Thompson and Timmons (2017) indicate that almost all education systems in developed countries around the world are now committed to enacting a policy of inclusion – meaning that their schools are expected to meet the learning needs of learners across a wide range of abilities from giftedness to intellectual impairment. These learners also come from different family and socio-economic backgrounds, have different life experiences, different cultural origins, different academic skill levels, and in many cases a different first language. Authentic inclusive education is regarded as something to which all schools should aspire in order to accommodate the diversity that always exists within the learner population. Since this research study was conducted in a setting that was representative of learners with diverse learning abilities, varied socio-economic backgrounds, different racial orientation and language proficiency, it was imperative for the researcher to employ a manner that was sensitive to the needs of all participants. At no stage during the research process was any participant marginalised or discriminated against in any way. This was done by employing multiple data collection methods and strategies, and ensuring that there was no infringement upon the individuality of the learners.

Westwood (2018) claims that teachers in inclusive classrooms depend heavily on having appropriate materials at the right level of difficulty for involving their learners actively and productively in the processes of learning. Simplified or augmented material should be a component of any course that applies the principles of universal design for learning. Adapted or modified materials can provide the means for all learners to study the same topic and work towards the same curriculum goals. Without the ability to control all elements of the classroom setting, researchers can only focus on a few aspects of classroom interaction at a time (e.g. changes in learner achievement, teacher-learner relationships, gestures, vocabulary learning, dialogic talk, meta cognitive strategy, group dynamics, etc.), leading to diverse and often disjointed accounts of the learning process within classroom settings (Chan et al., 2017).

Nationally, schools are increasingly segregated by race and poverty as a result of demographic shifts and a changing legal and political landscape. Based on evidence that learners benefit academically and socially from attending integrating settings, many school districts are exploring options for providing diverse learning experiences (Kotok & De

Matthews, 2017). In the context of classroom learning, multiple participants are involved each with different levels and kinds of knowledge and experience. The changes in their learning as an output are the result of their personal characteristics as well as their particular ways of interacting with each other as part of their different existing relationships and associations inside and outside of the classroom (Chan et al., 2017).

According to Panthi and Belbase (2017), language is not merely a means of communication, but it is also a vehicle of understanding. Learners make sense or create meaning in their language. The most efficient way to make meaning or creating a concept of mathematics is in one's mother language. There is a lack of ability and lack of understanding because learners' languages are different in the school and home context. The language forms and strategies used in mathematics teaching differently favour some social groups over others.

Curriculum policy is developed at a national or state level. Hence, teacher needs are influenced directly by content-driven curricula (e.g. syllabi) and relevant instructional strategies. Ashman and Conway (2018) similarly emphasise that implementing the curriculum requires teachers and other school or system personnel to make judgements about how it can be taught and learned. New initiatives and technologies are evaluated in relation to current teaching practices and the underlying philosophies held at the time. Therefore, any new technology must be evaluated in the light of the time available for teachers to adapt their current procedures or strategies and to implement changes that are consistent with the requirements of the curriculum.

In order to tease out the complexity of the social aspects of learning, the basic structure of this research study was to strategically increase the complexity of the classroom activities under investigation, varying the social unit of the classroom (individual, small group work and whole class discussion) and the interaction foci, from mainly focusing on learner-learner interactions by minimising the directive role of the teacher (data collection phase 1), to gradually increasing the role that the teacher plays within the classroom, particularly in the support provided for learner collaborative activity (data collection phase 2). This structure allows for maximum experimental control, while employing classroom activities that are familiar to the participating learners and teachers (Chan et al., 2017).

This research study was conducted in a class of learners with diverse learning abilities, therefore a variety of teaching strategies were used, namely, group work, the use of manipulatives and the use of technology.

3.4. Conclusion

This chapter examined the theoretical framework that formed the foundation upon which the rest of the research study was built. Using the concepts of motivation, collaboration, ZPD, and peer and mentored scaffolding, this study aimed to enhance the Grade 5 learners' skills, tools and knowledge while they engaged in the learning of fractions. The chapter began with a description of the socio-constructivist theory and its principles, followed by a discussion of the zone of proximal development, scaffolding and connectivist theories. The impact of technology and diverse influences on the study concludes the chapter.

The next chapter will focus on the research design and methodology employed during data generation.

Chapter Four: Research Design and Methodology

4.1. Introduction

The preceding chapter discussed the theoretical frameworks that guided this study. The focus of this chapter is on the research methodology and design used to obtain data for the study. Thereafter, the key research questions are revisited and the sampling procedure and techniques that were used to generate data are explained. The chapter goes on to explain the research design employed and concludes with a brief summary of the research methodology.

4.2. The key research questions

Technology has the potential to make complex and abstract mathematical ideas more accessible to learners, especially those who have difficulties with challenging curricular concepts (Kaplan & Alon, 2013). The aim of this study was to explore Grade 5 learners' perceptions on the use of technology when learning fractions in mathematics. The data collected during the study ties in with the following research questions:

i. What are Grade 5 learners' perceptions on the use of technology when learning fractions in mathematics?
ii. How do Grade 5 learners use technology when learning fractions in mathematics?
iii. Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics?

4.3. The research paradigm

In this study the interpretive research paradigm was used. It is theoretically understood that the interpretive paradigm allows researchers to view the world through the perceptions and experiences of the participants. In seeking answers for research, the investigator who follows the interpretive paradigm uses those experiences to construct and interpret his understanding from generated data. Specifically, interpretivism supported scholars in terms of exploring their world by interpreting the understanding of individuals (Thanh & Thanh, 2015). Furthermore, Gunbayi and Sorm (2018) indicate that the interpretive paradigm has been applied popularly in guiding qualitative research such as case study, grounded theory, ethnography, phenomenology, narrative study, systematic review, discourse analysis etc. It is the study of human experience and the way in which things are perceived as they appear to consciousness. The focus is on people's perceptions of the world. Phenomenological research is directed by the interpretive paradigm because its objective of inquiry is delving into experiences**.** For data collection, phenomenologist only attempt to understand and then describe on what the participants respond. There is no intervention from the researcher.

This approach was ideally suited to my research study, since the involvement and experiences of the participants formed the core structure of the research itself. Answers to the research questions, analysis of data and conclusions drawn at the end of the study were all constructed from the interpretations and experiences of the learners who participated in the study. This study lent itself, and was directly linked, to the interpretive paradigm as it involved exploring the perceptions of Grade 5 learners who were learning fractions in mathematics. By linking this study to the interpretive paradigm I was able to further probe into the perceptions of the participants by asking a series of questions based in an interview schedule. The participants shared their views and experiences on the use of technology when learning fractions, which allowed me to draw meanings from the discussions that arose around the focus group interview questions.

Thanh and Thanh (2015) observe that in seeking the answers for research, the investigator who follows interpretive paradigm uses the experiences of participants to construct and interpret his understanding from generated data. Interpretivism is much more inclusive, because it accepts multiple viewpoints of different individuals from different groups. This will significantly facilitate educational researchers when they need 'in-depth' and 'insight' information from a population rather than numbers by statistics. Along the lines of these perspectives, I needed to interpret the information generated in the audio recordings so as to draw out a deeper understanding of how learners view the use of technology in the learning of fractions.

Similarly, Alase (2017) notes that the interpretive paradigm gives researchers the best opportunity to understand the innermost deliberation of the lived experiences of research participants. As an approach that is participant oriented, the interpretative approach allows the interviewees (research participants) to express themselves and their lived experience stories the way they see fit without any distortion and/or prosecution. The learners in this study who are of diverse intellectual ability come from different social and economic backgrounds. The use of an interpretive approach has allowed me to obtain more diverse and multifaceted information, from the learners who are directly involved in the phenomenon under question, which is: the use of technology in the learning of fractions in a Grade 5 class. The data that I have generated from the learners' responses to the task-based worksheets and my interaction with the participants during the focus group interviews is based on the manner in which the participants have responded based on their assimilation of the learning content that was administered to them.

As a qualitative research approach, the interpretive paradigm gives researchers the best opportunity to understand the innermost deliberation of the lived experiences of research participants. As an approach that is participant oriented, the interpretative approach allows the interviewees (research participants) to express themselves and their lived experience stories the way they see fit without any distortion and/or prosecution.

4.4. Research design and methodology

Research by Rumrill and Bellini (2018) indicates that within the domain of research methods, the concept of research design refers to the specific plans or arrangements that are used to examine questions of interest. The quality of the methodology and design of a given investigation forms the essential basis for the strength of the knowledge claims or conclusions that researchers may derive from the research findings.

A rapidly developing area in childhood research has been the use of digital media which are now embedded as valuable tools in the lives of learners and adults, perhaps most importantly for communication (Christensen & James, 2017). The choice of the research topic was made in view of the observation that technology has a significant place in the lives of learners. In line with this observation, Chen (2015) concludes that information and communications technology (ICT) plays an increasingly important role in various social sectors in the information age. Individuals are expected to be equipped with crucial digital competencies in order to effectively participate in the economic, political and social aspects of this new age. The rise in the use of mobile devices among learners and their families influences ICT access in schools. Given that digital literacy is becoming increasingly important in the so-called information age, it is of significant public interest to examine this area and to probe possible digital divides within the public education system, in order to inform policy-making and future research. Technology has been incorporated into the lifestyles of families for the purpose of employment, entertainment and communication. This research study extends the use of technology further, by incorporating it into the classroom to facilitate the teaching and learning of fractions in Grade 5.

In this research study I have employed the use of a projector, a laptop and screen in order to present a lesson in PowerPoint form, to one class of Grade 5 learners. The use of technological devices could be viewed as tools to perk the interest of learners and to enhance the understanding of fractions as a part of the mathematics curriculum.

4.4.1. Qualitative methodology

Qualitative research design served as a guideline that connected the interpretive paradigm, and the strategies for investigations and data collection methods (Ngozwana, 2018). Furthermore Leavy (2014) maintains that qualitative research is generally characterised by inductive approaches to knowledge building aimed at generating meaning. Researchers use this approach to explore; to robustly investigate and learn about social phenomena; to unpack the meanings people ascribe to activities, situations, events, or artefacts; or to build a depth of understanding about some dimension of social life. Qualitative research is generally appropriate when your primary purpose is to explore, describe, or explain.

According to Pipere and Micule (2014), similar to participant observation, qualitative interviewing has long been a staple in classroom research. Such interviews use varied levels of structure to elicit responses from participants regarding the issue being investigated. Although interviews vary in their degree of formality, there exists a clear division between the researcher and the participant. One of the strengths of qualitative research, which is particularly beneficial for this study, is indirect and unobtrusive inquiry into the subjects' views on the research problem. The participation in the focus group interview was voluntary, anonymous, confidential and based on the written consent.

A qualitative approach was used in this study, as my focus was to gain information-rich, descriptive data from the participants so as to explore and understand the impact of the use of technology on the learning of fractions in the Grade 5 class. Information contained in the responses to the focus group interview questions, as well as the task-based worksheets, was interrogated thoroughly so as to elucidate descriptive data pertaining to this research study.

4.4.2. Context of the study

The research study was conducted at a primary school in the Ilembe district on the north coast of KwaZulu-Natal. The choice of school was based on the fact that I am a teacher there and it was convenient for research to be conducted at this school. It is an ordinary public school which has English as the language of teaching and learning, isiZulu as the first additional language, and Afrikaans as the second additional language. The teaching staff of the school is made up of the principal, the deputy principal, two departmental heads in the foundation phase, two departmental heads in the intermediate and senior phase, two administration clerks and twenty seven teachers. The school caters for learners from Grades R to 7. This school has a learner enrolment of approximately 1100 learners, with approximately 142 learners in Grade 5. This research study was conducted in one out of the three Grade 5 classes at the school. The learner population is made up of learners from diverse racial, cultural and socio-economic backgrounds, some of whom travel long distances to attend school. The school embraces the principles of inclusive education in that immigrant learners, learners with special needs, gifted learners, autistic learners, and learners who speak different languages make up the learner population. The school provides a holistic development of learners by offering various codes of sport, embarking on field trips and engaging learners in extra- and co-curricular activities.

The choice to conduct the research at Cato primary school was made after the consideration of a variety of factors. This school is the place of employment of the researcher which made it convenient to interact with the participants, without having to take leave of absence from work. Had the research been conducted at another school, the teaching and learning process would have been interrupted at two schools: the school where the researcher was employed as well as the school where the research was conducted. The times of leave taken from work by the researcher would have to be carefully monitored so as to coincide with the mathematics learning period of the learners who participated in the study. At the same time, there would have to be a replacement teacher to monitor the classes left unattended by the researcher. The research study, in its entirety, would have required a few days of leave for the researcher. The CAPS mathematics curriculum requires guidelines and time frames to be followed, which does not allow for much disruption of notional time. Data for the completion of the study involved gaining access to learner records in terms of age and school attendance, which were readily available at the school where the researcher was employed. The findings of the study were not influenced in any way by the fact that the researcher was a teacher at the school where the study was conducted. The researcher ensured that the study was not affected by personal beliefs, opinions, feelings, views or attitudes. The focus group interviews conducted during this study were transcribed verbatim so that the data was not influenced in any way by the opinions of the researcher. Since the researcher was the mathematics teacher of all three grade 5 classes, the class that participated in the study was chosen randomly with no preferences or bias in the process. Furthermore, the selection of the learner participants was done in accordance with the consent of the learners' parents, which was independent of the personal feelings and choices of the researcher.

The importance of mathematics in most fields of human endeavour is highlighted by Tella (2017). Its usefulness in science, mathematical and technological activities as well as commerce, economics, education and even humanities is almost at par with the importance of education as a whole. Teachers' interest in the teaching of mathematics could be described as their feeling of wanting to teach the subject and learn more about it. The mathematics teachers at the school where this research study was conducted are a dedicated band, who are passionate about the subject. There are four mathematics teachers in the intermediate and senior phase, each of whom teaches all the learners of a particular grade from Grades 4 to 7. All mathematics teachers at the school have attended training workshops organised by the Department of Education to facilitate the optimal implementation of the content prescribed within the CAPS curriculum in the classroom. The mathematics department at this school has professional learning communities in the foundation phase as well as the intermediate and senior phase. Teachers who attend any developmental workshops or seminars use the professional learning communities as a platform to cascade information to other mathematics teachers. The chairperson and committee members in each phase meet on a regular basis to discuss challenges teachers might encounter, challenges being experienced by learners, assessment tasks, mathematics achievement levels of learners and strategies to improve results, or any other mathematics-related activities.

Bidabadi, Esfahani, Jafari and Abedi (2019) emphasise that learners' learning at school may be influenced by their engagement during instruction. Improving mathematics performance was affected by the task-avoidant behaviour of learners. A high initial level of task-avoidant behaviour caused less and slower progress in mathematics achievement. Also, an increase in learners' mathematics performance across time was associated with a decrease in their task avoidance. In order to stimulate interest in mathematics learning and foster a preference for tasks in the subject, learners need to be constantly motivated using creative methods of teaching and learning. Learners at this school engage in various co-curricular mathematics activities that are organised by a mathematics association, which has been formed by a group of mathematics teachers in the Ilembe district. Learners from Grades 4 to 7 engage in non-routine mathematics problem-solving and games designed to learn mathematics in a fun way, at competitions where learners from rural schools and urban schools participate alongside each other. Learners are very enthusiastic about participation in these activities.

Mathematics is all about finding solutions to problems. The depth of mathematical knowledge an individual has, dictates the level of accuracy of his/her decision. This implies the fact that before an individual can function well in society he/she must possess or have relatively good knowledge of mathematics especially in this technological age. Technological development is highly rooted in the study of mathematics (Tella, 2017). The mathematics curriculum at this school, as in all other public schools in South Africa, is embedded within the NCS, which represents a policy statement for learning and teaching in South African schools. This statement, which has been implemented in South Africa since 2012, comprises CAPS, national policy pertaining to the programme and promotion requirements of the NCS (Grades R to 12), and the national Protocol for Assessment (Grades R to 12) (Motshekga, 2011). According to the NCS, the teaching and learning of mathematics aims to develop a critical awareness of how mathematical relationships are used in social, environmental, cultural and economic relations, as well as to develop confidence and competence to deal with any mathematical situation without being hindered by a fear of mathematics (DBE, 2011).

The creation of an environment conducive to learning is vitally important in the academic achievement of learners. Such an environment extends beyond the classroom and school to include the home. Both school and home environments play significant roles in learners' mathematics performance. It is from these environments that learners draw resources, both tangible and intangible, that impact on their educational experience (Visser, Juan & Fez, 2015). The school where this research was conducted is fairly well-resourced, in so far as educational resources are concerned. All learners from Grades 1 to 7 are issued with a DBE mathematics workbook. In addition to this, learners from Grades 4 to 7 are issued with mathematics textbooks, which are used as additional resources, on loan for the duration of a year. Learners have access to a fully functional school library, where books are available to them on loan for limited periods of time. Learners do not have access to computers at this school however the library/media centre has a projector and screen which are available for teachers to utilise for lesson presentation. Mathematics and other subject related wall charts are also available as supplementary teaching and learning resources. Learners who attend this school come from a diverse range of socio-economic backgrounds, and as such, the availability of learning resources at their homes depends on what is affordable within each family.

4.5. Sampling

Whereas quantitative research requires sufficiently large sample sizes to produce statistically precise quantitative estimates, smaller samples are used in qualitative research. This is because the general aim of sampling in qualitative research is to acquire information that is useful for understanding the complexity, depth, variation or context surrounding a phenomenon, rather than to represent populations as in quantitative research (Gentles, Charles, Ploeg & McKibbon, 2015).

This research study needed to be conducted at a school, since the topic for the research was: exploring Grade 5 learners' perceptions on the use of technology when learning fractions in one Grade 5 class. In order to proceed with any type of research at the school, the researcher needed to obtain permission from the research office at the Department of Education in KwaZulu-Natal. On receipt of the letter stating that permission had been granted by the DBE, the principal of the school had to be informed in writing about the intention to conduct research at the school. This letter can be found in Appendix A. Thereafter the research was allowed to proceed.

Aksakal, Bilecen and Schmidt (2018) indicate that the population of interest, from which the sample is drawn, is to a large extent determined by the research question(s). A carefully developed sampling strategy is therefore necessary in order to assure that the collected data can be used to answer the research question(s), which to a large extent determines the success or failure of an investigation. This study involved the collection of data from participants who fitted the sampling profile. Sampling is the process of selecting individuals or groups from the population of interest to study these groups with the aim of drawing conclusions. The purposive sampling technique, also called judgment sampling, is the deliberate choice of a participant due to the qualities the participant possesses. Simply put, the researcher decides what needs to be known and sets out to find people who can and are willing to provide the information by virtue of knowledge or experience. It is typically used in qualitative research to identify and select the information-rich cases for the proper utilisation of available resources. This involves identification and selection of individuals or groups of individuals that are proficient and well-informed with a phenomenon of interest. In addition to knowledge and experience, availability and willingness to participate and the ability to communicate are also important (Etikan, Musa & Alkassim, 2016).

Sim, Saunders, Waterfield and Kingstone (2018) claim that a range of contributing factors, including methodological considerations such as the nature and purpose of the individual study and the epistemological stance underpinning it, but also practical considerations around time and resources are at play when making sampling decisions in qualitative research; i.e. the need to satisfy practical requirements of indicating sample size in advance, while at the same time seeking to adopt a sampling approach that is in keeping with the methodological considerations pertinent to the particular study. The participants in this study were selected using a purposeful sampling technique. The participants had to meet specific requirements in order to be selected for the research study. The participants were Grade 5 learners who were all in one class, learning mathematics at a school where English was the medium of instruction. The sample of learners was representative of gender, diverse learning ability and of diverse racial and cultural orientation. However, these factors were not important as they did not influence the outcome of this study in any way.

Rosenthal (2016) emphasises that determining the appropriate sample size for in-depth interviews or focus groups is an important step in the research process. In quantitative studies researchers are particularly concerned with obtaining a generalisable sample. However, generalisability is not the primary objective for in-depth interviews of focus groups, but rather the objective is to develop an understanding of the meaning behind behaviours. Therefore, sampling for in-depth interviews or focus groups is about balancing between the need to obtain a rich experiential description from interviewees, without sacrificing the equal representation of experiences across the population of possible participants.

Researchers Korstjiens and Moser (2018) point out that the first few minutes of an interview are decisive. The participant wants to feel at ease before sharing his or her experiences. In a focus group interview, you would start with open questions related to the topic, which invite the participant to talk freely. The questions aim to encourage participants to tell their personal experiences, including feelings and emotions and often focus on a particular experience or specific events. As you want to get as much detail as possible, you also ask follow-up questions or encourage telling more details by using probes and prompts or keeping a short period of silence. You first ask what and why questions and then how questions.

A purposive and convenience sampling strategy was employed in this study. The study was conducted at the school where the researcher was the Grade 5 mathematics teacher since data collection became easier from population members who were conveniently available to participate in the study. The researcher was the mathematics teacher of the grade 5 class which formed the research site for this study. This particular class was chosen at random, for no specific reason. The class that was selected for this research study had a total enrolment of 48 learners made up of 26 girls and 22 boys. The average age of the participants at the time of the research was between 11 and 12 years.

4.5.1. The pilot study

Story, Leslie and French (2018) describe pilot studies as preliminary research activities undertaken to establish the viability of more extensive future research by examining areas of methodological uncertainty. Pilot studies are not designed to test the effectiveness of the intervention, and often do not need a formal sample size. Pilot studies are not limited to evaluating future randomised controlled trials; they are just as relevant to reducing research uncertainty before large observational and epidemiological studies. The pilot study was conducted with learners from the other two Grade 5 classes at the same school. Learners who participated in the pilot study possessed the same characteristics as the participants from the main study.

When preparing for qualitative interviewing it is important to be familiar with the data recording equipment being used. The venue of the focus group interview should also be considered as it may affect the data collection. Interviews should be conducted at a time and place of the respondents' convenience, in a comfortable setting, free from any potential disruptions and noise (McGrath, Palmgren & Liljedahl, 2018). The participants for the pilot study were four groups of five learners who were representative of the racial, cultural and gender demographics of the school. The data generating tools, as well as the venue used during the focus group interviews, was tested in the pilot study. It was also crucial to verify and assess the quality of the audio-recording device used to record the focus group interviews, so that accuracy, precision and validity could be maintains during the transcription of data.

Adjusting the questions after the initial interviews allows the interview guide to be fine-tuned during the interview process in a pilot study. Some questions might turn out to be misunderstood, others to be irrelevant or outside the scope of the research questions (McGrath et al., 2018). Evaluation of the feedback from the pilot study allowed me to make the necessary amendments and adjustments to the research instruments and focus group interview questioning techniques, so that the reliability and validity of my research study could be enhanced. The major research was thereafter conducted with the 40 participants from one class of Grade 5 learners.

4.6. Research methods

The method of any study, according to Netolicky and Barnes (2018), is an idiosyncratic journey for the researcher; it is a process, not a destination. Data, summaries of findings, publications, and presentations, are stops along the way, rather than final products that allow the research to be neatly packed away as finished. Method evolves through a series of decisions, influenced by a multiplicity of factors such as conceptual framework, literature, data, research questions and participant decisions. Method is driven and shaped by purpose and possibility.

Patten and Newhart (2018) explain that research methods are the building blocks of the scientific enterprise. They are the "how" for building systematic knowledge. One way you know things is through your own personal experiences. The empirical approach to knowledge simply means that it is based on observation, direct or indirect, or in other words, on experience. Similarly Rumrill and Bellini (2018) state that within the domain of research methods, the concept of research design refers to the specific plans or arrangements that are used to examine the questions of interest. The quality of the methodology and design of a given investigation forms the essential basis for the strength of the knowledge claims or conclusions that researchers may derive from the research findings.

In line with these descriptions of research methods, this research study sought to investigate how Grade 5 learners perceive the integration of technology into their learning of fractions in mathematics. In order to probe an in-depth study into this phenomenon, it was necessary to use more than one tool to generate information. These tools included the use of the first task-based worksheets, second task-based worksheets and a focus group interview schedule.

4.6.1. Data collection

Data collection only ensues after the preliminary steps of the research design have been fully implemented. After turning to a phenomenon that seriously interests us and commits us to the world, a research question is asked that can potentially answer and help achieve the goals of the study. The research question is the starting point and the primary determinant of the design. Consequently, the researcher plans how to generate the information (data collection) and what to do with this information to make sense of it (data analysis) (Cypress, 2018). Doing qualitative research requires an unparalleled degree of immersion by the researcher as the instrument of data collection. As such, the qualitative researcher must be a sensitive instrument of inquiry, capable of flexibility and on-the-spot decision making about following leads. Whereas the heart of a quantitative report is its statistical findings, a qualitative report is a pieced together, tightly woven whole greater than the sum of its parts (Padgett, 2017).

Halcomb (2016) states that the use of creative methods of data collection may facilitate participant engagement and enhance the richness of the data generated. There are many ways of generating data to capture the multiple realities and gain a deep understanding of the human experience. While interviews, focus groups and observations may be the most common methods of qualitative data collection, qualitative research inherently invites creativity and the use of innovative methods to gain an insight into the participants' world.
The process of data collection in this research study was conducted in the following order:

the learners from all three Grade 5 classes were engaged in the teaching and learning of fractions in mathematics. Thereafter, the learners from the three classes were divided into groups of four or five to complete the first task-based worksheet, with the aid of diagrams and paper folding. The learners from all classes were then shown a PowerPoint presentation and video based on the fraction syllabus for the term in Grade 5, after which a second task-based worksheet was completed by all learners. In accordance with the curriculum content as prescribed by CAPS, mathematics lessons are prepared and forecast prior to being delivered to learners. The learning content and information disseminated to learners is the same for all learners across the grade. Even though this research study involved only one grade 5 class, all three classes had to complete the same activities and engage with the same resources as indicated in the teacher's lesson preparation and forecast. In keeping with the curriculum guidelines provided for the grade 5 mathematics syllabus, all grade 5 learners were exposed to the same learning content. Furthermore, learners from all the grade 5 classes were excited at the idea of using technology to learn fractions in mathematics. Task-based worksheets completed by all grade 5 learners had to be marked and the necessary feedback given to them. Although all three classes participated in the technology-enhanced lessons, the performance of learners was analysed for the extraction of data only from the one class that was involved in the research study. Finally, focus group interviews were conducted, with the participants from the one class who had written permission from their parents to participate in the research study.

4.6.2. Informed consent

While there is no ideal standard for the informed consent process, this researcher looked at informed consent with the assumption that the consent process should be understandable, that participant satisfaction with the consent process matters, and that a good consent process would improve retention and adherence within a study. The intent is to enable an individual to make a decision about participation on the basis of a clear understanding of the research, its risks and benefits, and the commitments associated with enrolling in the study. An effectively communicative informed consent process may aid recruitment, but the goal should be for potential research participants to make an informed decision, not simply to opt in to a research study (Hallinan, Forrest, Uhlenbrauck, Young, & McKinney Jr., 2016).

Furthermore, Ryen (2016) identifies the three ethical issues of consent, confidentiality and trust which are closely linked. Informed consent means the research subjects have the right to know that they are being researched, the right to be informed about the nature of the research and the right to withdraw at any time. Confidentiality means we are obliged to protect each participant's identity, places and the location of the research.

Prior to the commencement of this research study, each learner of the chosen Grade 5 class was provided with a synopsis of the research study, a description of the situation of the research topic within the school curriculum and within the mathematics syllabus as prescribed by department of education. Parents and learners were informed about the research questions and aims of the study, as well as the data generating tools and techniques to be adopted during the research process. Parents and learners were further assured that participation in the research was voluntary and participants were free to withdraw from the project at any time during or after data collection, without penalty. Anonymity of all participants and the school was guaranteed. Parents and learners were provided with relevant details of personnel at the university and the department of education. Each participant was required to provide written consent to participate in the study. The parents or guardian of each participant were also required to provide written consent for their learners or wards to participate in the research study. Only those learners who furnished written consent from their parents were included in the study. Out of a total of 48 learners in the Grade 5 class, four learners' parents did not grant consent to participate in the study and four learners did not return the consent letters. A total of 40 learners participated in the study. A copy of the informed consent letters to parents and learners may be found in Appendix A. The information in Table 3 provides details of the participating learner in terms of age and gender.

Table 3: Description of participating learners

Number of boys	Number of girls	Number of learners at age 11	Number of learners at age 12
19	21	38 (17 boys and 21 girls)	2 (boys)
Total number of participating learners: 40			

4.6.3. Data generating techniques

Etikan et al. (2016) maintain that data generating is crucial in research, as the data is meant to contribute to a better understanding of a theoretical framework. It then becomes imperative that selecting the manner of obtaining data and from whom the data will be acquired be done with sound judgment, especially since no amount of analysis can make up for improperly collected data.

According to Sohn, Thomas, Greenberg and Pollio (2017), the principal mode of accessing first-person accounts of human experience is interviewing. Researchers are encouraged to create an atmosphere for the interview dialogue that ensures privacy, safety, trust and rapport. This atmosphere can best be created by conducting the audio-taped interviews face-to-face, although some have successfully conducted interviews using distance technology such as Skype.

In addition Rosenthal (2016) believes that in focus groups, interviewers should be unobtrusive, draw all interviewees into the discussion by encouraging interaction, and use strategic summarisations of the discussion to help the group refine its thoughts or explanations. From a technical perspective it is also important to consider how to capture the data collected during the in-depth interview or focus group. Typically both in-depth interviews and focus groups are audio recorded for the purposes of later transcription.

Focus group interviews are the data generating tools that were used during this research study. The choice of focus groups was made in an attempt to break down the imbalance of power between researcher and participant, as well as to create a non-invasive and non-confrontational atmosphere during the interviews. Focus group interviews provided the participants with the opportunity to speak with fewer inhibitions in a non-threatening environment.

4.7. Phases of data collection

Data collection, management and analysis according to Cypress (2018), are critical and essential to qualitative research studies. When implemented properly, these processes enhance the quality and rigour of naturalistic inquiries. Data collection and management are also often neglected aspects of qualitative research. Sutton and Austin (2015) reiterate that whatever philosophical standpoint the researcher is taking and whatever the data collection method (e.g. focus group, one-to-one interviews), the process will involve the generation of large amounts of data. In addition to the variety of study methodologies available, there are also different ways of making a record of what is said and done during an interview or focus group, such as taking handwritten notes or video recording. If the researcher is audio or video recording data collection, then the recordings must be transcribed verbatim before data analysis can begin. The role of the researcher in qualitative research is to attempt to access the thoughts and feelings of study participants. This is not an easy task, as it involves asking people to talk about things that may be very personal to them. Field notes allow the researcher to maintain and comment on impressions, environmental contexts, behaviours, and nonverbal cues that may not be adequately captured through the audio recording. Field notes can provide important context to the interpretation of audio-taped data and can help remind the researcher of situational factors that may be important during data analysis.

Cypress (2018) elaborates further that data collection as a series of interrelated activities aimed at generating information to answer emerging research questions. The initial design of a qualitative inquiry should have provision for the kinds of data collection activities that will likely be done at different stages of the study. Data can be collected from more than one source, which could be either from human or nonhuman sources. The human instrument falls back on techniques as interview (ranging from close-ended to open-ended to one-on-one, focus groups or web-based interactions), observation (from participant to nonparticipant), and nonverbal cues. New forms of data have emerged in recent years, such as texts from e-mail messages, short and multimedia messages, living stories, metaphorical visual narratives, digital archives, autobiography, journal, field notes, letters, conversations, personal-family social artefacts, poems, music, sounds, ritual objects and postings from social media. A good qualitative researcher uses rigorous data collection. The process for collecting data during this research study comprised five phases.

4.7.1. Phase 1: Teaching fractions

The first phase of data collection during this research study involved the teaching and explanation of the various sub-topics that together constitute the learning content found in the topic ‘common fractions’, as prescribed for the fourth term in Grade 5.

Research by Beilstein (2019) indicates that within the curriculum of primary mathematics education, fractions are, both for teachers (regarding the knowledge they need to adequately teach fractions) and learners, a complicated topic to teach and learn. Furthermore, according to Koopman, Thurlings and den Brok (2019), fractions are among the most difficult topics that learners encounter in primary mathematics education. Learner proficiency regarding fractions is often problematic. In Grade 5 in the Netherlands, for example, learners find it difficult to solve problems related to improper fractions and mixed numbers or addition and subtraction including fractions, even though instruction has been provided to them about these topics.

Mathematics education research by Wilkins and Norton (2018) indicate that the challenge with fractions may stem from the limitations of part-whole concepts of fractions, which is the central focus of the fractions curriculum and instruction. Learners' development of more sophisticated concepts of fractions, beyond the part-whole concept, lays the groundwork for the later study of important mathematical topics such as algebra, ratio and proportions.

As prescribed in the CAPS curriculum, the fractions syllabus taught in term four must include: counting forwards and backwards in fractions, addition and subtraction of fractions with common denominators, addition and subtraction of mixed numbers, fractions of whole numbers which result in whole numbers, solving problems in contexts involving common fractions, recognise and use equivalent forms of common fractions with denominators which are multiples of each other. All the learners of this class were involved in this activity. After teaching the lessons on fractions, learners were expected to use their knowledge to complete the first task-based worksheet.

4.7.2. Phase 2: First task-based worksheet

The most abstract concept that learners encounter in the basic mathematics education curriculum is fractions and fractions are one of the biggest hurdles in the mathematics learning process in terms of learners (Mumcu, 2018). Current research by Obersteiner, Dresler, Bieck and Moeller (2018) suggest that the human cognitive system is in principle prepared for processing natural numbers and fractions. Although proficiency with natural numbers is fundamental to learning fractions, the transition from natural numbers to fractions requires modifications of the initial concept of numbers, and natural number processing can interfere with fraction processing. Thus, when teaching fractions, it seems important to draw on learners' fundamental abilities to process fractions, while explicating fraction properties that are conceptually different from those of natural numbers.

Mumcu (2018) went on to emphasise that depending on the abstract structure and the different representations, fractions cannot be easily understood by the learners, thus it is important to use novel, innovative pedagogic strategies in the classroom. It is important to use mathematical representations and concrete manipulatives when making abstract concepts or situations as concrete and understandable as possible, especially when the majority of learners at primary level are thought to be in the process of concrete operations.

According to Amalia et al. (2018) teacher-designed learning in each mathematics topic will have an effect on learners' mastery of mathematical concepts. Therefore, teachers must prepare appropriate learning tools. One means to increase learner activity during learning is by using learner activity worksheets. Teacher-made worksheets should be integrated with technology. Teachers must be able to design mathematical tasks using an attractive, varied display of images, stimulating curiosity and understanding of the material.

In line with the socio-constructivist theory of learning, the second phase of the data collection process involved dividing the learners into groups of five or six. Socio-constructivist scholars Amineh and Asl (2015) emphasise that individuals make meanings through their interactions with each other and with the environment they live in. Young learners develop their thinking abilities through interaction with other learners, adults and the physical world. With the importance given to collaboration, knowledge, and creativity through both social constructivism and constructivism, learners can start learning in pair work, group work and teamwork, and later make their own contributions to the world of knowledge.

During this activity it was necessary to group the learners in such a manner that those learners who formed a part of the study sample were grouped together and those learners who were not a part of the study sample were grouped together. As powerful as some apps and technology can be, technology should only complement the teaching and learning of mathematics side by side with explicit teaching and multi-modal activities that encourage verbal and written communication, group discussions and the use of physical manipulatives that encourage kinaesthetic learning (Smith & Harvey, 2014).

As a result of rapid development in technology, utilising materials in education has become important. To date, researchers have often explored the effects of using educational materials in mathematics instruction on academic achievement (Kul, Celik & Aksu, 2018). In general terms, manipulative materials have been central to the call to reform mathematics teaching. Through touching, seeing and doing, learners are enabled to gain deeper and lasting understandings of mathematical concepts. Research also indicates that learners of all ages can benefit by first being introduced to mathematical concepts through the use of manipulative materials. Manipulative materials are used to create an external representation that stands for a mathematical idea in order to eventually develop an internal representation (Day & Hurrell, 2017). A task-based worksheet was administered to each learner in all the groups in the classes. Learners were able to discuss questions with their peers, use diagrams, visual manipulatives and paper folding, to solve the given questions in the worksheet. The responses from all learners' worksheets were reviewed. However, only those worksheets completed by learners who formed a part of the study sample were analysed.

After the completion of the first task-based worksheet, I engaged learners in an interactive teaching and learning session with the aid of a PowerPoint presentation, which integrated the key topics of the fractions syllabus.

4.7.3. Phase 3: Technology-based intervention

For many years, there has been keen discussion about how to change the goal of education from supplying and transferring content knowledge to fostering the learners' ability to learn, which may be the reason why the use of technology in teaching is becoming increasingly popular in schools (Poon, 2018). The development of information and communication technology, according to Zakaria and Khalid (2016), has affected educators' teaching methods through its application in learning and teaching mathematics. The benefits of applying information and communication technology in teaching mathematics are: it attracts learners' interest in learning mathematics; it increases their motivation and performance; it encourages lifelong learning; and it facilitates interactions and relationships. However, Bozkurt and Ruthven (2018) maintain that although the influence of new digital technologies has been increasing over recent decades, their incorporation into mainstream mathematics education has been slow. It has become apparent that teachers play a central role in integrating technology use in mathematics classrooms. The third phase of the research study involved the use of technology to support learners when learning fractions in mathematics.

Technological devices are widely used in various forms and for various purposes with educational systems. In the classroom setting, various methods, techniques, tools and equipment should be utilised in order to improve the efficiency of the teaching and learning process, and one such method is the incorporation of the use of technology (Islim, Ozudogru & Sevim-Cirak, 2018). Responding to the growing demands for informed technology integration into education, the current study explores the perceptions of Grade 5 learners on the use of technology when learning fractions. Studies by Kohen (2019) show that technology enables leveraging of the learning process by helping to create more enjoyable and interesting lessons. Additionally Hensberry, Moore and Perkins (2015) posit that computer technology**,** when coupled with reform-based teaching practices, has been shown to be an effective way to support learner learning of mathematics. The incorporation of technology into the teaching of fractions in the Grade 5 mathematics lesson was intended to assist learners in decoding and resolving those issues that hinder a clear understanding of the concepts being taught.

Furthermore research by Chen (2015) indicates that while using technology is an important competency for learners, technology could also function as an enabler of teaching and learning. Technologies could extend learning to spaces beyond classrooms, allow for new curricula that bring real-world problems into schools, and support new forms of assessment that are more formative and immediate.

The Grade 5 learners were taken to the school media centre where they were given the opportunity to view a PowerPoint presentation, the content of which included the different sub-topics in the fractions syllabus. During this presentation learners were able to engage in an interactive session, where they were able to express their views on the lesson presentation and ask questions pertaining to the content of the PowerPoint presentation. This was an important point at which to gauge how learners perceive the incorporation of technology into their learning of fractions. The use of technology in classroom activities has become increasingly important and has given a digital dimension to learning mathematics. This method of teaching learners is in keeping with the work of Yilmaz, Ozdemir and Yasar (2018) who posit that technology has begun to change teaching and learning processes related to mathematics, because the use of technology helps learners to visualise mathematical concepts and makes these concepts more understandable instead of promoting memorisation of complex and abstract mathematical topics.

At the end of the technology-based lesson on fractions, learners were required to complete the second task-based worksheet.

4.7.4. Phase 4: Second task-based worksheet

Amalia et al. (2018) indicate that the teacher can make a guided discovery of the material through a worksheet designed by the teacher. This is because the teacher knows his/her learners better and the teacher knows how to explore the knowledge and curiosity of his/her learners. A worksheet can be designed to help learners identify and analyse important mathematical concepts.

Phase four of the research process was a stage to elaborate and reinforce all the concepts that the learners were exposed to within the sub-topics of fractions in mathematics. The content and style of questioning within the second task-based worksheet was very similar to that of the first task-based worksheet. Learners were asked to answer questions based on the fraction number line, ordering of fractions, addition and subtraction of fractions, addition and subtraction of mixed numbers, equivalence of fractions, fractions of whole numbers that result in whole numbers and fraction word problems. The aim of the post-task worksheet was to ascertain whether the intervention of technology had influenced the way in which learners answered questions on the teaching and learning of fractions in Grade 5. All learners completed the post-task worksheet consisting of the content taught during the classroom activities, as well as the PowerPoint presentation. However, the worksheets completed by learners who had parental consent to participate in the research were used for the purposes of analysis.

4.7.5. Phase 5: Focus group interviews

Moser and Korstjens (2018) emphasise that in a focus group discussion, the sequence is intended to facilitate the interaction between the participants, and you might adapt the sequence depending on how their discussion evolves. Working with an interview guide or questioning route enables the researcher to collect information on specific topics from all participants. Researchers are in control in the sense that they give direction to the interview, while the participants are in control of their answers. However, the researcher needs to be open-minded to recognise that some relevant topics for participants may not have been covered in the interview guide or questioning route, and need to be added. The interview guide and questioning route might include open and general as well as subordinate or detailed questions, probes and prompts. Probes are exploratory questions, for example, ‘Can you tell me more about this?’ or ‘Then what happened?’ Prompts are words and signs to encourage participants to tell more.

The data collection process in this research study was concluded by conducting focus group interviews using semi-structured methods, guided by a schedule of open-ended questions. According to Zahle (2018) the methods of focus group interviews require the researcher to pose questions to a research participant, who is permitted or encouraged to digress, to expand on her responses, to exemplify her points, and to introduce her own concerns. Focus group interviews are usually conducted in the settings in which the research participants live their lives. In the focus group interview, the researcher has prepared various questions, and she guides the conversation to a degree that produces data that allow the researcher to understand the research participants’ perspectives, their experiences, views and the like.

Similarly, Reeves et al. (2015) describe qualitative interviews as tools which afford researchers opportunities to explore, in an in-depth manner, matters that are unique to the experiences of the interviewees, allowing insights into how different phenomena of interest are experienced and perceived. Considering the relationship between participants and researchers and the emphasis on the exploration of human phenomena, interviews have traditionally been a data-collection method linked with qualitative research. Qualitative interviewing is a data-collection tool that is useful in a range of methodological approaches and may therefore be applied to address a number of research questions. However, qualitative research interviews are preferable when the researcher strives to understand the interviewee’s subjective perspective of a phenomenon rather than generating generalisable understandings of large groups of people.

At this point, only those learners who had signed assent forms and whose parents or guardians signed consent forms, were part of the focus group interviews. A total of 40 participants, grouped into eight groups of five learners each, were interviewed during this research. Building rapport and establishing comfortable interactions in the qualitative interview situation is important and is preferably done well in advance of the interview, but also during the interview itself. In qualitative research, the researcher is the prime instrument of data collection. Consequently, the interviewer needs to be reflexive, conscious, and aware about how his or her role might impact the conversation between the interviewer and interviewee (McGrath et al, 2018). I did not use any prescriptive methods to group the participants in this focus group interview session. I allowed the participants to choose the group they preferred, as I wanted the participants to be comfortable among their peers so that they could engage in the focus group interview session without any inhibitions or feelings of intimidation. It was anticipated that this strategy would allow me to extract thick, information-rich data from the participants.

Focus group interviews were conducted to investigate how the participants developed their fraction conceptual understanding before and after the use of technology (Ito, 2015). Lochrie, Curran and O'Gorman (2015) state that as a long-established research method, qualitative interviews involve a conversation between the researcher and the subject, towards developing an understanding of central themes and research questions. The interviewer has to be able to listen, prompt appropriately, and interact with the interviewee effectively. Good interviewers are personable, fostering a trust and rapport with the interviewee. Gaining valuable data from an interviewee who is relaxed and enjoying the process is far easier than one who is on edge and suspicious. The use of focus group interviews allowed me as the researcher, to generate interactive conversation among the participants relating to their experiences and perceptions about the learning of fractions. By creating an informal atmosphere, I ensured that participants felt relaxed and comfortable, thus enabling me to minimise the power hierarchy between researcher and participants.

Once the focus group interviews were conducted the next step was the transcription of the audio recordings to written text for further analysis. The conversations were recorded using a digital recorder and information was transcribed verbatim.

4.8. Ethical considerations

Cypress (2018) maintains that data collection involves more than the different forms of data and the procedures for collecting them. It involves consideration of the ethical issues involved in gaining entry and approval from the research site, protecting the rights of the participants including informed consents, choosing and conducting an appropriate sampling strategy, planning the mode of recording information, storing the data securely, and properly using and disseminating findings. Respondents should be fully and completely informed that an interview is taking place and how many times, the purpose, and how the resulting information will be used. Focus group interviews entail certain steps and are at times conducted more than once. The researcher should prepare for the focus group interview, take initial steps and pace the interview according to how the interviewees respond and to keep the process productive. Permission should be obtained to gain access to the research site, participants should sign the informed consent, and care should be taken in the recording and storing of data to protect the privacy and confidentiality of information.

In this study the publication of results was carried out without bias, honestly and by citing the original reliable resources and references. Furthermore Moosavi and Hasani (2017) state that general principles and ethical considerations in qualitative research with learners as participants are similar to other qualitative research and include attention to learners' participation, obtaining informed consent, ability to establish friendly and honest relationships, confidentiality and researcher's sensitivity regarding publication of information and the imbalance of power. The ability to establish a friendly relationship and win the learner's trust play an important role in the learner's active participation in the research process as well as reducing the imbalance of power between the researcher and the learner. Thus, research involving learners ought to be carried out in a valuable, supportive and safe environment using appropriate methods that support their social and mental abilities, so that learners are able to easily express their opinions.

The participants in this research study were assured of confidentiality of information divulged during the data generating process at all times, as well as anonymity at all stages of the research process. The questions and discussions were clearly and carefully structured so as to alleviate any misconceptions or misunderstandings, which could impact negatively on the quality of the data.

4.9. Validity and reliability

Qualitative research, according to Haven and Van Grootel (2019), often uses language as its data, often collected via an interview, a focus group (structured group discussion), or via observation. Qualitative research tries to reveal the perspectives of the subjects that the research question regards. It uses an emergent design, referring to the iterative process of combining data analysis, preliminary data inspection, and data collection. The flexibility of this emergent design can strengthen and deepen the rigor and validity of the qualitative study, instead of undermining it. The qualitative researcher typically functions as part of the measurement instrument itself, and has a great say in generating findings from the data.

Triangulation is a strategy used to reduce the risk that the researcher's conclusion will reflect only the systematic biases or limitations of a specific source or method and allows one to gain a broader understanding and more secure understanding of the issues under investigation. If the data generated from different sources are found to be consistent, the credibility of the study is promoted. Richer descriptions of phenomena thus result and better validity and accuracy of the findings (Cypress, 2018). The incorporation of more than one data-generating tool, such as task-based worksheets and focus group interviews, means that triangulation has been used as a strategy in this research study. The use of multiple data collection strategies to corroborate the findings, allowed for triangulation of the participants' responses about the use of technology when learning fractions in Grade 5.

4.10. Trustworthiness

Cypress (2018) refers to trustworthiness as quality, authenticity and truthfulness of findings of qualitative research. It relates to the degree of trust, or confidence, readers have in results. Trustworthiness addresses methods that can ensure one has carried out the research process correctly. In each study, researchers should establish the protocols and procedures necessary for a study to be considered worthy of consideration by readers (Amankwaa, 2016). As qualitative research becomes increasingly recognised and valued, it is imperative that it is conducted in a rigorous and methodical manner to yield meaningful and useful results. To be accepted as trustworthy, qualitative researchers must demonstrate that data analysis has been conducted in a precise, consistent, and exhaustive manner through recording, systematising, and disclosing the methods of analysis with enough detail to enable the reader to determine whether the process is credible (Nowell, Norris, White & Moules 2017).

The necessary procedures and conventionalities were abided by during data collection so as to validate the data in multiple ways.

4.11. Limitations

Identifying limitations, and explaining to the reader what impact these limitations have on the study results, not only demonstrates rigour but also gives the authors a chance to identify clear directions for future research (Greener, 2018).

Both convenience sampling and purposive sampling share some limitations which include non-random selection of participants, that is to say the researcher is subjective and biased in choosing the subjects of the study. This impedes the researcher's ability to draw inferences about a population (Etikan et al., 2016). The sampling technique used in this study was purposive and convenience sampling. Although I was the mathematics teacher of the participants, and this could have led to bias and subjectivity, I ensured at all times that my involvement did not influence the responses of the learners in any way. The collection and analysis of data in this research study was not influenced by, and remained independent of my opinions, beliefs and viewpoints at all times.

The limitations that were anticipated prior to commencement of the research included the reluctance on the part of participants to volunteer answers during the focus group interview. That would have had a negative impact on the generation of information-rich data which was beneficial to my research study. Initially, during the focus group interviews the participants appeared to be nervous and reluctant to engage in any discussions emanating from the interview questions as per the interview schedule. The participants seemed to be looking for some sort of reassurance or hints from the researcher that their responses met with the approval of the researcher. In order to allay their concerns and overcome the problem, I engaged in informal conversations with the participants, reassuring them all the time that all their answers were acceptable as there were no right or wrong answers. This led to some excitement among the participants and their reluctance soon gave way to eager and audible explanations. Another limitation is that the sample size in this research study was small. My strategy to overcome this was to conduct an in-depth study in order to extract detailed, information-rich data.

4.12. Conclusion

This chapter included the design and methodology within which this study is located. The chapter goes on to discuss the data collection methods and techniques, the sampling procedures and context of the study. As indicated by Christensen and James (2017), it became evident during the research process that researchers need not adopt different methods per se when researching learners and childhood. Rather, they need to adopt practices that resonate with learners' cultures of communication, their own concerns and fit in to their everyday routines. At the end of the data collection process, focus group interviews were transcribed and relevant information was assimilated. The next chapter focuses on a discussion of the detailed analysis of data generated for this research study.

Chapter Five: Presentation and Analysis of Findings

5.1. Introduction

In chapter four the research methodology, which included the design and techniques of data collection, was discussed. This chapter is devoted to the presentation and analysis of findings arising from the data that was generated from the first task-based worksheet, the second task-based worksheet, as well as the focus group interviews conducted with the learners.

This chapter begins with a description of the responses extracted from participants in the first and second task-based worksheets. A brief account of the background to the focus group interviews is presented, after which the impact of technology on the learning of fractions and findings from the focus group interviews are discussed.

5.2. Analysis of the frameworks used in the study

The theories that framed this study included the socio-constructivist theory, the anchored instruction theory, the cognitive flexibility theory, the ZPD, scaffolding and the collaborative learning theory. The socio-constructivist theory offers that the acquisition of knowledge becomes a reality as a result of social interaction, thus proposing that learning is a shared experience rather than an individual one. The aim of the anchored instruction theory is to promote the problem solving skills of learners with the use of technology. The cognitive flexibility theory recommends that in order for effective learning to take place, learners must embrace the use of multiple methods when approaching new learning content. ZPD highlights the social aspect of learning by advocating that what learners can achieve with support and assistance is more substantial than what they achieve by learning individually. The main tenet of scaffolding indicates that the temporary support that is given to learners gives them the confidence to use that support when engaging in independent learning. Collaborative learning involves communication amongst learners as they engage in group work, where ideas are shared and a higher level of thinking is promoted.

This study employed the use of all of these theories as the researcher sought to answer the key research questions. Social interactions amongst learners when engaging in group work were rooted in the scaffolding and collaborative learning theories. The use of technology in the learning of fractions lends itself to the anchored instruction theory, which identifies the use of technology as an anchor for learning to take place. The cognitive flexibility theory came to the fore with the use of multiple methods of teaching and learning which included worksheets, visual manipulatives and technology. Furthermore, the support that learners received from their peers, learning resources and teacher is associated with the ZPD and scaffolding. All these theories linked with each other and came together in providing the researcher with information-rich data for the study.

5.3. Qualitative analysis

Qualitative analysis, the method employed during this research study, involves the analysis of textual, visual, or audio data and covers a spectrum from confirmation to exploration (Mihas, 2019). Furthermore, Bhattacharya (2017) posits that there are different ways in which one can approach data management and analysis in qualitative research. Data management is the process through which the researcher manages a large volume of data. Often this process could include chunking small analytic units from the larger body of raw data for closer analysis. Inductive analysis in qualitative research refers to working "up" from the data. Interpretation of qualitative research involves developing narratives about the ways in which the researcher is co-constructing meaning with her participants. Often this involves analysing data, looking within various chunks of data, identifying analytical insights, and reflecting on the insights gained through some narrative format. Along these lines, this research study involved looking at textual and audio data obtained from worksheets and learner responses to the focus group interview questions for the purpose of analysis and extraction of information-rich data.

Similarly, Braun, Clarke, Hayfield and Terry (2018) believe that familiarisation, which requires the researcher to shift focus from data generation (including transcription) to analysis, is fundamentally about appreciating the data as data. The process involves becoming immersed in the data and connecting with them in different ways: engaged, but also relaxed; making casual notes, but being thoughtful and curious about what you are reading. It is not about attaching formal labels but about looking for what is interesting about the data and what you notice about possibilities, connections (between participants, data, and existing literature). By providing a solid foundation of interrogating and thus knowing your data, it certainly makes the rest of the analysis much more enjoyable.

One of the challenges to qualitative research is the open-ended nature of data as opposed to numbers only. Examples of qualitative data can include interview transcripts, newspaper articles, questionnaire responses, diaries, videos, images, or field observations. Text as data is often more difficult to reduce and identify patterns than numbers as data (Castleberry & Nolen, 2018).

The data analysis procedure in this research study resonates with the ideas presented by Braun et al. (2018), who go on to say that familiarisation includes listening to audio data, watching video data, and/or reading and rereading textual data, noticing interesting features, and making notes about individual data items, as well as the whole dataset. These notes should be shaped by your research question(s), as well as broader questions about what is going on in the data.

Interview scripts, field notes and observations provided a descriptive account of the study for the purpose of data analysis. Employing the socio-constructivist theory as the theoretical lens, data generated from this study were analysed in response to the research questions.

Data collection for this research study included task-based worksheets, as well as, focus group interviews conducted in accordance with an interview schedule. The first task-based worksheet was completed by all learners, prior to the introduction of technology into the lesson. The second task-based worksheet was completed after learners had watched a video and PowerPoint presentation, which incorporated the various topics related to fractions within the prescribed mathematics curriculum. Figure 7 is a diagrammatic representation of the four phases that were followed during collection of data in this research study.

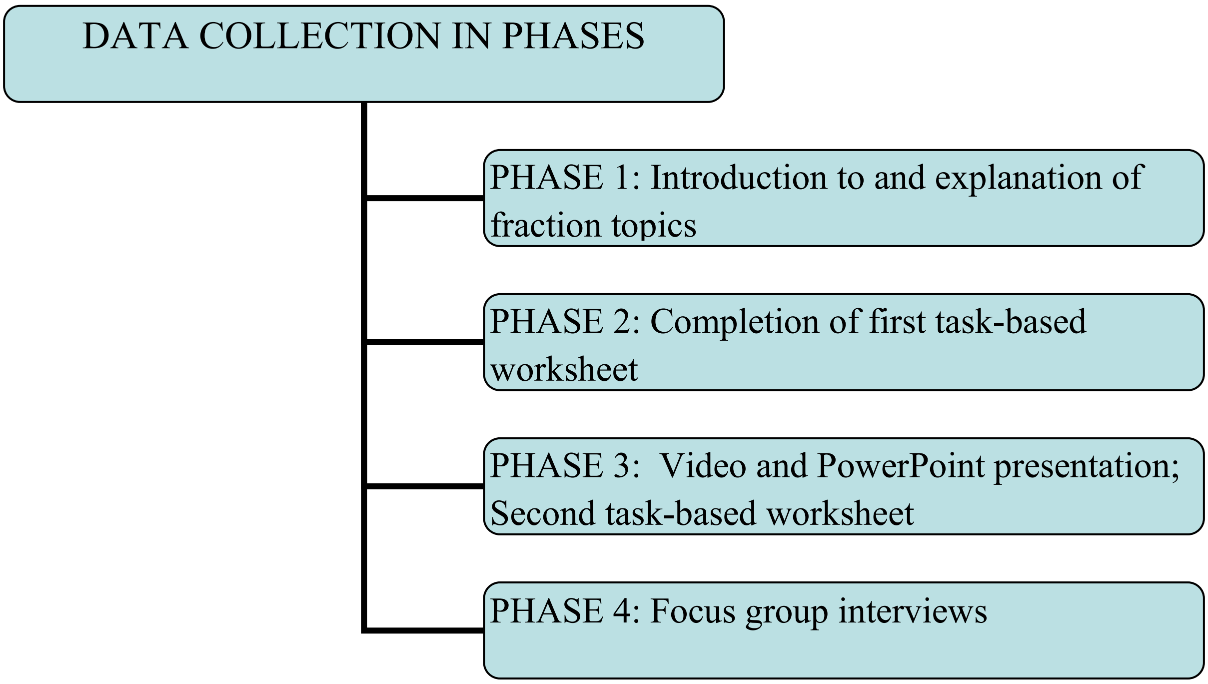


Figure 7. Phases of data collection (Researcher's own construction)

5.4. Presenting the responses of participants

During the first stage of the research study the relevant topics and sub-topics related to fractions were taught and explained to the Grade 5 learners. At this stage learners engaged in inquiry-based learning by becoming involved in discussions, questions and interactions around fraction problems. Thereafter, written exercises involving fraction calculations were completed.

Prior to the presentation and discussion of the responses that were elicited from the participants in this research study, I provide a brief description of the participants, as well as the processes which were followed during collection of data. This is a vital component of this chapter since it is necessary to situate the findings in the wider context of the research study.

The Grade 5 class which was selected for this research study had an enrolment of 48 learners. Four learners did not participate in the research study because their parents did not consent to their participation, and another four learners did not return the consent forms. Hence, 40 learners were interviewed in this research study.

When the responses to the task-based worksheets have been examined, it can be seen that learners had experienced challenges in answering questions on fractions contained in the first task-based worksheet, which was done prior to the introduction of technology into the lesson. After the implementation of technology in the form of a video and PowerPoint presentation, some of the learners seemed to have achieved more clarity on the questions related to fractions in the second task-based worksheet. The examination of answers to questions in the second task-based worksheet indicate that learners made fewer mistakes than they did in the first task-based worksheet. However there were learners who were unable to solve fraction problems even though multiple methods were used in an attempt to clarify the misconceptions learners encounter when dealing with fractions in mathematics.

The aim of presenting the learners responses to questions in the task-based worksheets was to draw a comparison between the responses in the first task-based worksheet and the responses in the second task-based worksheet. In order to make a viable inference from the observations, the solutions to the same questions recorded by the same learners in both worksheets are presented in the extracts. The responses from the learners seemed to assert that the use of technology expanded the understanding of the learning of fraction content. For the purposes of this comparison I had to select only those learners who met certain criteria: learners had to complete both the first and second task-based worksheets; learners had to be those who had written permission to participate in the study. Three learners did not complete the first task-based worksheet in groups as they were absent from school, hence there were 37 learners who fulfilled all the criteria, of which 20 were girls and 17 were boys.

5.4.1. Responses from the first task-based worksheet

In order to complete the first task-based worksheet during the data collection process, learners were allowed the use of visual manipulatives, pictures and diagrams. In line with the principles of the socio-constructivist theory, learners were first divided into groups of five or six, after which the worksheet was completed by all learners. The worksheets were collected by the researcher for review and further analysis. In the responses that were reviewed it was found that the learners encountered challenges when engaging in activities that involved solving problems related to fractions. Learners seemed to experience difficulty in solving questions related to fractions on a number line, equivalent fractions, addition and subtraction of fractions, fractions of whole numbers and fraction word problems. The responses to questions in the first task-based worksheet are presented in Figures 8, 9, 10 and 11.

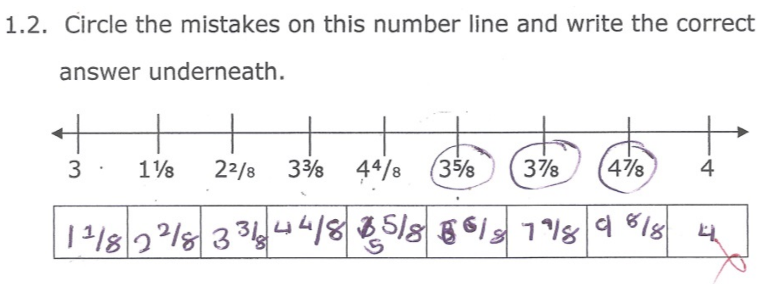


Figure 8. Nancy's response to the question on number lines

Figure 8 provides evidence of the way in which Nancy responded to the question relating to fractions on a number line. It is clear that she experienced much difficulty and confusion when approaching this question.

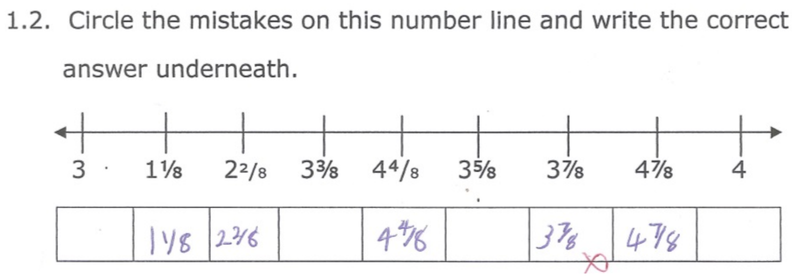


Figure 9. Peter's response to the question on number lines

Similar to Nancy's response, Figure 9 indicates that Peter too was unsuccessful in answering the question based on fractions on a number line. There seemed to be much uncertainty among learners when asked to order the fractions on a number line in question 1.2 of the first task-based worksheet.

The responses to the questions based on fractions on a number line can be related to the findings of Widodo and Ikhwanudin (2018) who indicate that the part-whole aspect is dominant in learners' thinking, and learners have difficulties in perceiving a fraction as a number on a number line. The types of errors learners make when they deal with fractions on the number line are the error of unit confusion and the estimation error.

Data in Figures 10 and 11 led this researcher to infer that the questions on fractions of whole numbers proved to be a challenge for Kim and Thabo who were unable to calculate the fractions of whole numbers. There seemed to be confusion and lack of understanding when it came to answering questions based on fractions of whole numbers. The data reveals that learners found this question to be challenging as only 26% of the learners answered the question correctly in the first task-based worksheet.

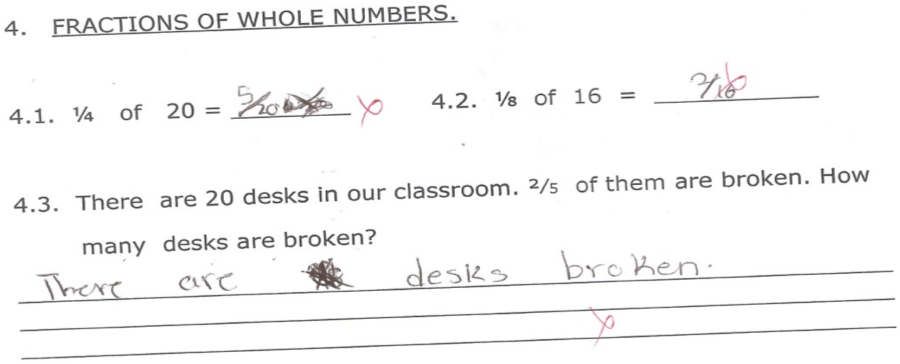


Figure 10. Kim’s response to the question on fractions of whole numbers

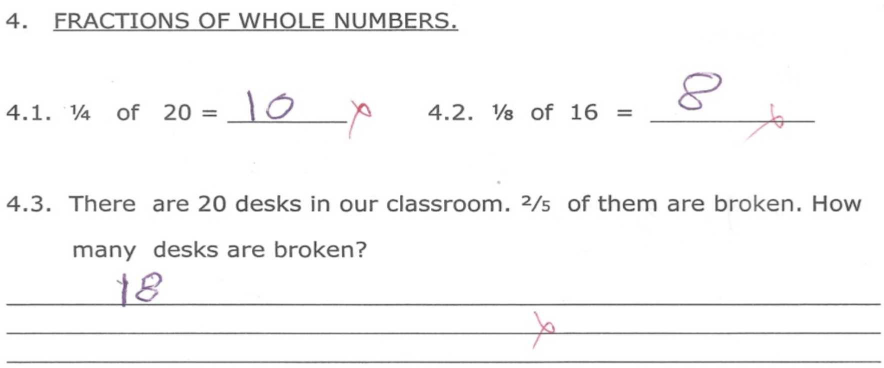
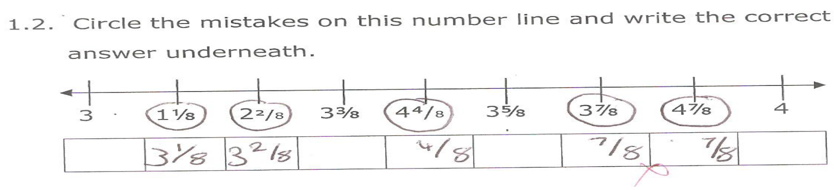


Figure 11. Thabo’s response to the question on fractions of whole numbers

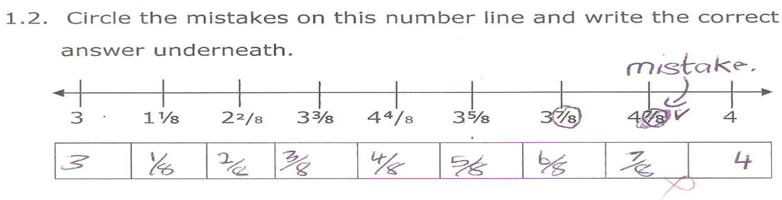
The figures that follow present responses by other learners to the questions in the first task-based worksheet. The responses were selected randomly and are included to reflect on how learners interacted with the questions in the first task-based worksheet.

Question 1 (1st task-based worksheet)

Pam



Nkosi



Sally

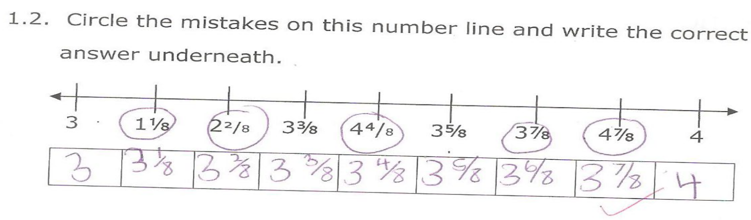


Figure 12. Selected learners' responses to Question 1 (1st task-based worksheet)

Question 2 (1st task-based worksheet)

John

2. EQUIVALENT FRACTIONS.

Use the diagram below to write the equivalent fraction for.

1 WHOLE							
½				½			
¼		¼		¼		¼	
⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛

2.1. ¼ = 4/4

2.2. 4/8 = 8/8

Siba

2. EQUIVALENT FRACTIONS.

Use the diagram below to write the equivalent fraction for.

1 WHOLE							
½				½			
¼		¼		¼		¼	
⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛

2.1. ¼ = 1/8

2.2. 4/8 = 5/8

Nkosi

2. EQUIVALENT FRACTIONS.

Use the diagram below to write the equivalent fraction for.

1 WHOLE							
½				½			
¼		¼		¼		¼	
⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛

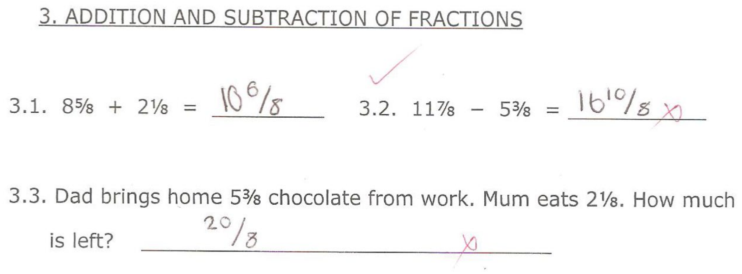
2.1. ¼ = [illegible]

2.2. 4/8 = [illegible]

Figure 13. Selected learners' responses to Question 2 (1st task-based worksheet)

Question 3 (1st task-based worksheet)

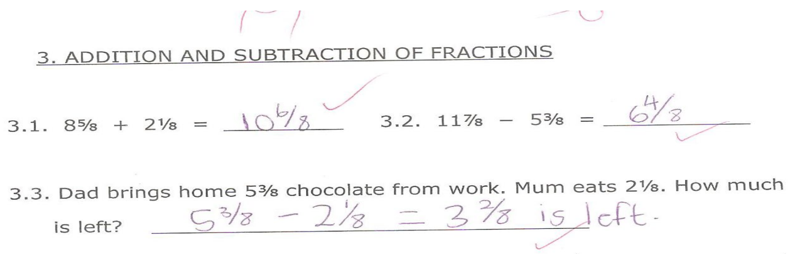
Pam


3. ADDITION AND SUBTRACTION OF FRACTIONS

3.1. 8⅝ + 2⅛ = 10 6/8 3.2. 11⅞ − 5⅜ = 16 10/8

3.3. Dad brings home 5⅜ chocolate from work. Mum eats 2⅛. How much is left? 20/8

Sally


3. ADDITION AND SUBTRACTION OF FRACTIONS

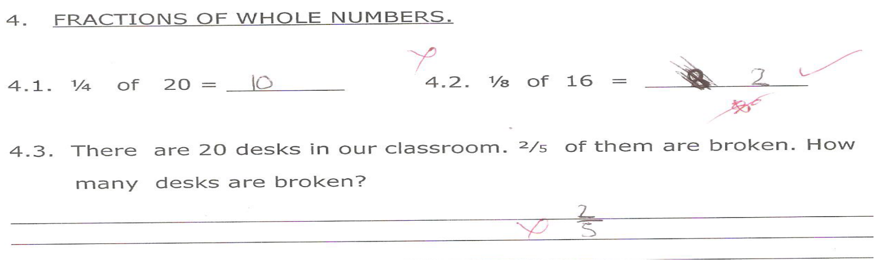
3.1. 8⅝ + 2⅛ = 10 6/8 3.2. 11⅞ − 5⅜ = 6 4/8

3.3. Dad brings home 5⅜ chocolate from work. Mum eats 2⅛. How much is left? 5 3/8 − 2 1/8 = 3 2/8 is left.

Figure 14. Selected learners' responses to Question 3 (1st task-based worksheet)

Question 4 (1st task-based worksheet)

John

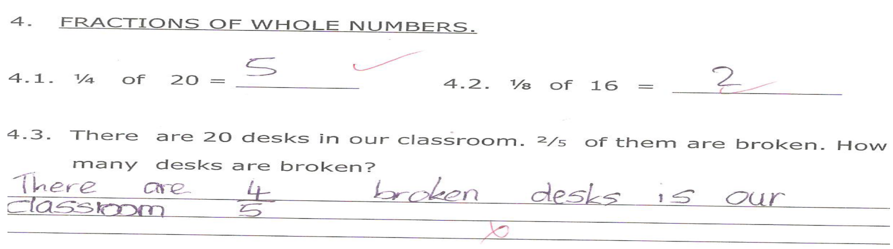

4. FRACTIONS OF WHOLE NUMBERS.

4.1. ¼ of 20 = 10 4.2. ⅛ of 16 = 2

4.3. There are 20 desks in our classroom. ⅖ of them are broken. How many desks are broken?

2/5

Sally


4. FRACTIONS OF WHOLE NUMBERS.

4.1. ¼ of 20 = 5 4.2. ⅛ of 16 = 2

4.3. There are 20 desks in our classroom. ⅖ of them are broken. How many desks are broken?

There are 4/5 broken desks is our classroom

Figure 15. Selected learners' responses to Question 4 (1st task-based worksheet)

The responses to the questions in the first task-based worksheet suggest that learners experienced challenges in solving questions related to the different aspects of fractions. While some of the learners managed to answer the questions correctly, there were others who were not able to solve the fraction-related problems successfully. This is indicative that the topic of fractions requires further interrogation and explanations that may assist in clarifying any misconceptions. As it is the aim of this research study to explore the use of technology when learning fractions in mathematics, the researcher employed the use of videos and a PowerPoint presentation as tools to support the learners in their learning of fractions.

Table 4: Summary of results from the first task-based worksheet

QUESTION NUMBER	CORRECT ANSWER	INCORRECT ANSWER	% CORRECT	TOPIC
1.1.	21	16	57	Ordering & Comparing Fractions/ No. lines
1.2.	17	20	46	
2.1.	8	29	22	Equivalent Fractions
2.2.	9	28	24	
2.3.a)	19	18	51	
2.3.b)	24	13	65	
				Addition & Subtraction of Fractions
3.1.	26	11	70	
3.2.	24	13	65	
3.3.	19	18	57	
				Fractions of Whole Nos./ Fraction Word problems
4.1.	11	26	30	
4.2.	15	22	41	
4.3.	3	34	8	

The summary of results from the first task-based worksheet indicates that learners had difficulty with answering questions based on many of the aspects related to fractions in mathematics. The section involving fractions of whole numbers proved to be the most challenging to learners with only 8% of learners getting question 4.3 correct. The two questions on equivalent fractions proved to be a challenge as well, producing 78% and 76% of incorrect answers.

5.4.2. Responses from the second task-based worksheet

The third stage of the data collection process included the incorporation of technology into the teaching and learning process to reinforce the learning content that learners had thus far been exposed to. Learners were presented with a lesson on the fraction content of the mathematics curriculum in the form of a PowerPoint presentation as well as a video recording. Thereafter, the learners completed the second task-based worksheet which consisted of the content that was taught and explained during the classroom activities, as well as, the content viewed in the video recording and PowerPoint presentation.

Learners may have found that the misconceptions they had about concepts and procedures related to fractions had become more coherent and intelligible after they had experienced the technology-enhanced lesson. While there were some learners who found that they had fewer misconceptions regarding the concepts and procedures related to fractions after the intervention of technology into the mathematics lesson, there were some learners who still experienced challenges when answering questions related to fractions in the second task-based worksheet. This could be attributed to the fact that learners who participated in this research study were of diverse learning ability. Learners' responses to the questions in the second task-based worksheet are presented in Figures 16, 17, 18 and 19 that follow.

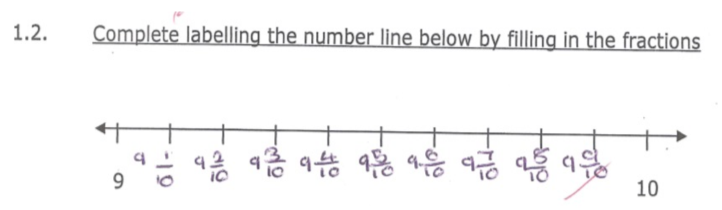


Figure 16. Nancy's response to a question on number lines

Figure 16 provides evidence of reorganisation in Nancy's reasoning with the way in which she solved a similar question in the first task-based worksheet. Nancy seemed to have achieved clarity on the question relating to fractions on a number line, in the second task based worksheet. The response of Peter indicates that he too experienced fewer difficulties in answering the questions in the second task-based worksheet.

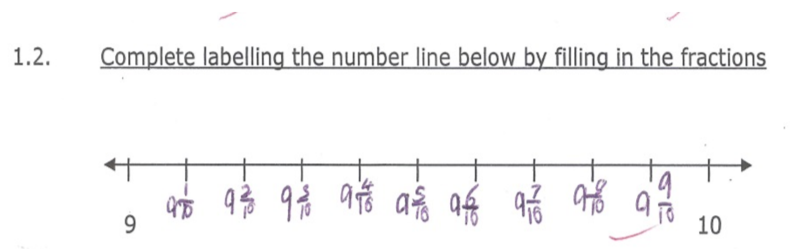


Figure 17. Peter's response to the question on number lines

Figure 17 presents data depicting Peter's thinking and understanding of how to order fractions on a number line. Peter answered the question correctly in the second task-based worksheet. The question on number lines was the one that attracted the most number of positive responses in the second task-based worksheet.

Kim and Thabo managed to solve the problems on fractions of whole numbers successfully, as is evident in their respective responses below.

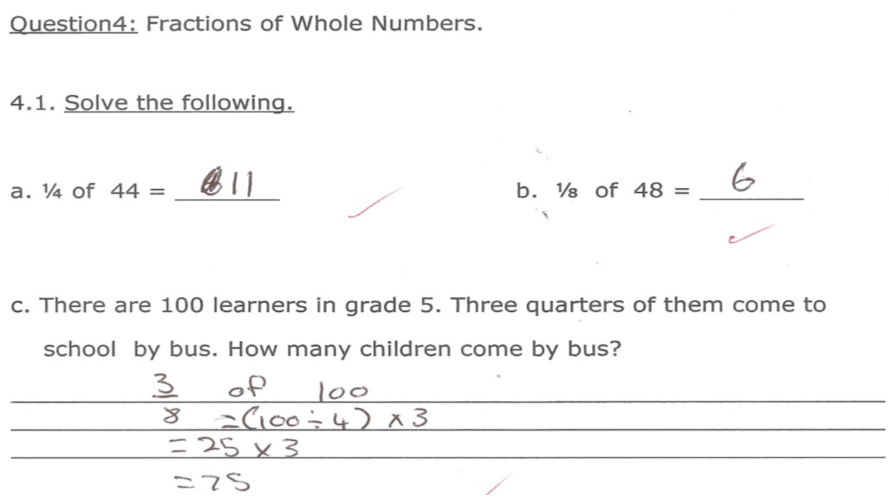


Figure 18. Kim's response to a question relating to fractions of whole numbers

Figure 18 illustrates Kim's ability to properly interpret and solve the questions on fractions of whole numbers, which she was unable to solve in the first task-based worksheet.

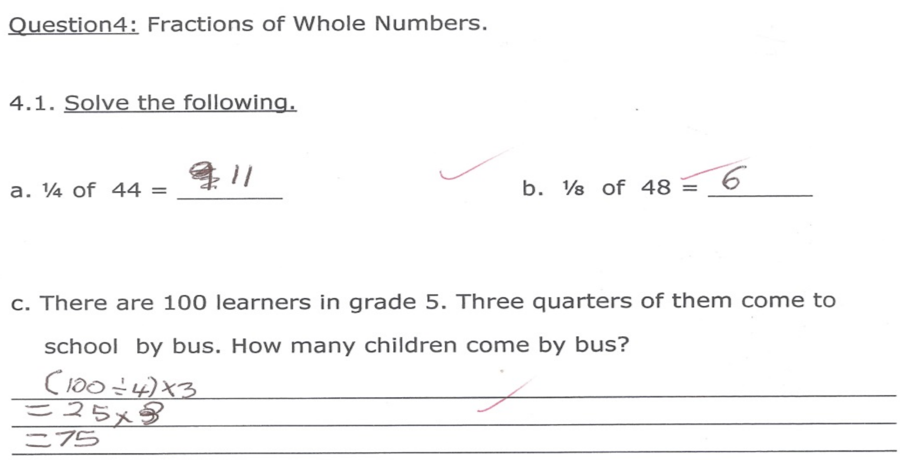


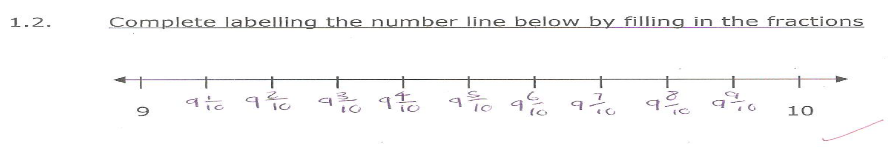
Figure 19. Thabo's response to a question relating to fractions of whole numbers

Similarly, Thabo's solution to the question on fractions of whole numbers (Figure 19) provides data that the incorporation of technology into the mathematics lesson contributed positively in assisting learners to gain a better understanding of fractions.

The responses of other learners to questions in the second task-based worksheet are presented in the figures that follow. The choice of learners' responses was random, and were included to stregthen the observations from figures 16 to 19, that the use of technology had a positive impact on the learning of fractions.

Question 1 (2^{nd} task-based worksheet)

Amanda



Alice

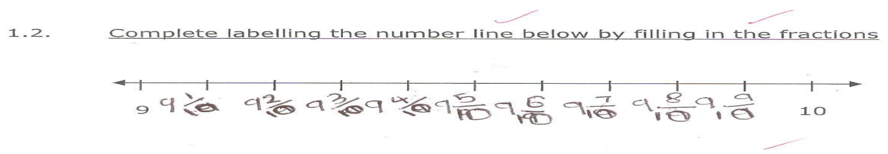
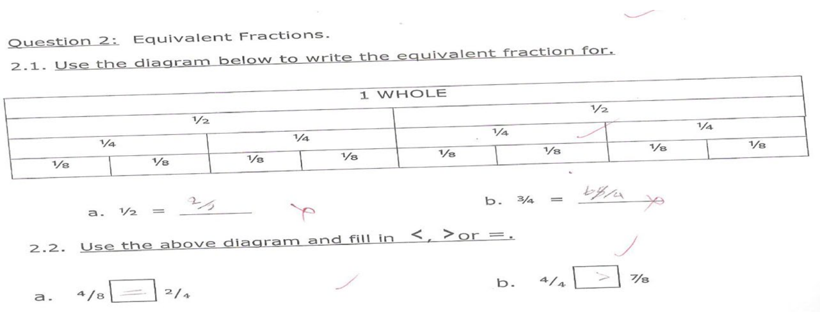


Figure 20. Selected learners' responses to Question1 (2^{nd} task-based worksheet)

Question 2 (2nd task-based worksheet)

Sihle


Question 2: Equivalent Fractions.

2.1. Use the diagram below to write the equivalent fraction for.

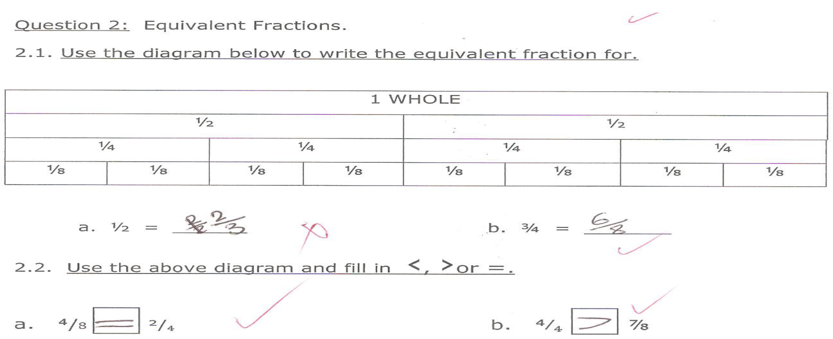
1 WHOLE							
½				½			
¼		¼		¼		¼	
⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛

a. ½ = 2/3 b. ¾ = 6/4/8

2.2. Use the above diagram and fill in <, > or =.

a. 4/8 [=] 2/4 b. 4/4 [>] 7/8

Alice


Question 2: Equivalent Fractions.

2.1. Use the diagram below to write the equivalent fraction for.

1 WHOLE							
½				½			
¼		¼		¼		¼	
⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛

a. ½ = 2/3 b. ¾ = 6/8

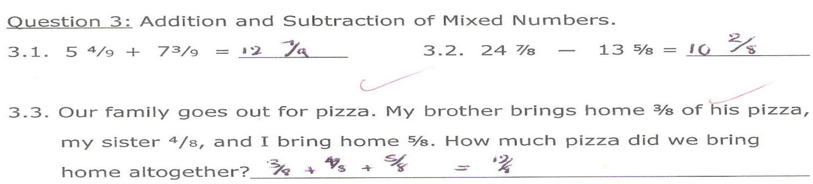
2.2. Use the above diagram and fill in <, > or =.

a. 4/8 [=] 2/4 b. 4/4 [>] 7/8

Figure 21. Selected learners' responses to Question 2 (2nd task-based worksheet)

Question 3 (2nd task-based worksheet)

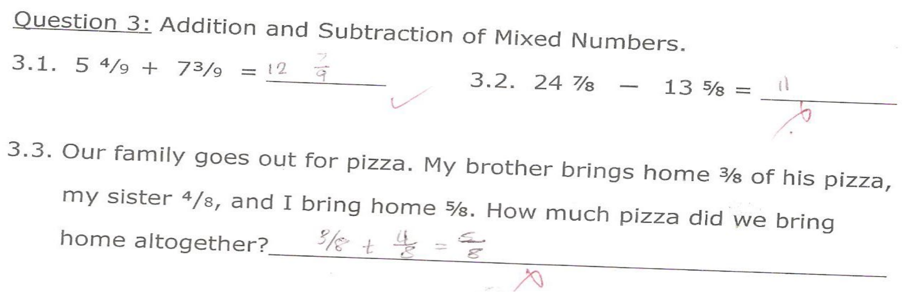
Amanda


Question 3: Addition and Subtraction of Mixed Numbers.

3.1. 5 4/9 + 7 3/9 = 12 7/9 3.2. 24 7/8 — 13 5/8 = 10 2/8

3.3. Our family goes out for pizza. My brother brings home 3/8 of his pizza, my sister 4/8, and I bring home 5/8. How much pizza did we bring home altogether? 3/8 + 4/8 + 5/8 = 12/8

Sihle


Question 3: Addition and Subtraction of Mixed Numbers.

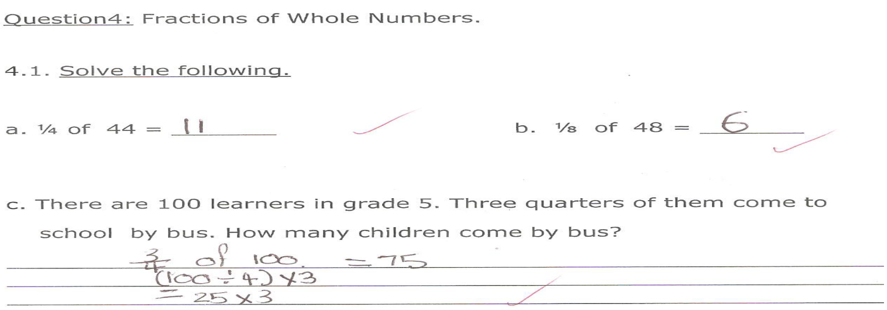
3.1. 5 4/9 + 7 3/9 = 12 7/9 3.2. 24 7/8 — 13 5/8 = 11

3.3. Our family goes out for pizza. My brother brings home 3/8 of his pizza, my sister 4/8, and I bring home 5/8. How much pizza did we bring home altogether? 3/8 + 4/8 = 5/8

Figure 22. Selected learners' responses to Question 3 (2nd task-based worksheet)

Question 4 (2nd task-based worksheet)

Alice


Question4: Fractions of Whole Numbers.

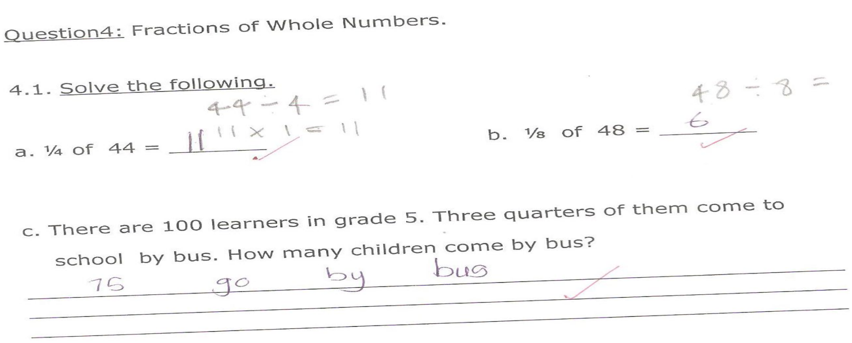
4.1. Solve the following.

a. ¼ of 44 = 11   b. ⅛ of 48 = 6

c. There are 100 learners in grade 5. Three quarters of them come to school by bus. How many children come by bus?

¾ of 100 = 75
(100 ÷ 4) x3
= 25 x 3

Amanda


Question4: Fractions of Whole Numbers.

4.1. Solve the following.

44 ÷ 4 = 11   48 ÷ 8 =

a. ¼ of 44 = 11 11 x 1 = 11   b. ⅛ of 48 = 6

c. There are 100 learners in grade 5. Three quarters of them come to school by bus. How many children come by bus?

75 go by bus

Figure 23. Selected learners' responses to Question 4 (2nd task-based worksheet)

Figures 20 to 23 are further examples of learner responses which indicate that learners performed more successfully in solving problems related to fractions in the second task-based worksheet. The incorporation of technology as an addition to the teaching tools used in this study, aided in clearing some of the misconceptions associated with the learning of fractions.

Table 5: Summary of results from second task-based worksheet

QUESTION NUMBER	CORRECT ANSWER	INCORRECT ANSWER	% CORRECT	TOPIC
1.1.	30	7	81	Ordering & Comparing Fractions/ No. lines
1.2.	36	1	97	
2.1.a)	25	12	68	Equivalent Fractions
2.1.b)	19	18	51	
2.2.a)	26	11	70	
2.2.b)	25	12	68	
3.1.	27	10	73	Addition & Subtraction of Fractions
3.2.	25	12	67	
3.3.	22	15	60	
4.1.a)	27	10	73	Fractions of Whole Nos./ Fraction Word problems
4.1.b)	25	12	68	
4.1.c)	32	5	87	

The summary of results from the second task-based worksheet indicates that learners achieved better results than they did in the first task-based worksheet. A total of 89% of learners answered question one correctly, as opposed to 51% who answered correctly in the 1st task-based worksheet. Equivalent fractions which was challenging for learners in the first task-based worksheet (41% correct), saw an improvement of 23% in the second task-based worksheet. Similarly, learners achieved better results when solving problems associated with fractions of whole numbers and fraction word problems (an improvement of 50%).

5.4.3. Responses from focus group interviews

Maher, Hadfield, Hutchings and de Eyto (2018) indicate that deep and insightful interactions with the data are a prerequisite for qualitative data interpretation. The researcher must also employ imaginative insight as they attempt to make sense of the data and generate understanding and theory. Research is also dependent upon the researchers' creative interpretation of the data. To support the research process, researchers surround themselves with data, both as a source of empirical information and inspiration to trigger imaginative insights. Constant interaction with the data is integral to research methodology.

Along similar lines, Erlingsson and Brysiewicz (2017) maintain that a common starting point for qualitative content analysis is often transcribed interview texts. The objective in qualitative content analysis is to systematically transform a large amount of text into a highly organised and concise summary of key results. Analysis of the raw data from verbatim transcribed interviews to form categories or themes is a process of further abstraction of data at each step of the analysis; from the manifest and literal content to latent meanings.

The data collection process in this research study was concluded by engaging learners in focus group interviews, conducted in accordance with an interview schedule comprising a series of open-ended questions. The focus group interview schedule was used as a guide by the researcher in order to pursue a line of questioning relevant to the research topic that would elicit data which could be related to the key research questions.

Roberts, Dowell and Nie (2019) describe focus group interviews, as utilised in this case study, aspects of descriptive research which allow a comprehensive summary of events in everyday terms, and allow for in-depth exploration of a specific phenomenon. The aim is to understand phenomena through meanings that people assign to them. Through the ability to investigate this descriptive data, new perspectives, concepts and themes may be uncovered. Although the inquiry may be value-bound, the researcher aims through the adoption of their ontological and epistemological lens to identify a range of beliefs without introducing bias from their own world view.

At the beginning of the focus group interviews, learners seemed a bit nervous and reluctant to answer the questions freely. Having reassured the learners that there were no right or wrong answers and by using probes and prompts, the participants became more relaxed and began to answer the questions with fewer inhibitions.

Castleberry and Nolen (2018) state that compiling the data into a useable form is the first step to finding meaningful answers to the research questions. Compiling might mean transcribing so that the researchers can easily see the data. If the data needs transcribing from an interview or focus group, some experts recommend that the researcher do the transcription herself. While this takes much more time, the closeness to the data that is achieved during this process can jumpstart the other steps of the data analysis process.

In line with the views of Castleberry and Nolen (2018), the data in this research study was transcribed verbatim by the researcher. To reinforce the data presentation and discussion, the actual verbatim responses of the participants are cited. Since this study is situated within qualitative research, the researcher endeavoured to encapsulate the lived experiences of the participants through their voices and perceptions.

In all of the focus group interviews conducted during this research study, the participants indicated that the use of technology in the mathematics curriculum had a positive impact on the learning of fractions. Participants indicated that initially they faced challenges in the various sub-topics that form the content of the fractions syllabus. These challenges ranged from recognising the numerator and denominator to addition and subtraction of fractions, arranging fractions on a number line, equivalent fractions, working with whole numbers and fractions together, fractions of whole numbers and fraction word problems. However, after the learners watched the video and PowerPoint presentation on fractions, the learners felt a bit more confident when tackling problems associated with the learning of fractions.

5.4.3.1. The impact of technology on the learning of fractions

Technology takes learners to a multidimensional world where processes such as imagination, perception and emotion are intertwined. Accordingly, their learning experience and preference of learning methods contribute to the formation of their conceptions of learning (Cheng, 2018). The 21st century has seen unprecedented investment from governments around the world in educational technologies in schools (Kearney, Schuck, Aubusson & Burke, 2018). Furthermore, Magdalene and Sridharan (2018) define educational technology as the field of technology that contributes towards the development and application of the methods that aid or promote education. It can also be looked at as the study and practice of simplifying the learning process by using, creating or managing the technological resources available. E-Learning can simply be stated as instruction delivered on a digital device that is intended to support learning. The process of e-learning is simplified by using the available resources and enhancing the experience of remote learning. Technology, in the form of e-learning as described by Magdalene and Sridharan (2018), was used in this research study which seeks to promote a better understanding of fractions in mathematics, a topic which many learners find challenging at school.

Likewise, Agrawal (2019) concurs that the benefits of using technology in education can no longer be denied as it infiltrates every area of our lives. In fact, the advantage of using technology in education is that technology enhances the fun in learning, better prepares learners for the future, promotes interaction and engagement, and allows for self-paced and personalised learning. Teaching and learning that incorporates the use of a digital device is becoming popular at institutions of learning all around the globe. This research study aims to investigate the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics. Hence it is of great significance to this study to highlight the rapid growth of an industry that promotes the use of technology in learning. The steady increase in the use of digital devices as shown in Figure 16 is indicative of the fact that teaching and learning at schools is changing from the traditional way of learning to incorporating e-learning in the classroom. Furthermore, Mnisi (2015) highlights that it is critical for learners to know how to communicate, collaborate, and present their ideas in order to navigate through various challenges in the real world. In most instances, these learners are generally using technology such as the internet and social media or technological equipment like smart phones and iPads. A graphic representation of the growth of the e-learning industry is depicted in Figure 24 that follows.

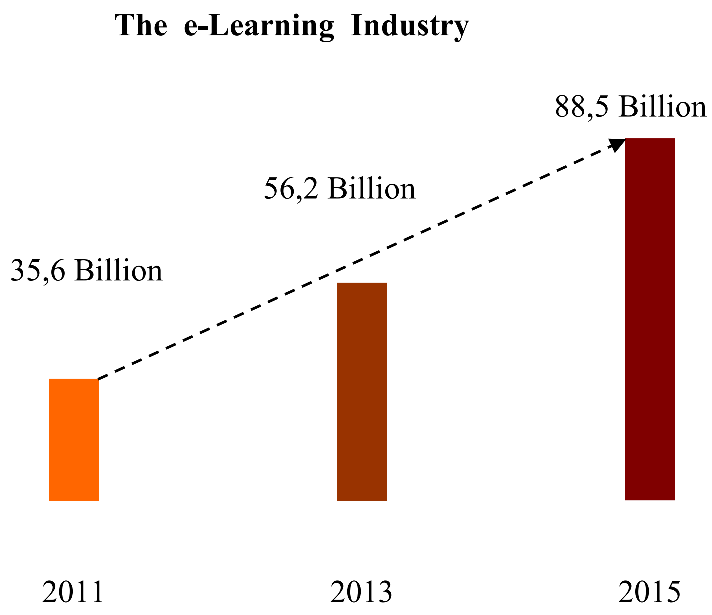


Figure 24. Growth of the e-learning industry from 2011 to 2015
Adapted from Magdalene and Sridharan (2018, p. 60)

5.4.3.2. Findings from the focus group interviews

In order to explore the perceptions of grade 5 learners on the use of technology, learners were expected to answer a series of questions during a focus group interview session. In this section the findings from data that address the key research question are presented.

From the focus group interviews and observations it became apparent that the use of technology had a positive impact on the learning of fractions for the Grade 5 learners who participated in this research study. All the learners seemed to be unanimous in their conclusion that the use of technology in mathematics learning has enhanced their understanding of fractions, thus making fractions seem easier and more accessible. The responses of learners to the questions in the first task-based worksheet indicated that 55% of learners did not fully understand how to perform calculations that involved the use of fractions. However, the responses that were recorded after the intervention of technology indicate that 72% of learners were more interested in the task and their engagement in the activities was deeper, thus producing more correct answers to the questions.

5.4.3.2.1. What are the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics?

In response to the first key research question, learners were asked the following questions in the focus group interviews: Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this? The following narrative captures the response of one of the participants:

"…I loved watching how all the fractions were explained. It was different from how we did fractions before…" (John, age 11, Grade 5).

As a teacher of mathematics, it is not often that one hears positive comments from learners when referring to the learning fractions. Fractions are the aspect of mathematics that learners find to be challenging and confusing. The positive comments made by the learner in the above extract reciprocates the impact made by the use of technology as a teaching tool. A further analysis in light of the above extract revealed that there was a consensus among participants that fractions became simpler to understand with the use of technology when learning fractions in mathematics.

"…Yes. It is easy when you showed us how it works out…" (Kim, age 11, Grade 5)

"…Yes…I was a bit confused before but now I understand…" (Siba, age 11, Grade 5).

It was found that all forty of the participants agreed that fractions were easier to understand after watching the video. However, participants had different reasons for finding it easier. Another learner sounded optimistic when she revealed that the explanations offered in the PowerPoint presentation supplemented the information that was provided during class teaching and the use of manipulatives, thus enabling her to solve the fraction problems in the worksheet with more confidence.

"...I think it is easy because they explained how to do the sums… like if it is mixed numbers you can understand how to do it…" (Lihle, age 11, Grade 5).

The learners' statements are reinforced by Mendoza and Mendoza (2018) who assert that the application of adequate and innovative resources and strategies, such as the introduction of technology in mathematics activities, favours the flexibility of learners' thinking because it stimulates the encounter of different solutions to the same problem. Besides, it allows a wider deployment of learners' cognitive resources to facilitate the processes of meaningful learning building; that is the reason why it is important to promote the use of technology as a teaching tool.

With the growing incorporation of ICT into learning and teaching, the use of technology offered an alternate method of instruction in the classroom setting because of its ability to provide an environment for learners to effectively acquire knowledge. The research findings corroborate with the hypothesis that technology-based learning is more effective when combined with traditional class-based learning in acquiring mathematical knowledge.

5.4.3.2.2. How do Grade 5 learners use technology when learning fractions in mathematics?

The next section of the research study embraces the participants' responses to the second key research question: How do Grade 5 learners use technology when learning fractions in mathematics?

One of the problems identified during the teaching and learning of fractions was the misconception that the numerator and denominator are two separate whole numbers instead of one rational number. In the current mathematics curriculum (CAPS) for Grade 5 learners at South African public schools, the learning content does not include fractions in the first quarter of the academic year. Learners therefore become familiar with natural numbers during the first three months of their new grade. When fractions are introduced in the second quarter of the year, learners have to adjust to a new concept and this could be the reason why they continue to treat the numerator and denominator as two separate natural numbers. Research by Loc, Tong and Chau (2017) offer a similar observation that before learners learn fractions, they have to work with natural numbers for a long time. Therefore, it is certain that they will be influenced by the previous knowledge when learning new knowledge. The use of technology provided a tool to stimulate interest and improve proficiency in the learning of fractions in mathematics.

Deringol (2019) offers the following explanation regarding confusion of the numerator and denominator: As learners think the characteristics of fractions are the same as those of other numbers, they try to apply the same rule, and this leads to the development of their misconceptions. In the primary school mathematics curriculum, fractions are after the introduction of integers. However, fractions have different characteristics. While operations with fractions conceptually resemble those with integers, they are different to integer operations due to their numbers of operational steps. Learners perceive the denominator and the numerator in fractions as two separate integers. The main reason for this is that learners use their knowledge on natural numbers when they encounter fractions. A visual explanation of the numerator, denominator and other fraction concepts provided a means to address the misconceptions that individual learners may have, thus allowing learners to achieve success in fraction problem solving.

Moreover, textbooks present the concept of fractions as the number of equal parts in a whole. Learners are taught the concept through observing the picture of a circle divided into four equal parts in which three parts are shaded in the same colour, as can be seen in Figure 17 below. It is said that three over four is a fraction. This attempt to introduce the concept of fractions may not be sufficient to clarify the difference between natural numbers and fractions to Grade 5 learners. It therefore becomes imperative that teachers utilise all available resources in an effort to elucidate and further explain the concept of fractions to learners.

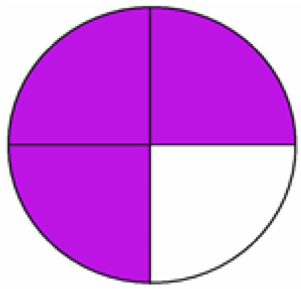


Figure 25. Diagram representing $\frac{3}{4}$ as a fraction

During the focus group interviews learners were asked: Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video? Affirming the notion that the use of technology is beneficial in learning fractions, one learner responded in the following manner:

"...Yes, so I don't get confused when we just say fractions…" (Ann, age 11, Grade 5).

The confusion with natural numbers and fractions is exacerbated further when learners are required to add and subtract fractions. When asked to add two fractions many learners continue to add the numerators together and add the denominators together. Once again this was explained in detail during the video presentation, thus clarifying the method of addition and subtraction of fractions to learners. Another question related to the numerator and denominator of fractions was: How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? One learner responded thus:

"...Now I understand which ones to add and which ones not to add…" (Lihle, age 11, Grade 5).

Larry (age 11, Grade 5) explained that:

"...It's much easier… I can see that you only add the numerator not the denominator…"

Mark (age 11, Grade 5) reiterated that:

"... I know it now….you plus the top and the bottom stays the same…"

The challenges of adding and subtracting fractions are examined further by Loc et al. (2017) who state that for teachers there is nothing difficult, but for learners in primary school, because they are thoroughly conversant with adding two natural numbers, their knowledge of adding two fractions may be similar to that of adding two natural numbers.

This idea is further supported by Alkhateeb's (2019) statement that learners add or subtract two fractions in the same way that they add and subtract the integers. The strategy of dealing with fractions as integers is the most noticeable; learners treat the integer part and the decimal part as if they were all integers with a certain separator between them, and treat the numerator and denominator of the regular fraction as two independent integers.

The learners in this study used technology as a learning tool to support their learning of fractions in a way that allowed them to make sense of the content, engage in critical thinking and expand their learning experience. The use of videos and the PowerPoint presentation served to bring a sense of excitement to the learning process, and to motivate enhanced understanding of fractions in mathematics.

5.4.3.2.3. Why do Grade 5 learners use technology when learning fractions in mathematics in the way that they do?

The participants in this study were able to identify factors for discussion around the third key research question: Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics?

At the school where this research study was conducted, the teachers, management and administrative staff have access to computers, the internet and email. However, the learners at the school do not have access to any technological facilities. Teachers are allowed to make use of the projector and screen available in the school library. For learners at primary school level the aspect of fractions in mathematics is seen as a daunting and boring subject. As such learners would welcome any form of deviation from the mundane, routine methods of teaching fractions that teachers traditionally use. When asked to air their views on the video presentation, the enjoyment and fun aspect to learning fractions was cited by many of the participants. Learners seemed to discover a lighter side to learning, which would assist in alleviating the notion of mathematics anxiety which learners experience. The element of enjoyment and appeal is captured in the learners' views which are expressed in the statements that follow:

"...At first I thought that fractions were hard, but then our teacher showed us this movie about fractions. Now I think that fractions are easy. I understand what a numerator and denominator are after the PowerPoint presentation…" (Susan, age 11, Grade 5).
"…Yes it made me learn too much of things…and it was fun too…" (Akhona, age 11, Grade 5).

"...It reminds me about the movies we watch…it makes you learn a lot of things…"(Siba, age 11, Grade 5).

What is evident from the response of the participants is that in order to attract learners' attention to learning, methods of teaching and learning should be fun as it might be difficult to gain their interest once they have lost it. Furthermore, Lee and Chan (2019) propose that if we can make learning more fun and enjoyable, the learning content can inspire learners' interest in learning mathematics and the qualities inspired by mathematics such as the power of reasoning, creativity, critical thinking, problem-solving ability, and effective communication skills can be more easily developed in the future. It is hoped that by enabling learners to create, share, and discuss fun-based problems for others to solve, they would feel encouraged to create and share knowledge, and eventually, have a greater appreciation of mathematics and technology. Likewise, Rahayu, Putri, Zulkardi and Hartono (2019) emphasise that it is important to adapt the process of learning activities to the progress of the times, in such a way that learning becomes fun.

The participants believed that the use of technology when learning fractions enabled them to remember what they had learnt. They were able to use more than one of their senses and the visuals and images made the learning content more accessible to them. This view is captured in Mark's response that follows:

"... Fractions are easy after we watched the video. The video actually helped us…so we can remember our work…" Mark (age 11, Grade 5).

Other learners echoed similar views on why they use technology in the way that they do when learning fractions in mathematics:

"…It made me understand more about fractions and it made me see that it's easier than what people think it is…" (Lihle, age 11, Grade 5).

Learning by using technology supports memorisation, problem solving, learners' capability development, language and mathematics (Rahayu et al., 2019). Previous research has shown that one of the potential ways to diversify the learning experiences of young people in the classroom and promote active learning, is by using technology. Videos, animations and math manipulatives are typical mediums that are used to help visualise math concepts in computer-based environments. Some learners felt that this new way of doing maths had helped them grasp abstract maths concepts and as a result helped them remember better (Fabian, Topping & Barron, 2018).

Furthermore, the findings from the study of Dele-Ajayi, Strachan, Pickard and Sanderson (2019) provide insights into the changes that occur in the dynamics of the traditional classroom through the introduction of digital technology, especially in settings where it has not been previously used. In order to create an engaging experience for learners, mathematics classrooms should introduce ways to make learning exciting and adventurous. There ought to be a shift from the traditional method of teaching to those that engage better by appealing to more than one of the senses.

The learning experiences of learners' were manifested in their comments about the use of technology as an unconventional method of disseminating information regarding fractions in mathematics. Learners explained that it was an alternate learning experience, which had intrigued them to an extent where this technology-based lesson would leave a lasting impression on them.

"…This was the first time I saw a maths movie… I really enjoyed it and I learned a lot…" (Akhona, age 11, Grade 5).

"…This was the first time we used a computer (laptop) for maths. It will be fun to do our other subjects like this too…" (Larry, age 11, Grade 5).

It is to be expected that when learners are exposed to something new, it is viewed as a novelty by them. This was achieved by exposing the learners to other styles of teaching which they could relate to, thus allowing information to be imprinted in their minds. Collins and Halverson (2018) echo a similar view by stating that all around us people are learning with the aid of new technologies: learners are playing complex video games, workers are interacting with simulations that put them in challenging situations, learners are taking courses at online high schools and colleges, and adults are consulting social media. New technologies create learning opportunities that challenge traditional schools and colleges.

Technological developments lead to changes where the teacher as a source and provider of knowledge becomes a facilitator and the learner a learning partner. One of the teacher's roles in improving the effectiveness of learning in the classroom is by using technology-based media (Rahayu et al., 2019). These new learning niches enable people of all ages to pursue learning on their own terms. We all know that technology has transformed our larger society. It has become central to people's reading, writing, calculating and thinking, which are the major concerns of schooling. And yet technology has been kept in the periphery of schools, used for the most part only in specialised courses (Collins & Halverson, 2018). Similarly, Mendoza and Mendoza (2018) highlight that technology is an alternative innovation resource that helps learners to improve their learning by successfully mastering content.

After the intervention of the technology-based lesson, learners mentioned that they felt more relaxed and less anxious about learning fractions. The comments made by some of the learners confirmed that there was a sense of confidence that they would be able to retain the acquired knowledge. The use of technology in teaching fractions to the Grade 5 learners in this research study has made a positive impact on their experience of learning. When the novelty aspect is combined with the fun aspect of the lesson, it is bound to be an experience that learners will remember well. The introduction of technology into the lesson has changed the mind-set of the learners into a feeling of self-assurance arising from an appreciation of their own abilities to remember what they have learned. This change in attitude to learning is evident in the following statement made by Ann:

"...The videos made me more relieved that I don't have to worry. It taught me more..." (Ann, age 11, Grade 5).

Segumpan and Tani (2018) highlight one of the obstacles to successful mathematics learning as the attitude of learners towards the subject. To match the interests of the 21st century learners, the teachers now are challenged to create a learning environment outside the classroom instruction schedule which involves the use of technology. The use of technology also creates lighter atmosphere while discussing mathematics and caters for the growth of interests of the learners. The positive outlook that emanates from the above statement made by Ann is indicative of the creation of a more confident attitude that has been adopted by learners as they engage in fraction learning.

Mathematics anxiety is a common problem in many classrooms. Richardson and Suinn (1972) originally defined mathematics anxiety as a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations. According to Furner (2019) mathematics anxiety still continues to plague our society and affects our young peoples' success and achievement with the subject. Mathematics anxiety can be prevented by making use of innovative teaching methods such as the use of manipulatives, cooperative groups, discussion of mathematics, questioning and making conjectures, justification of thinking, writing about mathematics, problem solving approaches to instruction, content integration and technology.

Likewise Celik (2018) describes mathematics anxiety as a feeling of intense frustration or helplessness about one's ability to do mathematics. Learners experience extreme discomfort and feelings of anxiety when thinking or doing mathematics and the term generally used to describe this state is mathematics anxiety. Teachers' delivery techniques may have an effect on learners' mathematics anxiety. Overcoming mathematics anxiety means that we need to examine the classroom environment, and how we teach mathematics in the classroom. Addressing anxiety and self-esteem of learners, and improving their confidence and related attitudes to mathematics are crucial. The use of technology and innovative methods in teaching and learning can be a vital strategy to create a positive attitude to mathematics learning by learners who may have a fear of the subject. Improving learner enjoyment of mathematics is a key strategy to address the anxieties of learners.

The response of participants cited above accentuates the point that learners need the intervention of technology in their mathematics curriculum so as to facilitate successful teaching and learning. The idea that learning became easier with the use of technology is a common thread running through all of the responses. Similar notions were also manifested in the responses expressed by the learners in the study, indicating that technology can be used as a motivating resource in teaching and learning activities in mathematics. It became very clear that the presentation of the lesson in the form of a video influenced learner engagement positively, there by promoting deep and active learning.

5.5. Conclusion

In chapter five I presented the findings and analysis of the task-based worksheets and focus group interviews. Although the findings of this study emerge from a relatively small dataset, they do highlight some important issues. In summary, the findings of chapter five indicate that learners perceive the use of technology in the learning of fractions as an essential tool in achieving success.

Chapter six will entail a discussion of the findings and how I made sense of the data through the lens of the theoretical frameworks presented in chapter three.

Chapter Six: Discussion of themes that have emerged

6.1. Introduction

Chapter five was a presentation and analysis of the findings as per the data collected for this research study. The process of data analysis was discussed and the excerpts from task-based worksheets and focus group interviews were analysed. This chapter takes the analysis further by identifying the themes that were extracted from the narratives.

The chapter begins with manifesting the emergent themes in this research study. The key themes that emerged from the data will be presented as follows:

- Technology as a more appealing and fun way of learning
- Retention of acquired knowledge
- Providing an alternate learning experience
- Creating a positive attitude to the learning of fractions
- Reinforcing key skills/concepts

There will also be a discussion on the ways in which technology aids in the learning process where there might be a diversity of language among learners. The use of technology to promote multimodal learning exposure to other styles of teaching is then examined. A further discussion follows on the ways in which technology makes fractions simpler to understand and the link of technology-enhanced learning with scaffolding and the ZPD.

Descriptive content analysis studies are not based on a specific qualitative tradition and are varied in their methods of analysis. To obtain a sense of the whole, analysis starts with reading and rereading the data, looking at themes, emotions and the unexpected, taking into account the overall picture. The analysis of the content aims to identify themes, and patterns within and among these data (Moser & Korstjens, 2018).

Castleberry and Nolen (2018) articulate that a model of qualitative data analysis can be outlined in five steps as per Figure 26: compiling, disassembling, reassembling, interpreting and concluding.

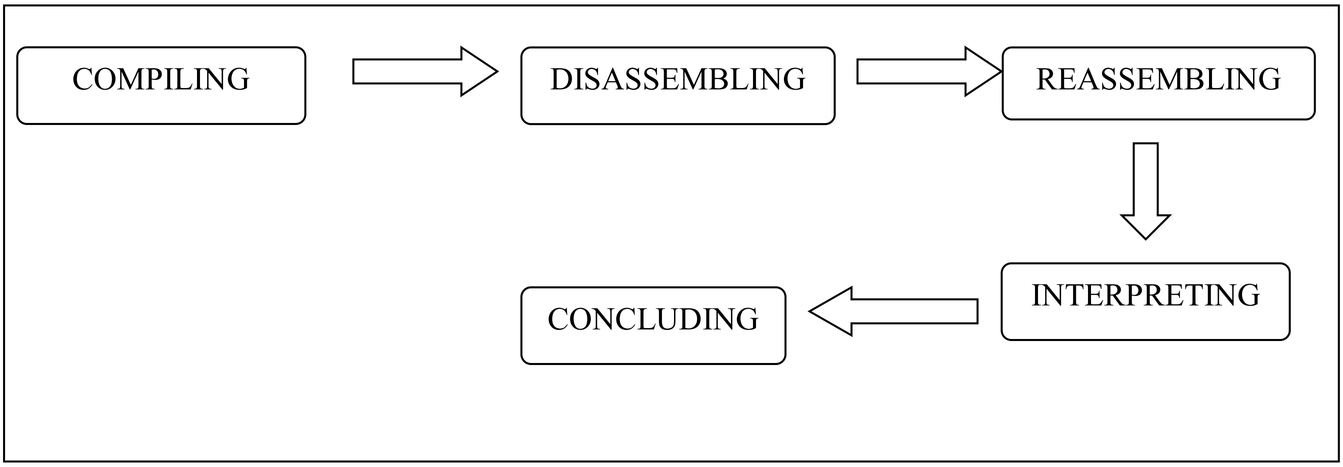


Figure 26. The steps in qualitative data analysis
Adapted from Castleberry and Nolen (2018, p. 808)

According to Erlingsson and Brysiewicz (2017) content analysis within qualitative analysis, is a reflective process. This means that identifying and condensing meaning units, coding, and categorising are not one-time events. It is a continuous process of coding and categorising then returning to the raw data to reflect on the initial analysis. In other words, analysis is a flexible reflective process of working and re-working the data that reveals connections and relationships. Once condensed meaning units are coded it is easier to get a bigger picture and see patterns and organise codes in categories.

Similarly, Braun, Clarke, Hayfield and Terry (2018), emphasise that the purpose of analysis is to succinctly summarise the diversity of responses across the scope of a project. Themes are conceptualised as meaning-based patterns, and result from considerable analytic work on the part of the researcher to explore and develop an understanding of patterned meaning across the dataset. Themes are built, moulded and given meaning at the intersection of data, researcher experience and subjectivity, and research questions. The focus of this chapter will be on the major themes that were extracted from the data and are significant for the purpose of responding to the research aims and questions of this study.

6.2. Manifesting emerging themes on the use of technology

This chapter is concerned with the thematic analysis and discussion of data from focus group interviews, task-based worksheets or other verbal expressions in relation to the use of technology in the learning of fractions in Grade 5. In its essence, Herzog, Handke and Hitters (2019) describe thematic analysis as consisting of the analytical construction of: (a) codes, (b) themes in qualitative verbal expressions; and (c) patterns of recurrence, evaluation or associations within these themes. Thematic analysis is particularly suitable for analysing experiences, perceptions and understandings and may integrate data of multiple kinds. It can be used to analyse a large variety of qualitative data and is a flexible method which can be applied within various theoretical frameworks. Furthermore, it is suitable for the analysis of small, medium-sized and even large data sets. Therefore, thematic analysis was well suited as a method of analysing data in this research study.

Navigating the world of thematic qualitative analysis can be challenging. The process involves the identification of themes with relevance specific to the research focus, the research question, the research context and the theoretical framework. This approach allows data to be both described and interpreted for meaning. The aim is to develop conceptual categories in order to develop ideas or themes about each category.

Braun, Clarke, Hayfield and Terry (2018) maintain that themes capture the essence and spread of meaning; they unite data that might otherwise appear disparate, or meaning that occurs in multiple and varied contexts. A theme summarises what participants said in relation to a topic or issue, typically at the semantic or surface level of meaning, and usually reports multiple or even contradictory meaning-content. The thematic issues are often based around data collection tools, such as responses to a particular interview question.

In line with my research agenda to explore the perceptions of learners on the use of technology during the learning of fractions, a discussion of the learners' perceptions are revealed in the themes that follow.

6.2.1. Theme 1: Technology as a more appealing and fun way of learning

Research by Beilstein (2019) indicates that fractions their concepts, procedures and symbolic notation are well known for the difficulty they present learners, beginning in elementary school, and often, persisting long after. However, promoting learners' development of flexible and robust conceptual knowledge in this content area is critical for their success both in and out of school. In order to make fractions more appealing to learners Fahmi, Soffi and Prabowo (2018) suggest that technology can be used as media in learning mathematics and could present in the form of graphics and media audio video. Of course this adds an attraction for learners in learning, so that the nature of the monotone presentation of teaching can be reduced.

Similarly, Gao (2019) observes that with the development of scientific and technological methodologies, modern information technology has been popularised and applied in the field of teaching, which has promoted the progress of educational undertakings. In the process of the application of information technology, the teaching concept in traditional teaching has been changed and the teaching method has been innovated. In this research study the traditional teaching and learning process was adjusted to incorporate a blended learning approach, which included computer-assisted learning. In line with the work of Fahmi et al. (2018), the lesson on fractions in mathematics was presented using video recordings and a PowerPoint presentation. Learners who normally find fractions to be a difficult section in mathematics were enthusiastic about learning fractions with the use of technology, since they were able to visualise the concepts being taught.

From the focus group interview responses it became apparent that all of the learners who responded to question one, made reference to the fact that the learning of fractions with the aid of technology made the mathematics lesson more fun and enjoyable. The fun aspect of learning resonates with the existing literature of Celik (2018), who maintains that as long as learners find the content and method of teaching for a subject fun and interesting they actively take part in the learning experience. Therefore, suitable choices of teaching activities during the processes in the classroom are significant in terms of learning.

According to Saylan, Onal and Onal (2018) the lack of technological equipment in classrooms affects learners' attitudes, interests and motivations towards the subject;

enjoyment in the lesson, learning entertainingly and participation in the lesson. If they cannot learn by having fun, learning will not be permanent. Mathematics is a subject that is entwined with technology. Thus, classrooms should be fully-equipped with technology. During the focus group interview session in this study, Susan and Akhona were emphatic that the introduction of technology into the mathematics lesson had changed their outlook on the learning of fractions to one of fun and enjoyment. Another learner took this idea of enjoying the technology-enhanced lesson further by reiterating that:

"... It's much better than doing mathematics in class like we do every time…" (Luke, age 11, Grade 5).

It is not often that learners admit to having fun while learning mathematics. However the Grade 5 learners in this research study seemed to have enjoyed the technology-enhanced lesson to an extent where they expressed their enjoyment by highlighting the fun aspect of learning mathematics. Sally had this to say:

"…Yes….it was so much fun to watch the video…" (Sally, age 11, Grade 5).

In order for meaningful learning to take place, learners must engage positively with the learning content and classroom activities. It is the aim of teachers to utilise available resources and creative methodologies to reach out to learners in a way that will facilitate the manifestation of the learners' full learning potential. As teachers encounter the diverse and heterogeneous personalities of the learners whom they teach every day, the ability to capture and sustain the attention or interest of the learners remains the common challenge. The success of a classroom-based lesson is influenced by the active participation of all learners. A change from the usual, routine and tedious teaching style is needed to elevate the interest and perk the curiosity of learners. Having fun while learning, would be an innovative step in making a mathematics lesson more accessible and approachable for learners.

This research study has brought to the fore that the introduction of technology into the learning of fractions has changed the mind-set of learners to one of fun and enjoyment. When the learning process is addressed as a fun activity, it supports the development of meaningful learning since learners learn best when they are having fun.

6.2.2. Theme 2: Retention of acquired knowledge

Emanating from the discussion of the fun aspect to learning, the theme of retaining or remembering what has been learnt comes to the fore. Retention of acquired knowledge means that learners are able to recall what has been learnt with greater ease, which in turn leads to better performance in a subject. In this regard, learners thought that if they do not have the technological equipment in their classroom they will have difficulty in learning and turn towards memorisation, and their learning will not be permanent. Also, learning motivation, attitudes and interests towards the subject, their participation in the lesson, and their learning by having fun may be affected by this situation (Saylan et al., 2018).

The essence of this theme, which involves the retention of what has been learnt, can be captured in the following excerpt, in which Susan likened the use of technology in presenting a mathematics lesson to her experience of watching a movie:

"…I always remember the stories that I watch in the movies. This mathematics period was like watching a movie, so I won't forget…" (Susan, age 11, Grade 5).

Learners are usually enthralled by what they watch in movies, and they are able to recall the highlights of what they have watched. They have the unique ability to sometimes recall their experiences in vivid detail and relate the story to others for a long time thereafter. In the opinion of Susan, the lesson on fractions presented with the use of a projector and screen, was similar to watching a movie. This would imply that the content of the lesson on fractions will also be committed to memory, to be recalled when required. The importance of remembering what has been learned is a crucial factor to be considered by all stakeholders, given the fact that the progression of learners is determined by the successful completion of formal assessment tasks. The ability to remember and recall pertinent information impacts positively on the performance of learners in assessment tasks which in turn leads to improvement in results at school. One learner was confident that she will retain what she had learnt in the mathematics lesson which engaged the use of technology.

"… Yes I will not forget now…" (Pam, age 11, Grade 5).

Zaranis (2019) reveals that today, the vast majority of learners in the developed world, regardless of their ethnic or socioeconomic background, have access to technological devices and mobile phones which are very popular among young learners and this trend is growing rapidly. This being the case learners can easily identify with and relate to the use of digital technology in the classroom. Young learners are captivated by the visuals on a screen, and seeing that this research study involved the presentation of a mathematics lesson on a screen, learners embraced the technology-enhanced lesson as something they will remember for its resemblance to movies they normally watch on a screen. This outlook of the learners of today is indicative of the fact that learning is most effective when learners are allowed to learn on their own terms. The inclusion of computer technology heightened the interest of learners in the lesson, which in turn supported the retention of the learning content in the learners' memory.

6.2.2.1. Diversity of language among learners

The purpose of this research study was to develop learning activities that accommodate individual differences and diversity in learning. Bussi and Sun (2018) have established that languages differ not only in pronunciation, vocabulary and grammar, but also in the different cultures of speaking. Language plays a common, key role in conveying mathematics concepts for learning and teaching and the development of mathematical thinking. The features of language can help to make numerical concepts transparent and support the understanding that occurs in learning discourse. A cross-cultural examination of languages should thus allow us to understand the linguistic support and limitations that may foster/hinder learners' learning and teachers' teaching of mathematics.

For the majority of learners who participated in this research study, English is not their home language. However, English is the language of teaching and learning at the Cato Primary School (the research site in this study), which means that all mathematics lessons are presented in English. This may be a contextual factor which could hamper the learning process and prevent effective learning from taking place for the learners in this research study. The aspect of fractions in mathematics, which is already a challenge to learners, is accompanied by a myriad of new words, concepts and terminology that may not be easily understood and interpreted by all learners. When learners encounter words that they are not familiar with, they may not fully understand what is being taught. It is often found that when learners do not fully understand what is being taught, they tend to lose interest in the lesson. The loss of interest and participation in any aspect of learning can be detrimental to the future progress of the learners concerned.

One of the fundamental aspects of the teaching guidelines prescribed by the CAPS curriculum, is English across the Curriculum (EAC). The EAC requires teachers to expound the terminology associated with the teaching of their lessons, so that learners are familiar with the vocabulary prior to beginning the lesson. Although the terminology is explained to the learners, not all learners may fully understand the meaning of the concepts. Presenting the fraction learning content visually allows the learner to see exactly what the words mean, which promotes greater understanding of the related concepts.

The confusion around the use of terms such as 'numerator' and 'denominator' can be identified in the responses of some of the learners, who indicated that they understood the terms only after having watched the video presentation. The use of technology afforded learners the support to access knowledge of mathematical concepts and processes with the aid of visuals. Although the language used in the video and PowerPoint presentation was English, the incorporation of visuals could combat the challenges experienced by those learners who were not so proficient in understanding the mathematics lessons that were presented in English. The pictures and visuals served as a medium to demystify and decode any misunderstood concepts, and realise the complete essence of what was being taught. Simply put, if the learners could not understand what was being said by the teacher then they could see what was meant in the visuals.

Existing literature by Hughes (2019) reinforces the positive impact that technology has on the teaching and learning of fractions by indicating that educators face significant challenges meeting the learning needs of diverse learners in classroom settings. When learners experience acute and chronic challenges while learning mathematics, additional supports and more intense interventions are required to better promote learning acquisition. Advancements and availability of technology have resulted in widespread use of hand-held and table-top technologies to support intervention intensity for learners. Unlike instruction in real time, a video of instruction can be edited for instructional precision, paused for learner processing time, and re-watched for consistent demonstration of a skill, thus allowing the intensity of the intervention to be differentiated for individual learning needs. The video provides a permanent resource that can be used over and over and to address needs of multiple learners at the same time and reused to provide a conspicuous review of skills.

This research study has brought to the fore the realisation that technological devices have the likelihood to accommodate individual differences in the learning process.

6.2.3. Theme 3: Providing an alternate learning experience

Research by Ben-Chaim, Shalitin and Stupel (2019) suggests that the human mind, by nature is curious and enjoys dealing, both independently and competitively, with intellectual challenges. Furthermore, Thong, Ng, Ong and Sun (2018) concur that as the quality of learning outcomes is frequently associated with learner engagement, educators are conscientiously trying to find ways to increase and motivate learner participation in purposeful learning activities. To a great extent, computer-assisted learning enables individualised learners' preferences of knowledge and content delivery, as well as place, time and pace of learning. It also enhances the overall learning and human-computer interaction which may allow learners to engage in higher order thinking skills. Vajravelu (2018) elaborates on the idea of an alternate learning experience by highlighting that a traditional curriculum, the standard in many classrooms, actively resists questioning, and creates difficulties in the establishment of defined criteria that can guide us into making allies with technologies currently available. It is important to change teaching techniques to blend the traditional with the modern techniques of learning. Rapid development of technology has influenced the teaching techniques used in classrooms.

The utilisation of the same routine and mundane teaching methods can easily lead to boredom of learners, monotony of the lessons and a lack of enthusiasm in the learning process. teachers are constantly trying to incorporate strategies that stimulate learner involvement in lessons and learner engagement with the learning content. The inclusion of technology as a resource when learning fractions provided learners with the unique opportunity of engaging in an alternate form of learning. The emerging theme that the use of technology in the learning of fractions provides an alternate learning experience can be drawn from the work of Golji and Dangpe (2016) who reiterate that learners are active learners rather than passive recipients of information. Thus, if learners are provided with the opportunity to explore their environment and are provided with an optimum learning environment then the learning becomes joyful and long lasting. This learning strategy means reversing the traditional teacher-centred understanding of the learning process and putting learners at the centre of the learning process.

The previous chapters in this research study have indicated that participants in the study have limited access to the use of technology during teaching and learning at school. The use of technology in presenting the lesson on fractions in mathematics was therefore a change from the routine way of teaching and learning in the classroom, and was seen as a novelty by learners. This alternate approach to presenting the lesson seemed to captivate the attention of learners in a way that had them engrossed and actively involved in the learning process. Providing learners with a progressive and unconventional way of learning helped to intensify their interest in the lesson as can be noted in the response of John:

"…Yeah…I loved watching how all the fractions were explained. It was different from how we did fractions before…" (John, age 11, Grade 5).

The technology-enhanced lesson seemed to awaken an inner passion and desire within the learners to learn mathematics. There seemed to be a spirited sense of eagerness to absorb all the information that was presented to them. One group of learners was eager to communicate their feelings of satisfaction that they had gleaned pertinent information from the mathematics to assist in their understanding of fractions.

"…Yes. The video gave us a lot of information that helped us…" (Amelia, Akhona, Nancy, Pam, Amber, age 11, Grade 5).

These findings also echo the existing findings of DeCoito and Richardson (2018), which emphasise that the shift in our society's growing reliance on technology demands that our learners' education emphasise technological literacy, thus benefitting learners who may or may not pursue technology based careers. Furthermore, there is a need for learners to experience opportunities in formal and informal settings that will result in enhancing 21st century learning skills.

6.2.3.1. Ability to use more than one sense-multimodal learning

Another finding of this study shows that the participants thought the use of technology in education facilitates mathematics learning, provides permanent learning, embodies abstract subjects, saves time and arouses learners' interest and curiosity facilitating learning by appealing to multiple senses (Saylan et al., 2018). Digital technologies are viewed by Brosseuk, Exley and Neumann (2019) as being complementary to other resources, rather than alternatives, or in competition with, traditional modalities. Multimodal learning ecologies can work to support emergent literacy which is viewed as a foundational skill needed by all learners in order to thrive in their learning.

According to Volta et al. (2018), recent results from psychophysics and developmental psychology show that learners do not integrate and use the same sensory modalities in the same way, but they rather have a preferential sensory channel to learn specific concepts. In schools, however, the visual channel is often the only one exploited for teaching, whereas the other channels are left to a marginal role. This research study explores the chance to create and evaluate new methodologies associated with teaching. In particular the study targets a deeper understanding of the use of technology in the learning of fractions. A major novelty of such a new technology is that it is based on the renewed understanding that specific sensory systems have specific roles for learning specific concepts.

The presentation of a lesson that was different from the usual situation of sitting at a desk and listening to the teacher provided the learners with an alternate way of learning fractions. A multimodal approach to learning in the classroom can be effective and an important source of creativity for both teachers and learners. This method of teaching learners has been discussed earlier in chapter four, where the use of technology in teaching mathematics is seen as a way to help learners to visualise complex and abstract mathematical concepts. The use of more than one sense in this method of learning engages the use of text, audio and images in a combination to promote constructive learning, as can be seen in Figure 27.

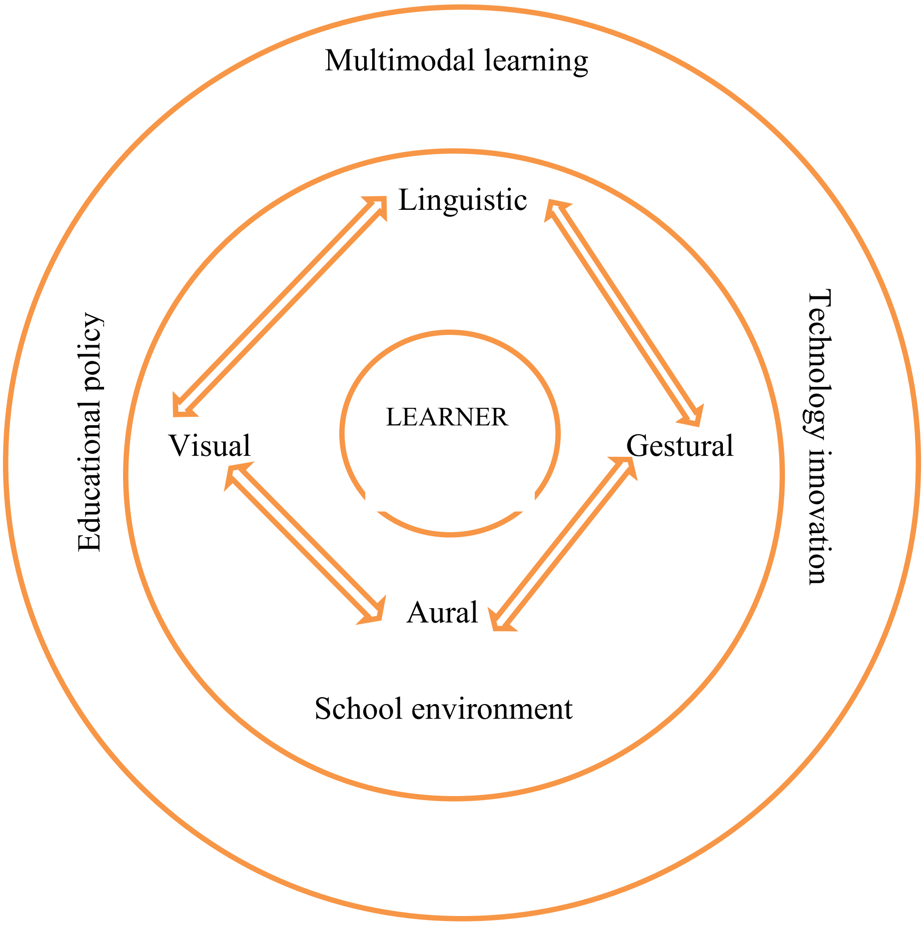


Figure 27. Technology-enhanced Learning – Using more than one sense when learning
Adapted from Hu and Yelland (2019, p.503)

The reality of the current situation at schools presents a very real gap between traditional teaching methods and what piques the interest of learners. Bridging this gap and connecting with ways in which learners prefer to learn at school is a challenge worth embracing, as effective teaching methods will result in positive learning experiences. The positive effect of using more than one sense when learning fractions comes to the fore in the following statements made by Siba and Sara:

"… I like to see the sums on the screen…I enjoyed watching…" (Siba, age 11, Grade 5).

"… Because we could see the size of the fraction…" (Sara, age 11, Grade 5).

Teachers who design rich cross-curricular tasks and lessons that harness the use of technology in their lessons, can successfully engage their learners in the teaching and learning process. The traditional teaching strategies blended with innovative technological methods have proven to have had a positive influence on the learning of fractions in mathematics.

6.2.3.2. Exposure to other styles of teaching

Kor, Teoh, Mohamed and Singh (2019) maintain that it is indeed worthwhile for teachers and educators to spend time and effort to help learners to achieve a solid foundation in fractions in the elementary years in particular if this can ensure learner success in later mathematics, career and life. In so doing, apart from exposing teachers to a variety of ways to improve initial fraction instruction for early elementary years, greater emphasis should also be given to learners' methods of visualising and solving problems on fractions.

According to Mendoza and Mendoza (2018) the application of adequate and innovative resources and strategies, such as the introduction of technology in mathematics activities, favours the flexibility of learners' thinking because it stimulates the encounter of different solutions to the same problem. Besides, it allows a wider deployment of learners' cognitive resources to facilitate the processes of meaningful learning building. That is the reason why it is important to promote the use of technology as a teaching tool. Moreover, it can be used as a motivating resource in teaching and learning activities in the mathematics area. Each learner is unique in his/her approach to learning. A variety of teaching styles affords learners the opportunity to see problems from different perspectives, thereby increasing the chances of successful learning.

Mathematics is seen by learners as a challenging and unattractive subject. This is further emphasised by Stando, Guncaga and Bacova (2018) who believe that it is generally known that mathematics is rather unpopular and a less interesting subject for learners at primary schools. Their imaginations and attitudes are on the scale from high admiration to rejection of mathematics as such. We suppose that the problem is not in mathematics itself but in the way and art of its teaching.

All around the world, including in South Africa, one hears people talking about the fourth industrial revolution. Some talk with enthusiasm, others with anxiety. Almost overnight we are hearing about coding and robotics being introduced into the school curriculum. On the 1 November 2019 the president of South Africa, Cyril Ramaphosa, included in his State of the Nation address that the education system of the country will undergo changes to include subjects such as coding and data analytics at a primary school level to prepare young people for the jobs of the future (Robinson, 2019). It becomes apparent from the message delivered by the president of South Africa that in the context of societal changes, teaching and learning strategies at schools in this country need to be adapted accordingly. Learners must be motivated and inspired to embrace the challenges of a changing society so as to prepare themselves adequately for the future in a technologically advanced environment. The introduction of technology into the classroom learning environment during this research study can be seen as a step in the right direction in preparation of learners for their encounter with the fourth industrial revolution. The use of technology stimulates the motivation and curiosity of learners and encourages them to develop their problem-solving strategies, as is evident in the excerpt below:

> *"…This was the first time we did mathematics like this…most of the time I feel mathematics is hard, but this helped me…"* (Sifiso, age 11, Grade 5).

It became apparent from the responses recorded in the focus group interviews that the technological mediation in the learning of fractions created a new dimension to the teaching and learning process. Learners appreciated the exposure to a different style of teaching as a welcome change from the normal classroom teaching and learning. A variety of techniques used by teachers to deliver the learning content serves to stimulate interest in the subject and sustain focus on learning.

6.2.4. Theme 4: Creating a positive attitude to learning fractions

Middle school learners have been pervasively described in research literature as exhibiting disaffection, disengagement and a lack of interest in mathematics classrooms (Wilkie & Sullivan, 2018). Sherman, Richardson and Yard (2019) illustrate this point further by elaborating that rational numbers are sometimes quite difficult for learners who were successful with whole numbers in the early grades. Understanding and becoming proficient in learning about numbers that represent parts, that have an infinite number of names, and do not automatically follow whole number computation procedures can be daunting. It is essential for teachers to provide opportunities to develop a deep conceptual understanding of the rational number system as a whole, the quantities rational numbers represent, and the key ideas that are the foundation of operation procedures. In line with the research of Sherman et al. (2019) the learners in this research study were afforded a multitude of strategies to clarify any misconceptions and confusion they may have had with regards to fraction learning. The researcher utilised the traditional classroom teaching technique, the use of manipulatives together with scaffolded learning, as well as the integration of technology in an effort to inculcate a deeper understanding of numbers that represent parts. This study investigated the ways in which the use of technology can create a positive attitude to learning fractions in mathematics by using the learners' own voice on their perceptions of learning fractions with the aid of technology.

According to the CAPS (DoE, 2011) document, the teaching and learning of mathematics aims to develop confidence and competence to deal with any mathematical situation without being hindered by a fear of mathematics. The goal of teaching is to impart knowledge, increase learner understanding, and develop critical thinking skills. Further, if technology can be used to create new learning experiences or enrich the educational experience inside the classroom, then it is a useful tool (Wangler & Ziliak, 2018).

This research study explored the ways in which the use of technology could ease the anxiety of learners and create a positive attitude to learning fractions in mathematics. Creating an environment that fosters effective teaching and learning is a step forward in establishing a positive attitude towards a subject. According to Michaelides, Brown, Eklof and Papanastasiou (2019) learners' motivations and attitudes influence their learning of and performance in assessments of school subjects, including mathematics. Generally, learners who demonstrate greater self-efficacy and interest in mathematics and those who value the subject more highly, achieve better.

One of the obstacles hampering learning in mathematics is the attitude of learners towards the class and factors that are related to the class. Factors such as course content, course presenter and readiness of the learners, ways of presentation, and learning and teaching environment determine the learners' attitudes. Attitudes emerge in learners as an effect of learning environment, and are expressed as a shape of cognition, affect and behaviour (Celik, 2018).

Likewise, Luttenberger, Wimmer and Paechter (2018) propose that in educational settings, individuals may suffer from specific forms of test and performance anxiety that are connected to a knowledge domain. Unquestionably, the most prominent of these is mathematics anxiety. Mathematics anxiety is a widespread problem for all ages across the globe. In the international assessments of the Programme for International Learner Assessment (PISA) studies, the majority of adolescents report worry and tension in mathematics classes and when learning mathematics. Mathematics anxiety interacts with variables such as self-efficacy or motivation in mathematics, which can intensify or counteract mathematics anxiety.

Along similar lines, Andamon and Tan (2018) maintain that mathematics is by nature an abstract discipline such that, learners have difficulty in comprehending mathematical concepts and operations. Learners tend to develop apprehension that they will not pass the subject. Feelings of anxiety and nervousness are easily developed among learners, hence mathematics phobia is evident. In order to allay any anxiety or fear learners may have been experiencing, this research study employed the use of multiple intervention strategies such as teacher support, peer support, use of manipulatives and technology-enhanced lessons to assist learners in their learning of fractions.

The notion that technology-enhanced learning had fostered a positive attitude to the learning of fractions is a recurring theme that manifests itself throughout this research study. This is evident in the following comments made by Abby and Sihle regarding their experiences of learning fractions with the aid of technology:

"*…Yes… It was hard before…but I can do it now…"* (Sihle, age 11, Grade 5).

"… This was the best mathematics lesson, so I will tell my friends what I saw on the video…" (Abby, age 11, Grade 5).

The learners in this study believed that the use of technology in the learning of fractions prompted them to exhibit greater enthusiasm for and a more positive attitude towards learning mathematics. Abby's ideas and perceptions exemplify other learners' views as well. The creative incorporation of technology into the learning process elevated the regular, passive learning that learners were accustomed to and facilitated collaborative learning with effective mathematical communication.

6.2.4.1. Making the learning of fractions simpler to understand

Although proficiency with natural numbers is fundamental to learning fractions, the transition from natural numbers to fractions requires modifications of the initial concept of numbers, and natural number processing can interfere with fraction processing. Thus, when teaching fractions, it seems important to draw on learners' fundamental abilities to process fractions, while explicating fraction properties that are conceptually different from those of natural numbers (Obersteiner, Dresler, Bieck & Moeller, 2018).

Millennials, according to Thong et al. (2018), are growing up in a digital world, pampered with the vast array of gadgets and software to stay connected. The relentless technological advances and diffusion have affected all aspects of human life. Needless to say, the educational landscape is not spared. As a result, the teaching-learning environment has undergone a tremendous paradigm shift, stemming from these technological advances and the rapid rise of computer-assisted learning programmes.

Furthermore, Collins and Halverson (2018) reveal that we all know that technology has transformed our larger society. It has become central to people's reading, writing, calculating, and thinking, which are the major concerns of schooling. The central challenge is whether our current schools will be able to adapt and incorporate the new power of technology-driven learning for the next generation of public schooling. Harper (2018) concurs by stating that technology promotes collaboration between teachers and learners during learning activities, and teachers who use technology leverage it to maximise their uses of strategies aimed at facilitating learning and promoting learners' exploration of content.

Practically, by becoming proficient in fractions, learners become poised for current and future success in everyday life since fractions are part and parcel of routine decision-making at home, out in the world, and at work. Mindful of the cognitive conflict learners experience during fraction learning, the current research study examined how learner's existing fraction knowledge is revealed through their use of manipulatives and technology and experimentally tests how variations in these tools support learner's development of flexible and generalisable fraction knowledge (Beilstein, 2019). The extracts presented below are indicative of the fact that technology is a major contributing factor that influences the learning of fractions in mathematics by making it simpler to understand.

"…I find plus and minus easy…" (Mark, age 11, Grade 5).

"… It was a very good video….it helped us in our worksheet…" (Brian, age 11, Grade 5).

The emergence of technology into the educational foray can be interpreted by the relevant stakeholders as an opportunity to extract all the benefits and advantages afforded by this innovative approach to learning. The significant manner in which technological mediation in the learning of fractions has contributed to making fractions simpler to understand, came to the fore during this research study. The analysis of responses from learners in the focus group interviews that were conducted, together with the analysis of responses obtained in the task-based worksheets, elucidates the theme that the learning of fractions became easier with the intervention of technology into the learning process.

6.2.5. Theme 5: Reinforcing key skills and concepts

Research conducted by Hurst and Cordes (2018) indicates that fraction and decimal concepts are difficult for learners to learn yet are a major component of elementary and middle school mathematics curriculum and an important prerequisite for higher order mathematics. Thus, recently there has been a push to understand how learners think about rational number magnitudes in order to understand how to promote rational number understanding. This is in line with the objectives of this research study which sought to explore how learners perceive the learning of fractions and how the assimilation of technology into the learning process impacted on understanding fractions better. The aim of incorporating diverse teaching strategies and resources into the learning process was to reinforce the learning content, clarify misconceptions and facilitate a deeper understanding of the various aspects within the fractions aspect of mathematics.

Several studies show that using technology as an intervention tool in mathematics influences learner outcomes, motivation to learn, and attitude about learning. Understanding how motivation and attitude changes and influences learner learning when technology is involved is essential in effectively using technology to enhance mathematical achievement (Higgins, Huscroft-D'Angelo and Crawford, 2017).

In chapter four reference is made to the work of Bidabadi et al. (2019) in which the task-avoidant behaviour of learners towards mathematics is discussed as a contextual factor that hinders improvement in mathematics performance. These researchers go on to propose that in order to stimulate interest in mathematics learning, learners need to be motivated by creative teaching methods.

The aim of teaching and learning mathematics is to ensure that the important mathematical concepts and problem-solving skills are mastered by the learners who are being taught which in turn ensures that meaningful learning takes place. The key skills and concepts related to the learning of fractions were deconstructed in the visual presentation that learners were exposed to. Learners who participated in this research study expressed their satisfaction that the technological intervention had impacted positively on their learning experience. In response to the question in the focus group interview schedule that asked: Which aspects of fractions do you find easy to understand? Learners confirmed that their understanding of several different sub-topics within the topic of fractions in mathematics had been reinforced after they had watched the video on fractions. Some of the responses from the learners are captured below:

"... I like the mixed numbers and it's easy to understand... also the number line..." (John, age 11, Grade 5).

"...Question 1.2... What fraction has been shaded..." (Amelia, age 11, Grade 5).

"... Addition and subtraction of fractions..." (Ben, age 11, Grade 5).

"...What fractions are shaded..." (Leon, age 11, Grade 5).

"... I find the number line easy to understand..." (Jane, age 11, Grade 5).

The responses obtained from learners are indicative of the fact that the technology-enhanced lesson did not clarify just one aspect of fractions, instead the key aspects had been positively reinforced. There seemed to be a consensus among the learners that their understanding and interpretation of fractions had become clearer and more accessible.

Chapter three of this research study described the principles of the socio-constructivist theory which included the use of scaffolding and the identification of learners' ZPD in order to promote effective learning. This chapter ties in the information presented in chapter three with the appropriate manner in which scaffolding and the ZPD relate to the theme of reinforcing the key concepts during the learning of fractions in Grade 5.

6.2.5.1. Scaffolding

To elaborate on the principles of scaffolding, Rahman, Zaid, Abdullah, Mohamed and Aris (2018) explain that the main implication of the socio-constructivist theory was to provide a scaffolding process, based on the roles of a more knowledgeable other, so that, learners could receive guidance from more competent individuals, such as teachers and peers. Scaffolding is a process of providing guidance by the teachers and more competent peers, until the needy learners are able to solve problems on their own. In other words, scaffolding is a guidance process to improve learners' learning potential. Furthermore, scaffolding is viewed by Wright (2018) as a process that provided temporary support to an individual learner, support offered by peers in collaborative situations, meta-cognitive self-scaffolding by the individual themselves, and support within technology mediated environments.

Scaffolding, with the intention of providing support to learners, was utilised at all stages in the data collection process during this research study. The study commenced with an introduction to the concept of fractions and an explanation of the different aspects of the fraction learning content, by the researcher. The introductory lessons employed the use of different coloured pens on a white board to depict a whole object divided into different numbers of pieces, and how each fraction name was derived from counting the number of parts the whole was divided into. This phase of the study aimed to clarify concepts and assist learners in completing prescribed tasks presented in their daily class work and homework exercises as per curricular requirements.

Building on the theory of scaffolding as a process that provides temporary support to learners, learners were divided into small groups of five or six as they completed the first task-based worksheet. The formation of the groups was random, so that there were learners of varying learning abilities together in one group. This process ensured that learners had the opportunity to engage in collaboration with their peers and enlist the support of their peers in order to intensify learner engagement in the learning process. In this way those learners who had greater difficulty in answering certain questions in the worksheet were able to discuss their challenges with their more knowledgeable peers within the group. In addition to this form of support, the worksheets comprised drawings and diagrams which learners were able to use to answer questions based on fractions. Furthermore, learners used paper folding as a visual tool to support their understanding of some of the terminology that presents itself when learning fractions. Learners were guided by the teacher to make a single fold in the paper to visualise halves, to make two folds in order to conceptualise quarters, and so on.

Instead of continuing with the traditional teaching methods, this research study embraced the use of technology in the classroom. Technological mediation in the form of a PowerPoint and video presentation was used as an intervention strategy to further scaffold or support the learners in their pursuit of successful learning of fractions in mathematics. A learning environment was created whereby learners were able to interrogate the use of technology to clarify any misunderstandings regarding the learning content, as well as to utilise the information that was presented to them as an advantage to improve their learning potential. This is in line with research by Prismana, Kusmayadi and Pramudya (2018), who emphasise that education should focus on both core academic subject mastery and 21st century skills development. These skills help learners to be ready for college and career life. There are various strategies by which to achieve 21st century skills, namely, problem-solving, critical thinking, collaborative learning, integration environment and digital tools in teaching.

As learners completed the second task-based worksheet, they were able to reflect on the various forms of intervention that had been used to maximise their learning experience. With an enhanced understanding of fractions facilitated by visual manipulatives and technological intervention, it was more likely that learners would be able to remember and recall what they had learnt. It may be seen from the results that learners participated in various learning activities that promoted engagement, participation and interaction. Diverse teaching methods were used to captivate and sustain learner interest, encourage active learner participation and keep the momentum of the lesson.

One of the questions that learners were asked in the focus group interviews was: Do you think the video that you watched helped you to answer the questions in the worksheet? In the responses that were offered by learners as presented below it is evident that Brian, Jess and Sipho concurred that the use of technology when learning fractions assisted in making it simpler to answer questions in the task-based worksheet:

"...It was a very good video…it helped us in our worksheet…" (Brian, age 11, Grade 5).

"... It helped us too much…" (Jess, age 11, Grade 5).

"... It was very helpful to answer the worksheet questions…" (Sipho, age 11, Grade 5).

According to Gonulal and Loewen (2018) scaffolding as a metaphor in teaching and learning describes the adaptive and temporary support provided by the teacher. The use of the various techniques does not automatically imply that scaffolding has been successfully provided. Teachers might use a variety of techniques to tap different learning styles and strategies, because not all learners respond to scaffolded help in the same way. In this research study it was found that the use of technology provided much support to learners and promoted an increase in the interactions and participation of learners in the learning and teaching context. This suggests that there may be a correlation between interactions in the learning and teaching context and the positive learning experiences that learners reported about using technology when learning fractions in mathematics.

6.2.5.2. Zone of Proximal Development

The findings from this research study are presented in chapter five. A few samples of learners' efforts and responses found in the first task-based worksheet are presented and the responses offered by the same learners to questions in the second task-based worksheet are presented. It can be clearly noted that learners were able to answer more questions correctly in the second task-based worksheet. The second task-based worksheet was given to learners after the intervention of the PowerPoint presentation. By the time that learners engaged in completing the activities contained in the second task-based worksheet, they had already received support with their learning of fractions in the form of the explanations offered by the teacher, collaboration with their peers, use of manipulatives and technology-based assistance. At this stage of the study it was therefore a viable possibility that the learners were able to attain a higher level of development.

With reference to group work, Morgan and Skaggs (2016) indicate that each member of a collaborative group would have a different level of ability, and so would have a different ZPD within the context of a project. Group work affords the opportunity to pool the abilities of those learners who have the knowledge and skills together with the abilities of those learners who do not. This allows peers to help members who have skills and knowledge that are different from their own, and thus provide the support necessary in a collaborative effort for the group to work together toward the same goal. Vygotsky views interaction with peers as an effective way of developing and extending learning.

Furthermore, Vygotsky described ZPD as the difference between the actual level of development of what a learner can do without support and the next level of development a learner needs to attain with the support from the capable adult or peers. The ZPD concept is deep rooted in the social theory of learning that learners learn best with others collaboratively and cooperatively, and it is through such collaborative activities with more skilled persons that learners learn and internalise new ideas and skills (Taukeni, 2019).

Throughout the teaching and learning process, the atmosphere in the classroom was one that allowed for flexible learning and encouraged creative thinking which would facilitate problem solving. The ZPD of the learners in this research study can be described as the difference between what they could do in the first task-based worksheet and how they were able to interrogate the questions that they encountered in the second task-based worksheet, with the support of the teacher, their peers and technological assistance. When learners are in their ZPD for a particular task, providing the appropriate scaffolding or support will enable the learners to reach their full potential and complete the task successfully.

In this research study, when learners had gone through the different phases of data collection, the final task before focus group interviews were conducted was the completion of activities found in the second task-based worksheet. At this point, the researcher provided learners with the opportunity to engage in a technology assisted PowerPoint presentation which can be viewed as the scaffolding that learners needed to complete the activities in the second task-based worksheet successfully. As indicated by the responses from learners, it became explicitly clear that the intervention of technology when learning fractions has impacted positively on the learning process. The explanations cited by participants Amber and Allan reinforce the concept that learning of fractions is significantly influenced by presenting information to learners through the medium of technology.

"*... I think the second worksheet was better… I could answer more…"* (Amber, age 11, Grade 5).

"*…..Yes….it' easy to work it out after watching the video…."* (Allan, age 11, Grade 5).

In line with the existing research of Lopes and Soares (2018) the teacher's role in this research study was transposed into a kind of guide and facilitator, indicating the way to go, avoiding to walk in a parallel path, or even ahead, but indicating the way to go, motivating learners in their own knowledge construction, letting them lead the way, following and supporting, constantly and carefully monitoring their learning outcomes, only interfering in the learning process as an anchor where learners can rely, adjusting the right paths when they seem to deviate from the predefined learning goals. Classroom time was consumed with open discussions, solving tasks and application problems, clarifying the supporting fundaments, in order to improve learners' engagement into their learning process in a collaborative environment.

As we move into a technology-based society, the role of technology in education is becoming a globally important concern and a great amount of investment and research in the field of educational technologies has been made throughout the world. For many years, researchers, educators, and policy-makers have been exploring the best ways to integrate technology in classrooms to enhance teaching and learning. The implementation of technology into the teaching process is directly or indirectly affected by dynamic variables such as learners, teachers, administrators (Saylan et al., 2018).

6.4. Conclusion

An apt summary of the way in which technology has infiltrated the lives of learners is provided by Leneway (2018) in which it is emphasised that in order to adapt to overwhelming amounts of information, and continual interaction with visual media and game playing, the newest generation of learners have neurologically changed their brains to try to keep pace and literately see and learn differently than their parents and grandparents, in that they see and remember visual images in place of text. Today's paper textbooks are about to be replaced by intelligent, colourful, multimedia response programs that fit on mobile devices such as iPads, smart phones and other digital devices that learners are now starting to bring to school. Thus, public education and its classrooms have to change. Perhaps the greatest hope for responsive change to both changing learning needs and external threads comes in the form of educators' attempts to transform classrooms with digital technology.

The analysis of data generated from this study suggests that learners in Grade 5 have embraced the use of technology to facilitate successful learning of fractions in mathematics. The data also reveals a feeling among the participants that the introduction of technology into the classroom improved the teaching and learning of fractions. The common thread that runs throughout this study is that the use of technology when learning fractions in mathematics is beneficial in improving learners' understanding of fraction concepts.

The next chapter concludes the study by reflecting on the researcher's thoughts, recommendations and limitations of the study.

Chapter Seven: Concluding thoughts, recommendations and limitations

7.1. Introduction

Chapter six encapsulated a discussion of the themes which emerged from the data that were generated in this study. This final chapter summarises the essential features that were fundamental to the study. The chapter commences with the focus of the study, which includes the key research questions. This is followed by the new knowledge that this study brings to the field. Thereafter, the recommendations and limitations are presented, followed by an amalgamation of the pivotal issues punctuated with researcher thoughts and reflections.

7.2. Focus of the study

The key purpose of this study was to explore the perceptions of learners on the use of technology when learning fractions in mathematics. This study sought to provide a platform for learners to express their views on the integration of technology into their learning of fractions in mathematics. The aim of this study was to work with participants who reflected the population I was studying. One class of Grade 5 learners was selected from Cato Primary School which lies in the ILembe district of KwaZulu-Natal in South Africa. The choice of the research site was purposive and convenient, since this location allowed the researcher to conduct the research study during school hours without having to disrupt teaching and learning by leaving the place of employment.

The study was primarily an exploration of Grade 5 learners' perceptions on the use of technology when learning fractions. With the use of multiple data generating tools and techniques, the researcher was able to elicit information-rich data. Initially, data was generated from information that was retrieved from the first task-based worksheet, a second task-based worksheet and focus group interviews, guided by a series of open-ended questions from a focus group interview schedule.

The administration of the first task-based worksheet followed the teaching of the various aspects of the fractions curriculum by the teacher. During this period of data generation, learners were engaged in cooperative learning and scaffolding with their peers within small groups. Learners worked in groups while completing the worksheet, making use of visual manipulatives in the form of paper folding, diagrams and drawings. Responses of the learners to questions in the first task-based worksheet were used to assimilate information that would contribute towards answering the key research questions.

The use of a PowerPoint and video presentation was a technological intervention aimed at supplementing the teaching and learning of fractions in mathematics. This was followed by the second task-based worksheet, which was completed by all learners in the class. Analysis of learners' responses to the questions in the second task-based worksheet allowed the researcher to interpret the effect that technology had on the teaching and learning process.

The focus group interviews with the learners conducted thereafter served as a technique that was most appropriate to obtain information-rich data. The qualitative data for this study which was captured from the participants proved to be suitable and effective in providing answers to the key research questions. The audio-taped focus group interviews elicited thick, descriptive data which was interrogated in order to draw out the main themes in this study. The final research instrument was intended to be a vehicle for the triangulation of the data generated thus far.

In order to corroborate the validity and reliability of this study, learners were actively engaged in the research process and the methodology was compatible with learners' perceptions of their learning experiences. Furthermore, a pilot study was conducted prior to the main study. Learner participation was encouraged in a collaborative rather than a confrontational manner, in order to combat the issue of an imbalanced power relationship between researcher and the participants.

7.2.1. What are grade 5 learners' perceptions on the use of technology when learning fractions in mathematics?

The first research question involved identifying the learners' perceptions on the use of technology when learning fractions. As indicated in chapter two of this study, previous research has revealed that learners encountered difficulty in interpreting the terminology associated with fractions, which impeded the understanding and learning of fractions in mathematics. Data generated from this study was analysed using thematic analysis as seen through a socio-constructivist lens. The findings suggested that learners embraced the use of technology when learning fractions in a positive manner. The data also revealed that after the introduction of technology into the mathematics lesson, learners were able to use the visuals to clear the misconceptions and confusion surrounding the learning of fractions. Learners felt less confused and more confident in their approach to solving problems that involve fractions in mathematics.

In examining the perceptions of learners on the use of technology when learning mathematics, data generated from the first task-based worksheet, the second task-based worksheet and the focus group interviews were interrogated. It was found that the learner participants had clear descriptions of their experiences of learning fractions with the aid of technology. The learners expressed their feelings of enjoyment in learning mathematics with technology, their conclusions that the technology-enhanced lesson had left an indelible impression on them, as well as the ways in which their anxieties about fraction learning had been allayed.

As indicated in earlier chapters, the learners at the school where this research study was conducted have limited access to any form of technology during the teaching and learning process. The mathematics lesson that was presented in the school media centre using a projector and screen, created much excitement and hype among the learners. The technology-enhanced lesson provided the learners with the opportunity to reassess their previous perceptions on the learning of fractions in mathematics.

The theme of a fun and enjoyable experience while learning with technology was highlighted by the learners in this study. The learners made a strong statement that they enjoyed learning with the aid of technology and that they would like their other lessons to be taught with including technology as well. Learners who identify a fun element in the learning process will also become more actively involved in the learning experience. This was vividly noticeable in this research study, as learners became deeply connected with the fraction learning content being explained to them via the PowerPoint and video presentation. Existing literature by Saylan et al. (2018) concurs with the learners' views by stating that technology makes the lesson enjoyable. They visualise the aspects of the subject. This is why they provide permanent learning. These programmes make learners understand the lesson better. It makes the subject more interesting and visual since the visuals are used.

The learners in this research study interpreted their experience of learning with the aid of technology as an unconventional way of learning that left a lasting impression and became imprinted on their minds. One of the outcomes of teaching is that learners should acquire the required level of knowledge and skills at the end of a lesson. It is evident from the analysis of responses from the learners in this study that the information garnered during the technology-enhanced lesson had been well understood, and their knowledge of fractions had improved.

Participating learners in this research study expressed their views by stating that they were less anxious about learning fractions after having watched the visuals and explanations integrated the PowerPoint presentation. Learners lack confidence and have a fear of getting answers wrong when learning mathematics, which may lead to mathematics anxiety. The development of a positive attitude towards learning mathematics is essential in overcoming the fears and insecurities developed within learners when they engage in mathematics learning. The introduction of technology into the learning process seemed to have motivated learners to negotiate the contextual factor which present challenges to their learning of fractions and forge ahead with learning.

7.2.2. How do grade 5 learners use technology when learning fractions in mathematics?

In response to the second research question, learners optimised the use of their senses when technology was used as a tool in the learning process. In the previous chapter, multimodal learning has been mentioned as a possible theme. In this chapter I extend that idea by focussing on the observation that learners were able to visualise the learning of fractions in mathematics. the visualisation of the learning content had a positive effect on the way in which learners use technology to learn fractions. Not all the fraction learning content in textbooks is supported by diagrams and pictures. By introducing technology as a tool to enhance learning, learners were able to achieve greater success in finding solutions to fraction problems that they would otherwise find challenging. The success in using the visuals to simplify the questions in the task-based worksheets is evident in the results which indicate that an average of 72% of learners had answered correctly in the second task-based worksheet as opposed to an average of 45 % who had correct responses in the first task-based worksheet.

According to Krishnan (2019), in educational contexts scaffolding refers to a variety of instructional strategies used to move learners progressively towards deeper levels of understanding and greater independence in the learning process whereby the instructor's role is to provide support and assistance at successive levels. The instructor encourages, motivates and guides the learners to reach higher levels of comprehension and skills acquisition. In that sense, we would agree that all teaching involves some form of instructional scaffolding.

The process of scaffolding was used as temporary support in this study to extend the knowledge and experience of learners who were in the process of learning fractions. The learners in the study were afforded the opportunity of scaffolding from their peers in groups, from the teacher, as well as from the instructional resources and tools used in the teaching and learning process. This resonates with the theory of socio-constructivism which implies that knowledge is socially constructed by learners who convey their meaning to others. Scaffolding in the study was also provided in the form of explanations by the teacher and feedback from learners, which in turn allowed learners to engage in independent learning.

In a similar manner, learners' social interactions with their counterparts allowed them to develop and assimilate the skills and information required to solve fraction problems in accordance with the principles of Vygotsky's Zone of Proximal Development. The ZPD can be interpreted as the potential of the learner to reach greater heights of achievement in solving a problem with assistance from someone who is more knowledgeable. Scaffolding is a procedure to help the learners to reach their ZPD.

Learners in this study were encouraged to work collaboratively, so as to build their self-esteem and confidence in solving mathematical problems. The introduction of technology as a learning tool enhanced the learning experience by providing an avenue for learners to explore and discover strategies to solve fraction-related problems. The visual representation of fractions promoted explicit and transparent explanations that learners found challenging.

7.2.3. Why do grade 5 learners use technology in the way that they do when learning fractions in mathematics?

The third research question sought to investigate why learners used technology in the way that they did when learning fractions in mathematics. Earlier in this chapter I stated that the learners who participated in this study had access to limited resources that could be used in the learning of mathematics. The mathematics textbook, DBE workbook, diagrams, charts and the chalkboard are used as a means to supplement classroom teaching. The grade 5 learners are familiar with the advances in digital technology in the form of mobile phones, laptops, computers and gaming devices. However, none of these devices had been used as a tool for learning mathematics before. The introduction of technology into the learning process came as a welcome change to the traditional routine manner in which lessons are presented. Learners embraced the change in a positive manner as it was a break from the normal routine, thus creating intrigue and interest among the learners. Using technology as a learning tool resulted in capturing the attention of the learners and sustaining it, such that they were able to respond in a positive way to the questions in the second task-based worksheet.

The main objective of the study was to foreground the issues that affect the ways in which learners approach the use of technology in learning mathematics. This research study, which leans towards an interpretive paradigm, allowed the researcher to view the world through the perceptions and experiences of the learner participants. Furthermore the interpretive approach is participant oriented, thus providing learners with the opportunity to express their views without any distortion or inhibitions.

Technology has the potential to impact positively on learning, thus making it a common teaching and learning tool to be incorporated into education. Educational technology is a valuable tool for developing learners' cognitive and social skills, and it has greatly attracted the interest of teachers and researchers alike. The learners in this study seemed to approach the change in the lesson presentation from the routine, mundane method to a progressive, unconventional way of teaching with technology, as a novelty and a welcome change. The learners were living in a digital age where they were exposed to advances in technology such as cell phones, computers, laptops and gaming in their homes, in their communities, among their parents, relatives and peers. The inclusion of technology into their school learning was accepted by them as a way of keeping up with the trends that they had become accustomed to. This was a teaching strategy that they could identify with and relate to, thus captivating their interest keeping them focused on learning.

In order to get learners to immerse themselves into their learning experiences, it is necessary to stimulate some or all of their human senses by engaging them in an environment that allows rich and intuitive interaction with the learning content. This rich interaction that combines multimodal stimulation and technology has the potential to draw learners into the learning experience and improve learning outcomes (Doumanis & Porter, 2019). An analysis of the focus group interviews in this study revealed that learners valued the use of technology to enhance their understanding of fractions in mathematics, since they were able to visualise the complex and abstract mathematical concepts on the screen. Learners indicated that the PowerPoint presentation assisted in dealing with their confusion and misunderstandings regarding fractions in mathematics. The creative incorporation of technology into the mathematics lesson seemed to elevate the regular passive teaching method to an exciting, activity-based lesson which allowed for effective interaction and communication.

7.3. Bringing new knowledge to the field

This research study sought to explore the perceptions of grade 5 learners on the use of technology when learning fractions in mathematics. The study fore grounded that the learning of fractions is positively enhanced by including visual manipulatives and technological tools. In previous chapters (2.2.1. and 6.2.1.) it has been mentioned that learners experience challenges when engaging in solving problems related to fractions. This study attempted to use technology as a tool in a way that would make it easier for learners to solve fraction related problems. The use of manipulatives, videos and a PowerPoint presentation allowed learners to employ the use of more than one of their senses, thus promoting multiple modes of learning. The visualisation of the part-whole concept, which forms the basis of fraction learning, assisted the learners in solving problems that were presented to them. The traditional teaching methods, supported by the intervention of technology, enabled the learners to grasp the concept of fractions in a positive manner, which promoted effective learning.

In this study technology was used to facilitate collaborative and individual learning and to stimulate learning by allowing learners to visualise fraction concepts in mathematics, thereby giving learners the confidence to approach fraction problems in a positive manner. The integration of technology into the learning of fractions invoked a sense of enjoyment and interest amongst learners, who achieved better results (72%) in the second task-based worksheet than they did in the first task-based worksheet (44%). The findings from this research study bring to the fore that fractions in mathematics can be learned and remembered more effectively when technology is incorporated as a tool in the teaching and learning process. The data generated in this study indicates that technology can be used successfully to promote the effective learning of fractions in mathematics.

7.4. Recommendations

In line with the exploration of the use of technology in teaching learners, the Minister of Basic Education in South Africa (2019) announced that after numerous policy changes and the stop-and-start implementations of various models, South Africa's education system has finally turned a corner. More than 40 000 teachers had been trained in computer skills and the Department of Basic Education would be introducing a coding and robotics curriculum to learners from Grades R to 9. The aim of the changes within the school curriculum was to build a better quality education sector by being faster and smarter (Digital Innovation).

An analysis of data from this research study indicates that the use of technology-based tools when learning fractions in mathematics had a positive impact on all learners who participated in the study. The study was conducted with learners from one Grade 5 class, which is in the intermediate phase. It is pertinent that consideration is given to the incorporation of technology into the teaching and learning of fractions in other grades and phases as well. Learners can benefit greatly from the clarification of misconceptions, when they are able to engage with visual representations of the part-whole concept which forms the foundation of fractions in mathematics.

Considering the responses that have unfolded in the research process during this study, the use of technology can be incorporated into the teaching practices at any school that has the necessary resources. This technique of blending teaching methods can be used in classrooms which comprise learners with diverse learning abilities as well as classrooms where the language of teaching is different from the learners' home language. This research study has shown that the blending of multiple techniques can be effective in classrooms with a large number of learners.

It became inherently evident during this research study that the teacher assumed the role of facilitator, while the learners were actively involved in the learning process. This learner-centred approach to teaching and learning augers well for learners to become intrinsically motivated and to take responsibility for their own learning.

This study highlights the immense value of introducing and encouraging the use of technology in classroom settings, through the voice of the learners themselves. Learners reported positive attitudes towards the use of technology to enhance their learning of fractions in mathematics. In the focus group interviews, all the learners indicated that the technology- enhanced lesson helped them to understand the mathematical concepts related to fractions. Learners found the activities useful because they brought a change in their monotonous classroom pattern of learning. The provision of multiple ways of teaching was beneficial in meeting the needs of learners who experienced challenges in the learning of fractions. It is hoped that this research will provide insights that will guide curriculum developers and teachers in deciding whether and how to incorporate technology into teaching and learning activities at school.

7.5. Limitations

The analysis of data in this study relied on the use of thematic analysis to extract emerging themes from the data that was collected. One of the limitations in thematic analysis can be sampling and the limited scope provided through the use of convenience sampling. In this study the sampling framework was modified to purposive convenience sampling, so as to make the data collection site easily accessible in order for the researcher to collect information-rich data. A true random sample was unlikely to be feasible in this study as it was necessary for the interviewee to be involved in the subject or in the research itself. This may have given a somewhat skewed view within the results of the analysis of data (Roberts, Dowell & Nie, 2019).

The research in this study was limited to one class of learners in one school only. There would have been a wider range of participants, competency levels, learning environments and teaching styles, had I included learners from other schools in the study. There are many schools within the Department of Basic Education in South Africa that are situated in deep rural areas, where there is a lack of basic amenities such as electricity and running water. Research conducted at a school which has no electricity may have yielded different results.

Furthermore, the choice of learners who participated in this study was limited to one class in one grade only. This study could have been extended to include learners from other grades and other phases in order to generate more in-depth information about the perceptions of learners on the use of technology when learning fractions in mathematics. Since learners at each phase of learning approach the learning content and teaching methods in different ways, a more varied sample would have provided a greater scope for generalisation of findings of the study (Hajaree, 2015). Although the findings of this study emerge from a relatively small dataset, they do highlight some important issues.

Another limitation to this study was the restricted use of technology-based tools in accordance with the availability of resources at the school where the research was conducted. The only technological resources available at the school at the time of the study were the projector, a laptop and a screen. Had the learners been allowed to access learning via their own cell phones, tablets, computers and internet facilities, they would have been able to explore other variations to learning with technology. While this may have provided a broader perspective on the use of technology when learning fractions, the findings of this study are worthy of consideration.

7.6. Researcher thoughts/reflections

Mathematics is a unique subject in that it is abstract and a large part of it is conceptual. Teaching mathematics to learners involves skilfully incorporating visuals and images, linking the curriculum content to the real-world experiences or situations that learners can identify with. Learners of mathematics tend to lose interest in the subject very easily, meaning that the medium of instruction needs to be captivating enough to sustain interest of the learners in the information that is being relayed to them. Any previous negative experiences learners may have had with specific aspects of mathematics, leads learners to believe that they will not be able to overcome those challenges. It becomes an onerous task on the part of the teacher to change the negative mindset of the learners and convince them that they can unravel and resolve their uncertainties. The learning of fractions is the one aspect in mathematics that proves to be a challenge to learners. Teachers often use varying strategies to achieve success in assisting learners to understand the different concepts and components that form the fraction syllabus. This observation warrants the exploration of using technology as a teaching strategy when learning fractions in mathematics.

Furthermore, according to White Paper 7 of 2004, the South African Minister of Education emphasised that ICT is central to the changes taking place throughout the world. Digital media has revolutionised the information society and advances in ICT have dramatically changed the teaching and learning process. ICT, when successfully integrated into teaching and learning, can ensure the meaningful interaction of learners with information. ICT can advance high order thinking skills such as comprehension, reasoning, problem solving and creative thinking. It is further a motivational tool that enhances productivity and employability. Success in the infusion of ICT into teaching and learning will ensure that all learners will be equipped for full participation in the knowledge society (Pandor, 2004).

Many teachers have become apathetic and teaching is viewed as a tedious and mundane activity. One of the ways in which to challenge and change this mind-set of teachers is highlighted by Dogan and Arici (2019) who foreground that today it is necessary to implement activities that will facilitate the learning of individuals, improve their thinking skills, and enable them to look at different aspects of an event or situation in the teaching-learning environment. In the education system, plans should be made to ensure the growth of the learners according to the changing world conditions, to establish connections among the disciplines and to transfer these connections in the field to the learners.

These observations led to the emergence of this study. In a quest to assist learners to change their outlook and attitude to learning mathematics, I incorporated the use of a blend of multiple teaching techniques and explored the use of a variety of resources. It was the use of technology that was able to transform the teaching environment into one of fun, enjoyment and assertiveness. The attitude of disinterest and lack of motivation were abandoned and learners were alert and engrossed in what was being taught.

Regardless of the fact that I had my own preconceived ideas of how technology should be incorporated into the teaching of mathematics, I was able to distance myself from my own perceptions and harness an understanding of the convictions, attitudes, interpretations and sentiments of the participants I was studying.

The journey through this study has been peppered with learning curves for me as a researcher. As an educator who has been using the traditional teaching methods for many years, I did not have much insight into the implementation of technology into teaching mathematics. I had not realised how much of an impact technology could make on the learning experiences of learners as young as 11 years old. I was able to cast aside my naivety and embrace the positive manner in which learners responded to the introduction of technology into their fraction learning experience, to an extent that has convinced me to blend my teaching strategies to include technology into the teaching of other subjects as well. I have found that my involvement in this study has forced me to move away from preconceived assumptions of teaching methods, styles and resources and reflect on issues relating to the incorporation of technology into teaching and learning. This reflection has allowed me to understand the dynamic nature of teaching, the importance of keeping abreast of the changes unfolding in society and the need to adapt teaching methods so as to provide learners with the opportunities to engage in meaningful learning. This journey has been challenging but ultimately a rewarding one. I have gained beneficial knowledge about an aspect regarding the teaching and learning of fractions in mathematics that I knew so little about.

The findings of this study resonate with existing research by Agrawal (2019) who emphasises that technology has become a way of life for learners. Even when they are not in school almost everything they do is connected to technology in some way. This has predisposed learners to be able to connect with technology in the classroom. It is much easier to connect with lessons through technology than reading a textbook or listening to a long lecture. Learners are also able to connect with the tools they need to be successful in the 21st century.

At the centre of this study are the learners' perceptions of learning fractions in mathematics with the use of technology-based tools. It is crucial to consider the ways in which learners perceive, interpret and interact with teaching tools that are used in the classroom, since the success of teaching is dependent on the achievement of the relevant learning outcomes. The participants in this study made a very strong case in favour of using technology while learning fractions in mathematics. It is crucial for the voice of the learners to be considered in this regard so that the teaching and learning process can be transformed to include technology in the classroom. An analysis of the data in this study revealed that learners were unanimous in their view that technology-enhanced teaching had allayed their anxieties related to learning of fractions, resolved the confusion around the terminology associated with the learning of fractions and brought out the fun and enjoyment in the learning of mathematics. The incorporation of technology into teaching and learning has become inevitable, and can be seen as the changing face of the classroom environment.

The research of Canavan (2018) encapsulates the essence of this study by stating that ultimately the use of technology in the classroom is hard to argue against and in reality, it's inevitable. If teachers are to prepare learners for the real world, then an ability to use technology in their everyday lives is essential. Integrating discussions and collaborative learning with technology is the key to successful teaching and is essential in preparing learners for the future. This research study has demonstrated the effectiveness of using technologically enhanced instruction in the teaching and learning of fractions, however, further research is needed to assess the extent to which blended learning has contributed to the success achieved.

7.7. Summary

Analysis of the data in this study has found that the use of technology has made a significant impact on the learning outcomes of learners who are learning fractions in Grade 5. The incorporation of technology-based tools in the teaching of mathematics had the unique ability to change the way in which the teacher taught the lesson and the way in which learners learnt. The evolution of the teaching process to include a technological angle is bound to have a positive impact on the lives of learners in the classroom as well as in the world around them.

Considering the research that was done in this study, the outcomes suggest that technology-enhanced learning can be used successfully in any classroom. The technique of using technological devices and tools may be the catalyst that is needed by education authorities to overcome the challenges faced by teachers in the delivery of the curriculum. The use of technology in teaching and learning may be seen as a way to address the issues of large class sizes and disorderly behaviour of learners, which are some of the obstacles that prevent effective learning.

A sense of enjoyment and the alleviation of the learners' mathematics anxieties resulted from the transformation of the classroom from the traditional teacher-centred environment to a progressive environment. It was evident from the data collected and analysed that traditional teaching methods supplemented by the use of technology, had a positive impact on learning mathematics.

It is clear from the analysis of results from the activities that learners engaged in, that the use of technology as a tool in education has the ability to stimulate learning, thereby making a positive impact on learning fractions in mathematics.

7.8. Conclusion

Chapter seven highlighted the focus of the study, which incorporated a summary of the salient points related to the key research questions. This study explored the perceptions of Grade 5 learners on the use of technology when learning fractions in mathematics. The data generated in this study elucidated the positive impact that technology had on learners who were learning fractions in mathematics. The introduction of technology into the mathematics lesson allowed learners to embrace the learning process as an appealing and fun activity, which assisted in remembering and retaining what was learned. The use of technology created an alternate way of learning, thus fostering a positive attitude to learning fractions in mathematics. Learners further emphasised the importance of technology in reinforcing key concepts and providing a multimodal dimension to learning fractions. The researcher made use of visual manipulatives, blended with scaffolding and the ZPD to enhance the learning of fractions in mathematics. The chapter concludes with the recommendations of the researcher, followed by the limitations that were identified within the study. Finally, the researcher's thoughts and a summary of the main findings are presented.

References

Abbas, N.J. (2017). The role of language scaffolds in enhancing college students' comprehension within Vygotsky's Zone of Proximal Development (ZPD). *Al-Fatih Journal, 13*(69), 1-22.

Abdullah, A.H., Julius, E., Yann, T.Y., Mokhtar, M. & Abd Rahman, S.N.S. (2018). Using cooperative learning to overcome students' misconceptions about fractions. *NeuroQuantology, 16*(11), 79-92. doi: 10.14704/nq.2018.16.11.1699

Abtahi, Y. (2018). Pupils, tools and the Zone of Proximal Development. *Research in Mathematics Education, 20*(1), 1-13, DOI: 10.1080/14794802.2017.1390691.

Akogwu, J.N., Abugu, G.N., Okeke, A.M. & Umakalu, C.P. (2019). Integrating Geogebra software in teaching and learning of mathematics: A remedy to students' declining interest in mathematics. *Abacus (Mathematics Education Series), 44*(1), 1-5.

Agrawal, V. (2019). 5 ways technology in the classroom can enhance student learning. *Lifehack.* Retrieved from https://www.lifehack.org/492485/5-ways-technology-in-the-classroom-can-enhance-student-learning, California.

Ahmad, F.K. (2015). Use of assistive technology in inclusive education: Making room for diverse learning needs. *Transcience: A Journal of Global Studies, 6*(2), 62-77.

Aksakal, M., Bilecen, B. & Schmidt, K. (2018). Qualitative sampling in research on international student mobility: *Insights from the Field in Germany, Globalisation, Societies and Education,17*(5), 610-621, doi: 10.1080/14767724.2018.1525282

Aksoy, N.C. & Yazlik, D.O. (2017). Student errors in fractions and possible causes of these errors. *Journal of Education and Training Studies, 5*(11), 26-79, doi: https://doi.org/10.11114/jets.v5i11.2679.

Alase, A. (2017). The Interpretative Phenomenological Analysis (IPA): A guide to a good qualitative research approach. *International Journal of Education & Literacy Studies, 5*(2), 9-19.

AlDahdouh, A.A., Osorio, A.J. and Caires, S. (2015). Understanding knowledge network, learning and connectivism. *International Journal of Instructional Technology and Distance Learning, 12*(10), 1-19.

Alkhateeb, M.A. (2019). Common errors in fractions and the thinking strategies that accompany them. *International Journal of Instruction, 12*(2), 399-416.

Amalia, R., Saiman, S., Sofiyan, S. & Mursalin, M. (2018). Designing computer-based fraction worksheets for junior high school. *Journal of Physics: Conference series, 1088.* Conference 1. Indonesia.

Amankwaa, L. (2016). Creating protocols for trustworthiness in qualitative research. *Journal of Cultural Diversity, 23*(3), 121-127.

Amineh, R.J. & Asl, H.D. (2015). Review of constructivism and social constructivism. *Journal of Social Sciences, Literature and Languages, 1*(1), 9-16.

Andamon, J.C. & Tan, D.A. (2018). Conceptual understanding, attitude and performance in mathematics of grade 7 learners. *International Journal of Scientific & Technology Research, 7*(8), 96-105.

Armstrong, F. & Tsokova, D. (2019). *Action Research for Inclusive Education: Participation and democracy in teaching and learning*. Routledge. London & New York.

Armstrong, F. (2019). Social constructivism and action research: Transforming teaching and learning through collaborative practice. In: *Action Research for Inclusive Education.* Routledge. London & New York.

Ashman, A.F. & Conway, R.N.F. (2018). *Using Cognitive Methods in the Classroom.* London. Routledge, https://doi.org/10.4324/9781315271019.

Attard, C. (2018) Mobile technologies in the primary mathematics classroom: Engaging or Not? In: Calder, N., Larkin, K., Sinclair, N. (eds) Using mobile technologies in the teaching and learning of mathematics. *Mathematics Education in the Digital Era, 12*, 51-65. https://doi.org/10.1007/978-3-319-90179-4_4

Bailey, L.W. (2019). New technology for the classroom: mobile devices, artificial intelligence, tutoring systems, and robotics. In Bailey, L. (Ed.), *Educational Technology and the New World of Persistent Learning, 11*(2), 47-50, doi:10.4018/978-1-5225-6361-7.ch001.

Baloche, L. & Brody, C.M. (2017). Cooperative learning: exploring challenges, crafting innovations. *Journal of Education for Teaching, 43*(3), 274-283, doi: 10.1080/02607476.2017.1319513

Barak, M. (2017). Science teacher education in the twenty-first century: a pedagogical framework for technology-integrated social constructivism. *Research in Science Education, 47*(1), 283–303, https://doi.org/10.1007/s11165-015-9501-y

Barakabitze, A.A., Lazaro, A.W., Ainea, N., Maziku, M.H., Matofali, A.X., Iddi, A. & Sanga, C. (2019). Transforming African education systems in Science, Technology, Engineering, and Mathematics (STEM) using ICTs: Challenges and opportunities. *Education Research International, 2019*, Article ID 6946809, https://doi.org/10.1155/2019/6946809

Beilstein, S.O. (2019). *Supporting learners' Conceptual understanding of Fractions with Manipulatives and Gesture*. (Doctoral dissertation) University of Illinois at Urbana-Champaign.

Ben-Chaim, D., Shalitin,Y. & Stupel, M. (2019). Historical mathematical problems suitable for classroom activities. *The Mathematical Gazette, 103*(556), 12-19, doi: https://doi.org/10.1017/mag.2019.2.

Bernstein, A., McCarthy, J. & Oliphant, R. (2013, October 24). Maths teaching in SA adds up to multiplying class divisions. *Mail & Guardian*. Retrieved from www.mg.co.za.

Bhattacharya, K. (2017). *Fundamentals of Qualitative Research: A Practical Guide*. Edition 1. Routledge. London and New York.

Bidabadi, N.S., Esfahani, A.R.N., Jafari, E.M. & Abedi, A. (2019). Developing a mathematics curriculum to improve learning behaviours and mathematics competency of children. *The Journal of Educational Research, 112*(3), 421-428, doi: 10.1080/00220671.2018.1547960.

Borthwick, A. (2019). Using manipulatives in the mathematics classroom. *Enriching Mathematics in the Primary Curriculum*. SAGE. UK.

Bozkurt, G. & Ruthven, K. (2018). The activity structure of technology-based mathematics lessons: A case study of three teachers in English secondary schools. *Research in Mathematics Education, 20*(3), 254-272, doi: 10.1080/14794802.2018.1474798.

Braem, S. & Egner, T. (2018). Getting a grip on cognitive flexibility. *Current Directions in Psychological Science, 27*(6), 470-476.

Braun, V., Clarke, V., Hayfield, N. & Terry, G. (2018). *Thematic Analysis*. Springer Nature. Singapore.

Bray, A. & Tangney, B. (2017). Technology usage in mathematics education research – A systematic review of recent trends. *Computers & Education, 114*, 255-273.

Brosseuk, D., Exley, B. & Neumann, M. (2019). "You know, I could trip and fall onto the track!" Inspiring Text Production, *The Reading Teacher, 73*(4), 453-460.

Bruce, C., Chang, D., Flynn, T. & Yearley, S. (2013). *Foundations to Learning and Teaching Fractions*: Addition and subtraction. Retrieved from http://www.edugains.ca/resources/Professional Learning/Foundations to Learning and Teaching Fractions. Canada.

Bryman, A. (2017). Quantitative and qualitative research: further reflections on their integration. In Brannen, J. (ed). *Mixing Methods: Qualitative and Quantitative Research*. Routledge. London.

Bulut, O. & Cutumisu, M. (2018). When technology does not add up: ICT use negatively predicts mathematics and science achievement for Finnish and Turkish students in PISA 2012. In Johnston, J. (Ed.), *Proceedings of EdMedia 2017,* (935-945). Washington, DC: Association for the Advancement of Computing in Education (AACE). Retrieved February 12, 2020 from https://www.learntechlib.org/primary/p/178407/. University of Alberta, Canada.

Bussi, M.G.B. & Sun, X.H. (2018). *Building the Foundation: Whole numbers in the Primary Grades.* The 23rd ICMI Study. University of Macau. Macao.

Campbell, A., Craig, T. & Collier-Reed, B. (2019). A framework for using learning theories to inform 'growth mind-set' activities. *International Journal of Mathematical Education in Science and Technology, 51*(1), 26-43, doi: 10.1080/0020739X.2018.1562118

Canavan, D. (2018). Embracing the new revolution: How to effectively teach with technology. *Access, 32*(2), 4-13.

Carcary, M. (2015). The research audit trial – Enhancing trustworthiness in qualitative inquiry. *The Electronic Journal of Business Research Methods, 7*(1), 11-24, available online at www.ejbrm.com.

Castleberry, A. & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents in Pharmacy Teaching and Learning, 10*(6), 807-815.

Celik, H.C. (2018). The effects of activity based learning on sixth grade students' achievement and attitudes towards mathematics activities. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(5), 1963-1977, https://doi.org/10.29333/ejmste/85807.

Chan, L.L. & Idris, N. (2017). Cooperative learning in mathematics. *International Journal of Academic Research in Business and Social Sciences, 7*(3), 27-57, doi: 10.6007/IJARBSS/v7-i3/2757 URL: http://dx.doi.org/10.6007/IJARBSS/v7-i3/2757.

Chan, M.C.E., Clarke, D. & Cao, Y. (2018). The social essentials of learning: An experimental investigation of collaborative problem solving and knowledge construction in mathematics classrooms in Australia and China. *Mathematics Education Research Journal, 30*(1), 39-50, https://doi.org/10.1007/s13394-017-0209-3.

Charles, A.S. (2018). *Rivers and Fireworks: Social Constructivism in Education*. In: Kapur, V. & Ghose, S. (eds) Dynamic Learning Spaces in Education. Springer. Singapore.

Chen, B. (2015). Exploring the Digital divide: the use of digital technologies in Ontario public schools. *Canadian Journal of Learning and Technology, 41*(3), 1-23, doi: https://doi.org/10.21432/T2KP6F.

Cheng, K. (2018). Surveying students' conceptions of learning science by augmented reality and their scientific epistemic beliefs. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(4):1147-1159, doi: 10.29333/ejmste/81811.

Cheng. H. (2018). *A Brief Analysis of SPOC's Advanced Mathematics Curriculum Exploration and Practice*. Xi'an Eurasia University, Xi'an, Shaanxi, China.

Christensen, P. & James, A. (2017). *Research with Learners Perspectives and Practices*. Third Edition. New York.

Cinquin, P.A., Guitton, P. & Sauzeon, H. (2019). Online e-learning and cognitive disabilities: a systemic review. *Computers & Education, 130*(1), 152-167, https://doi.org/10.1016/j.compedu.2018.12.004.

Clapper, T.C. (2015). Cooperative-based learning and the Zone of Proximal Development. *Computers & Education, 130*(1), 152-167 https://doi.org/10.1177/1046878115569044

Collins, A. & Halverson, R. (2018). *Rethinking Education in the age of Technology: The Digital Revolution and the School.* New York.

Collins, C.S. & Stockton, C.M. (2018). The central role of theory in qualitative research. *International Journal of Qualitative Methods, 17*(1), 1-10, https://doi.org/10.1177/1609406918797475.

Colter, R. & Ulatowski, J. (2017). The unexamined student is not worth teaching: preparation, the zone of proximal development, and the socratic model of scaffolded learning. *Educational Philosophy and Theory, 49*(14), 1367-1380, doi: 10.1080/00131857.2017.1282340

Cypress, B.S. (2018). Qualitative research methods: a phenomenological focus. *Dimensions of Critical Care Nursing, 37*(6), 302-309, doi:10.1097/DCC.0000000000000322.

da Silva, J.P., Nogueira, R., Rizzo, G. & Silveira, I.F. (2019). *FracPotion: An Open Educational Game to Teach Fractions in Brazil*. Mackenzie Presbyterian University, & Cruzeiro do Sul University.

Day, L. & Hurrell, D. (2017). Food for thought: The role of manipulatives in the teaching of fractions. *Australian Primary Mathematics Classroom, 22*(4), 39-40.

DeCoito, I. & Richardson, T. (2018). Using technology to enhance science literacy, mathematics literacy, or technology literacy: focusing on integrated stem concepts in a digital game. *Information and Technology Literacy: Concepts, Methodologies, Tools, and Applications, 22*(1), 410-433, doi: 10.4018/978-1-5225-3417-4.ch080

Dele-Ajayi, O., Strachan, R., Pickard, A. & Sanderson, J. (2019). Games for teaching mathematics in Nigeria: What happens to pupils' engagement and traditional classroom dynamics? *IEEE Access, 7*(1), 53248-53261.

Department of Education. (2004). *White Paper 7*. South Africa.

Department of Basic Education. (2011). *Curriculum and Assessment Policy Statements. Grades R – 12.* South Africa.

Department of Basic Education. (2019). TALIS 2018. South Africa country note. *Teachers and School Leaders as Lifelong Learners*. OECD 2019. Volume 1. South Africa.

Deringol, Y. (2019). Misconceptions of primary school students about the subject of fractions. *International Journal of Evaluation and Research in Education, 8*(1), 29-38.

De Villiers, J. (2019). *Computational Mathematics/Approximation Theory*. African Institute for Mathematical Sciences. University of Stellenbosch. South Africa.

Dogan, Z. & Arici, A. (2019). The effect of teaching fractions with the interdisciplinary approach on 1st Graders' learning in elementary school. *International Online Journal of Educational Sciences, 11*(2), 1-19.

Doumanis, I. & Porter, S. (2019). the impact of multimodal collaborative virtual environments on learning: A gamified online debate. *Computers & Education, 130*(1), 121-138.

Draper, A. & Swift, J.A. (2011). Qualitative research in nutrition and dietetics: data collection issues. *Journal of Human Nutrition and Dietetics, 24*(1), 3-12, doi:10.1111/j.1365-277X.2010.01117.

Dube, B.A., Nhamo, E. & Magonde, S. (2018). Factors affecting ICT integration in the teaching and learning of physical education in South Africa: A case of Johannesburg East cluster primary schools in the Gauteng Province. *International Journal of Sport, Exercise and Health Research, 2*(1), 88-92.

Dugas, D. (2017). Group dynamics and individual roles: a differentiated approach to social-emotional learning. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 90*(2), 41-47, doi: 10.1080/00098655.2016.1256156.

Durak, H. Y. & Saritepeci, M. (2017). Investigating the effect of technology use in education on classroom management within the scope of the FATİH project. *Cukurova University Faculty of Education Journal, 46*(2), 441-457.

Erdei, R., Springer, J.A., & Whittinghill, D.M. (2017). An impact comparison of two instructional scaffolding strategies employed in our programming laboratories: Employment of a supplemental teaching assistant versus employment of the pair programming methodology. *2017 IEEE Frontiers in Education Conference (FIE)*, 1-6.

Erlingsson, C. & Brysiewicz, P. (2017). A hands-on guide to doing content analysis. *African Journal of Emergency Medicine, 7*(3), 93-99. ISSN 2211-419X, https://doi.org/10.1016/j.afjem.2017.08.001.

Etikan, I., Musa, S.A. & Alkassim, R.S. (2017). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1-4, doi: 10.11648/j.ajtas.20160501.11.

Eun, B. (2017). The zone of proximal development as an overarching concept: A framework for synthesizing Vygotsky's theories. *Educational Philosophy and Theory, 51*(1), 18-30, doi: 10.1080/00131857.2017.1421941.

Fabian, K., Topping, K.J., & Barron, I.G. (2018). Using mobile technologies for mathematics: Effects on student attitudes and achievement. *Educational Technology Research and Development, 66*(5), 1119–1139, https://doi.org/10.1007/s11423-018-9580-3.

Fahmi, S., Soffi, W.P. & Prabowo, A. (2018). *Interactive Learning Media Development for Courses of Mathematical Logic and Set.* Paper presented at Ahmad Dahlan International Conference on Mathematics and Mathematics Education, University of Ahmad Dahlan, Yogyakarta, Indonesia.

Falck, O., Mang, C. & Woessmann, L. (2018). Virtually no effect? Different uses of classroom computers and their effect on student achievement. *Oxford Bulletin of Economics and Statistics, 80*(1), 1-38.

Fennell, F. & Karp, K. (2017). Fraction Sense: foundational understandings. *Journal of learning Disabilities, 50*(6), 648-650.

Finnegan, M. & Ginty, C. (2019). Moodle and social constructivism: Is Moodle being used as constructed? A case study analysis of Moodle use in teaching and learning in an Irish higher educational institute. *All Ireland Journal of Higher Education, 11*(1), 3-81.

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). *Preparing for life in a Digital Age* - the IEA international computer and information literacy study report. Australian Council for Educational Research (ACER) Melbourne, Australia.

Francois, K., Mafra, J.R.S., Ricardo, J., Fantinato, M.C. & Vandendriessche, E. (2018). Local mathematics education: the implementation of local mathematical practices into the mathematics curriculum. *Philosophy of Mathematics Education Journal, 33*(1), 1-18.

Frykedal, K.F. & Chiriac, E.H. (2018). Student collaboration in group work: inclusion as participation. *International Journal of Disability, Development and Education, 65*(2), 183-198, doi: 10.1080/1034912X.2017.1363381.

Furner, J.M. (2019). Tackling mathematics anxiety through photography while using GeoGebra. *Transformations, 5*(1), 59-75.

Gale, N.K., Heath, G., Cameron, E., Rashid, S. & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology, 13*(117), 1-8, doi:10.1186/1471-2288-13-117.

Gao, C. (2019). Research on the integration of modern educational information technology and mathematics teaching in colleges and universities. *Proceedings of the 4th international conference on Humanities, Science, Management and Education Technology (HSMET 2019)*. Singapore.

Gentles, S.J., Charles, C., Ploeg, J. & Mckibbon, K.A. (2015). Sampling in qualitative research: Insights from an overview of the methods literature. *The Qualitative Report, 20*(11), 1772–1789.

Gizem, K.Y.F., Gokkurt, O.B., Zehra,Y. (2018). *Using digital stories to reduce Misconceptions and Mistakes about Fractions*: An action study. Turkey.

Goldie, J.G.S. (2016). Connectivism: A knowledge learning theory for the digital age? *Medical Teacher, 38*(10), 1064-1069, doi: 10.3109/0142159X.2016.1173661.

Golji, G.G., & Dangpe, A.K.D. (2016). Activity-based learning strategies (ABLS) as best practice for secondary mathematics teaching and learning. *International Advanced Journal of Teaching and Learning, 2*(9), 106-116.

Gonulal, T. & Loewen, S. (2018). Scaffolding technique: Approaches and methods in English for speakers of other languages. Strategies and techniques in English for speakers of other languages. *The TESOL Encyclopaedia of English Language Teaching.* First published: January 2018, https://doi.org/10.1002/9781118784235.eelt0180

Gous, N. (2019, July 2). Angie Motshekga: Basic education in SA is 'firmly on the rise': *SowetanLive*. Retrieved from https://www.sowetanlive.co.za.

Govender, R. & Hugo, A.J. (2018). *Per Linguam: A Journal of Language Learning, 34*(1), 17-32. Department of Higher Education and Training (DHET). University of South Africa.

Gracia-Bafalluy, M. & Puyuelo-San Clemente, M. (2019). Mathematical learning and its difficulties in Southern European countries. In: Fritz, A., Haase, V. & Räsänen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer, Cham.

Greener, S. (2018). Research Limitations: The need for honesty and common sense. *Interactive Learning Environments, 26*(5), 567-568, doi: 10.1080/10494820.2018.1486785.

Gunbayi, I. & Sorm, S. (2018). Social paradigms in guiding social research design: The functional, interpretive, radical humanist and radical structural paradigms. Online submission, *International Journal on New Trends in Education and their Implications, 9*(2), 57-76.

Haase, V.G. & Krinzinger, H. (2019). Adding all up: Mathematical learning difficulties around the world. In: Fritz, A., Haase, V. & Rasanen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer. Germany.

Hajaree, S. (2015). *The Emotional Geographies of Learning Mathematics: Narratives of twelve learners.* (Unpublished Masters dissertation). University of KwaZulu-Natal, South Africa.

Halcomb, E. (2016). Creatively collecting qualitative data. *Nurse Researcher, 23*(3), 6-7. University of Wollongong, Australia.

Hallinan, Z.P., Forrest, A., Uhlenbrauck, G., Young, S. & McKinney, R. (2016). Barriers to Change in the Informed Consent Process. *IRB: Ethics & Human Research, 38*(3), 1-10.

Harasim, L. (2017). *Learning Theory and Online Technologies*. New York. Routledge, https://doi.org/10.4324/9781315716831

Harper, B. (2018). Technology and teacher–learner interactions: A review of empirical research, *Journal of Research on Technology in Education, 50*(3), 214-225, doi: 10.1080/15391523.2018.1450690.

Hart, C. (2018). *Doing a literature review*: Releasing the social science research imagination. London: SAGE.

Haser, C. & Ubuz, B. (2002). Conceptual and operational performance in fractions. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 24*(1), 64-69.

Haven, T.L. & Van Grootel, L. (2019). Preregistering qualitative research. *Accountability in Research, 26*(3), 229-244, doi: 10.1080/08989621.2019.1580147

Hensberry, K., Moore, E. & Perkins, K. (2015). Effective student learning of fractions with an interactive simulation. *Journal of Computers in Mathematics & Science Teaching, 34*(3), 273-298, https://www.learntechlib.org/primary/p/148049/.

Herzog, C., Handke, C. & Hitters, E. (2019). Analysing talk and text II: Thematic analysis. In: Van den Bulck, H., Puppis, M., Donders, K., Van Audenhove, L. (eds) *The Palgrave Handbook of Methods for Media Policy Research*. Palgrave Macmillan, Cham.

Higgins, K., Huscroft-D'Angelo, J. & Crawford, L. (2017). Effects of technology in mathematics on achievement, motivation, and attitude: A meta-analysis. *Journal of Educational Computing Research, 57*(2), 283-319, https://doi.org/10.1177%2F073563311774841.

Homanova, Z., Prextova, T. & Klubal, L. (2018). *Connectivism in Elementary School Instruction*. University of Ostrava, Ostrava, Czech Republic.

Hughes, E.M. (2019). Point of view video modelling to teach simplifying fractions to middle school learners with mathematical learning disabilities. *Learning Disabilities: A Contemporary Journal, 17*(1), 41-57. The Pennsylvania State University.

Hughes, S., Davis, T.E. & Imenda, S.N. (2019). Demystifying theoretical and conceptual frameworks: A guide for students and advisors of educational research. *Journal of Social Sciences, 58*(1-3), 24-35, doi: 10.31901/24566756.2019/58.1-3.2188

Hurst. M.A. & Cordes, S. (2018). Learners' understanding of fraction and decimal symbols and the notation-specific relation to pre-algebra ability. *Journal of Experimental Learner Psychology, 168*(1), 32-48, doi.org/10.1016/j.jecp.2017.12.003.

Hwa, S. (2018). Pedagogical change in mathematics learning: Harnessing the power of digital game-based learning. *Journal of Educational Technology & Society, 21*(4), 259-276. Retrieved from https://www.jstor.org/stable/26511553.

Hwang, W., Utami, I.Q., Purba, S.W.D. & Chen, H.S.L. (2019). Effect of ubiquitous fraction app on mathematics learning achievements and learning behaviours of Taiwanese students in authentic contexts. *IEEE Transactions on Learning Technologies*, doi: 10.1109/TLT.2019.2930045.

Ikhwanudin, T. & Suryadi, D. (2018). How students with mathematics learning disabilities understand fraction: A case from the Indonesian Inclusive School. *International Journal of Instruction, 11*(3), 309-326.

Islim, O. F., Ozudogru, G. & Sevim-Cirak, N. (2018). The use of digital storytelling in elementary mathematics teachers' education. *Educational Media International, 55*(2), 107-122, doi: 10.1080/09523987.2018.1484045.

Ito, T. (2017). *Effectiveness of ST Math in College Remedial Mathematics Students of Learning Fraction Concepts*. UNLV Theses, Dissertations, Professional Papers, and Capstones. https://digitalscholarship.unlv.edu/thesesdissertations/2988. University of Nevada. Los Angeles.

Jojo, Z. (2019). *Mathematics Education System in South Africa*. Intech Open, doi: 10.5772/intechopen.85325. Available from: https://www.intechopen.com/online-first/mathematics-education-system-in-south-africa. South Africa.

Jordan, N.C., Rinne, L. & Hansen, N. (2019). Mathematical learning and its difficulties in the United States: Current issues in screening and intervention. In: Fritz, A., Haase, V., Rasanen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer, Cham. USA.

Joshi, D.R. (2017). Influence of ICT in mathematics teaching. *International Journal for Innovative Research in Multidisciplinary Field, 3*(1), 7.

Juan, A. & Visser, M. (2017). Home and school environmental determinants of science achievement of South African students. *South African Journal of Education, 37*(1), 1-10.

Juma, S., Lehtomaki, E. & Naukkarinen, A. (2017). Scaffolding teachers to foster inclusive pedagogy and presence through collaborative action research. *Educational Action Research, 25*(5), 720-736, doi: 10.1080/09650792.2016.1266957.

Kaplan, R.G. & Alon, S. (2013). Using technology to teach equivalence. *Teaching Children Mathematics, 19*(6), 382-389. doi:10.5951/teacchilmath.19.6.0382

Kearney, M., Schuck, S., Aubusson, P. & Burke, P.F. (2018) Teachers' technology adoption and practices: lessons learned from the IWB phenomenon. *Teacher Development, 22*(4), 481-496, doi: 10.1080/13664530.2017.1363083. Australia.

Keleszade, G., Guneyli, A. & Ozkul, A.E. (2018). Effectiveness of history teaching based on social constructivist learning and development of historical thinking skills. *Education and Science, 43*(195), 167-191.

Khuzwayo, H.B. & Mncube, D.W. (2017). Progressive mathematics teaching in South Africa: A focus on curriculum reform from Outcomes-Based Education (OBE) to the Curriculum and Assessment Policy Statement (CAPS). Sabinet African Journals. *Gender and Behaviour, 15*(4), 10363-10375. South Africa.

Kiru, E.W., Doabler, C.T., Sorrells, A.M. & Cooc, N.A. (2017). A Synthesis of technology-mediated mathematics interventions for students with or at risk for mathematics learning disabilities. *Journal of Special Education Technologies, 33*(2). 111-123.

Kohen, Z. (2019.) Informed integration of IWB technology, incorporated with exposure to varied mathematics problem-solving skills: its effect on students' real-time emotions. *International Journal of Mathematical Education in Science and Technology, 50*(8), 1128-1151, doi: 10.1080/0020739X.2018.1562119.

Kong, S.C. (2019). Components and methods of evaluating computational thinking for fostering creative problem-solvers in senior primary school education. In: Kong SC., Abelson H. (eds) *Computational Thinking Education*, 119-141. Springer, Singapore.

Koopman, M., Thurlings, M. & den Brok, P. (2019). Factors influencing students' proficiency development in the fraction domain: the role of teacher cognitions and behaviour. *Research Papers in Education, 34*(1), 14-37, doi: 10.1080/02671522.2017.1390595.

Kor, L., Teoh, S., Mohamed, S.S.E.B. & Singh, P. (2019). Learning to make sense of fractions: Some insights from the Malaysian primary pupils. *International Electronic Journal of Mathematics Education, 14*(1), 169-182, doi.org/10.29333/iejme/3985.

Korstjens, I. & Moser. A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing, *European Journal of General Practice, 24*(1), 120-124, doi: 10.1080/13814788.2017.1375092.

Korucu, A.T. & Cakir, H. (2018). The effect of dynamic web technologies on student academic achievement in problem-based collaborative learning environment. *Malaysian Online Journal of Educational Technology, 6*(1), 92-108.

Kotok, S. & De Matthews, D. (2018). challenging school segregation in the twenty-first century: how districts can leverage dual language education to increase school and classroom diversity. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 91*(1), 1-6, doi: 10.1080/00098655.2017.1336405.

Knapp, D. (2019). Memorable experiences of a science field trip. *School Science and Mathematics, 100*(2), 65-72, https://doi.org/10.1111/j.1949-8594.2000.tb17238.

Kovecses-Gosi, V. (2018). Cooperative learning in VR environment. *Acta Polytechnica Hungarica, 15*(3), 205-225.

Krishnan, S. (2019). Scaffolding to improve learners' understanding. *International Journal of Academic Research in Business and Social Sciences, 9*(3), 809–814.

Kurniawan, H., Sutawidjaja, A., As'ari, A. R. & Muksar, M. (2018). The thinking process of students in representing images to symbols in fractions. *Journal of Physics: Conference Series, 1028*, conference 1.

Kwon, H. & Capraro, M.M. (2018). The effects of using manipulatives on students' learning in problem posing: The instructors' perspectives. *Journal of Mathematics Education, 11*(2), 35-47, doi.org/10.26711/007577152790026.

Laksov, K. B., Dornan, T. & Teunissen, P. W. (2017). Making theory explicit – An analysis of how medical education research(ers) describe how they connect to theory. *BMC Medical Education, 17*(18), 1-9, doi.org/10.1186/s12909-016-0848-1.

Larkin, K., Calder, N. (2016). Mathematics education and mobile technologies. *Mathematics Education Research Journal, 28*(1), 1-7, https://doi.org/10.1007/s13394-015-0167-6.

Le Donne, N. (2019). Admin tasks chip away at teaching time: In: *South African Government News Agency.* OECD. Paris.

Leavy, P. (2017). Research Design: *Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches*. The Guildford Press. New York.

Lee, C.S. & Chan, P.Y. (2019). Mathematics learning: Perceptions toward the design of a website based on a fun computational thinking-based knowledge management framework. In:

Kong, S.C., Abelson, H. (eds). *Computational Thinking Education*, 183-200. Springer, Singapore.

Leneway, R.J. (2018). Transforming K-12 classrooms with digital technology: A look at what works! *Information and Technology Literacy: Concepts, Methodologies, Tools, and Applications, 25*(1), 1-22, doi: 10.4018/978-1-5225-3417-4.ch078. Western Michigan University.

Lerman, S. (2019, March). *Researching Vygotsky, and Researching with Vygotsky in Mathematics Education.* Paper presented at Psychology for Mathematics Education and Yandex Russian Conference, 2019. Moscow.

Leung, L. (2015). Validity, reliability, and generalisability in qualitative research. *Journal of Family Medicine and Primary Care, 4*(3): 324–327.doi: 10.4103/2249-4863.161306

Lin, T.W. & Rosli, R. (2017). Rural school students' perception about learning mathematics in English. *Research Journal of Applied Sciences, 12*(2), 148-156.

Loc, N.P., Tong, D.H. & Chau, P.T. (2017). Identifying the concept "fraction" of primary students: The investigation in Vietnam. *Educational Research and Reviews, 12*(8), 531-539.

Lochrie, S., Curran, R. & O'Gorman, K. (2015). *Qualitative Data Gathering Techniques*. Oxford.

Lopes, A. P. & Soares, F. (2018). *Flipping a mathematics course: A blended learning approach.* Proceedings of INTED2018 Conference 5th-7th March 2018, Valencia, Spain.

Luttenberger, S., Wimmer, S. & Paechter, M. (2018). Spotlight on mathematics anxiety. *Journal of Psychology Research and Behaviour Management, 11*(1), 311–322, doi: 10.2147/PRBM.S141421.

Macblain, S. (2018). *Learning Theories for Early Years Practice*. SAGE London.

Magalhaes, S., Carneiro, L., Limpo, T. & Filipe, M. (2020). Executive functions predict literacy and mathematics achievements: The unique contribution of cognitive flexibility in grades 2, 4, and 6. *Child Neuropsychology, 26*(7), 934-952. DOI: 10.1080/09297049.2020.1740188.

Magdalene, R. & Sridharan, D. (2018). Powering e-Learning through technology: An overview of recent trends in educational technologies. *The Online Journal of Distance Education and e-Learning, 6*(1), 60-61.

Maher, C., Hadfield, M., Hutchings, M., & de Eyto, A. (2018). Ensuring rigor in qualitative data analysis: a design research approach to coding combining Nvivo with traditional material methods. *International Journal of Qualitative Methods, 17*(1), 1–13, https://doi-org.ukzn.idm.oclc.org/10.1177/1609406918786362.

Malik, S.A. (2017) Revisiting and re-representing scaffolding: The two gradient model. *Cogent Education, 4*(1), 1-13, doi: 10.1080/2331186X.2017.1331533

Malterud, K. (2015). Theory and interpretation in qualitative studies from general practice: Why and how? *Scandinavian Journal of Public Health, 44*(2), 120-129, https://doi.org/10.1177%2F1403494815621181.

Martin, M.O., Mullis, I.V.O. & Hooper, M. (2016). *Methods and Procedures in PIRLS 2016*. International Association for the Evaluation of Educational Achievement. TIMSS & PIRLS International Study Centre, Boston College. USA.

Mattar, J. (2018). Constructivism and connectivism in education technology: Active, situated, authentic, experiential, and anchored learning. *RIED. Revista Iberoamericana de Educación a Distancia, 21*(2), 201-218, doi.org/http://dx.doi.org/10.5944/ried.21.2.20055.

Maunder, R.E. & Crafter, S. (2017). School bullying from a socio-cultural perspective. *Aggression and Violent Behaviour, 38*(1), 13-20, https://doi.org/10.1016/j.avb.2017.10.010.

McGrath, C., Palmgren, P.J. & Liljedahl, M. (2018). Twelve tips for conducting qualitative research interviews. *Medical Teacher, 41*(9), 1002-1006, doi: 10.1080/0142159X.2018.1497149.

Mendoza, D.J. & Mendoza, D.I. (2018). Information and Communication Technologies as a didactic tool for the construction of meaningful learning in the area of mathematics. *International Electronic Journal of Mathematics Education, 13*(3), 261-271, https://doi.org/10.12973/iejme/3907.

Michaelides, M.P., Brown, G.T.L., Eklof, H. & Papanastasiou, E.C. (2019). The relationship of motivation with achievement in mathematics. In: *Motivational profiles in TIMSS Mathematics. IEA research for education (a series of in-depth analyses based on data of the International Association for the Evaluation of Educational Achievement (IEA)), 7*. Springer, Cham.

Mihas, P. (2019). Qualitative data analysis. *Oxford Research Encyclopaedia of Education*. Retrieved from https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-1195. USA.

Mildenhall, P. (2013). *Using Semiotic Resources to Build Images when Teaching the Part-Whole Model of Fractions*. Edith Cowan University. Melbourne.

Mnisi, S. (2015). *Exploring a Teaching Strategy using Clicker Mobile Technology for active learning in undergraduate mathematics classes*. (Doctoral dissertation). Tshwane University of Technology. South Africa.

Moosavi, S. & Hasani, P. (2017). Ethical considerations in qualitative research with children's participation. *Medical Ethics Journal, 11*(39), 63-73.

Morgan, C. (2014).Social theory in mathematics education: Guest editorial. *Educational Studies in Mathematics, 87*(1), 123–128. https://doi.org/10.1007/s10649-014-9572-0.

Morgan, D. & Skaggs, P. (2016). *Collaboration in the Zone of Proximal Development.* International Conference on Engineering and Product Design Education 8 & 9 September 2016, Aalborg University, Denmark.

Moser, A. & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice, 24*(1), 9-18, doi: 10.1080/13814788.2017.1375091.

Mumcu, H.Y. (2018). Using mathematical models in fraction operations: A case study. (Research article). *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 12*(1), 122-151, ISSN: 1307-6086.

Murphy, D. (2016). A literature review: the effect of implementing technology in a high school mathematics classroom. *International Journal of Research in Education and Science, 2*(2), 295-299.

Mushipe, M. & Ogbonnaya, U.I. (2019). Geogebra and Grade 9 learners' achievement in linear functions. *International Journal for Emerging Technologies in Learning, 14*(8), 206-219, https://doi.org/10.3991/ijet.v14i08.9581

Nami, F., Vaezi, S. (2018). How ready are our students for technology-enhanced learning? Students at a university of technology respond. *Journal of Computing in Higher Education, 30*(1), 510–529, https://doi.org/10.1007/s12528-018-9181-5.

Naude, M. & Meier, C. (2019). Elements of the physical learning environment that impact on the teaching and learning in South African Grade 1 classrooms. *South African Journal of Education, 39*(1), 1-11.

Netolicky, D.M. & Barnes, N. (2018). Method as a journey: a narrative dialogic partnership illuminating decision-making in qualitative educational research. *International Journal of Research & Method in Education. 41*(5), 500-513, doi: 10.1080/1743727X.2017.1295938.

Ngozwana, N. (2018). Ethical dilemmas in qualitative research methodology: Researcher's reflections. *International Journal of Educational Methodology, 4*(1), 19-28, doi: 10.12973/ijem.4.1.19. University of Swaziland.

Nguyen, M.A. (2017). Liberal education and the connection with Vygotsky's theory of the Zone of Proximal Development. *Cultural-Historical Psychology, 13*(1), 81-88, doi:10.17759/chp.2017130108 ISSN: 1816-5435 / 2224-8935 (online).

Noble, H. & Smith, J. (2014). Bias in research. *Evidence-Based Nursing, 17*(1), 100-101. University of Huddersfield & Queen's University, Belfast, UK.

Noorloos, R., Taylor, S.D., Bakker, A. & Derry, J. (2017). Inferentialism as an alternative to socio-constructivism in mathematics education. *Mathematics Education Research Journal, 29*(1), 437–453, https://doi.org/10.1007/s13394-017-0189-3.

Nowell, L.S., Norris, J.M., White, D.E. & Moules, N.J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1), 1-13, https://doi.org/10.1177%2F1609406917733847.

Obersteiner, A., Dresler, T., Bieck, S.M., Moeller, K. (2018). Understanding fractions: integrating results from mathematics education, cognitive psychology, and neuroscience. In: Norton, A., Alibali, M. (eds) Constructing Numbers. *Research in Mathematics Education.* Springer, Cham.

Padgett, D.K. (2017). *Qualitative methods in social work research (3rd edition)*. New York University. SAGE publications.

Pandor, G.N.M. (2004, September). White Paper 7. *Stadskoerant,* 15.

Panhwar, A.H., Ansari, S. & Ansari, K. (2016). Sociocultural theory and its role in the development of language pedagogy. *Advances in Language and Literary Studies, 7*(6), 183-188.

Panthi, R.K. & Belbase, S. (2017). Teaching and learning issues in mathematics in the context of Nepal. *European Journal of Educational and Social Sciences, 2*(1), 1-27.

Patten, M.L. & Newhart, M. (2018). *Understanding Research Methods*: An overview of the essentials. 10th Edition. New York. Routledge.

Pellegrino, J.W. & Brophy, S. (2008). From cognitive theory to instructional practice: Technology and the evolution of anchored instruction. In: Ifenthaler, D., Pirnay-Dummer P. & Spector, J.M. (eds) *Understanding Models for Learning and Instruction*, 277-303. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-76898-4_14.

Peltier, C. & Vannest, K.J. (2018). Using the concrete representational abstract (CRA) instructional framework for mathematics with students with emotional and behavioural disorders, Preventing School Failure: *Alternative Education for Learners and Youth, 62*(2), 73-82, doi: 10.1080/1045988X.2017.1354809.

Perry, N.D. (2018). *Teacher attitudes and beliefs about successfully integrating technology in their classroom during a 1:1 technology initiative and the factors that lead to adaptations in their instructional practice and possible influence on standardised test achievement.* (Doctoral thesis). Youngstown State University. USA.

Petit, M.M., Laird, R.E., Marsden, E.L., & Ebby, C.B. (2015). *A Focus on Fractions:* Bringing research to the classroom. Routledge.

Phillips, A.S., Sheffield, A. & Moore, M. (2016). An online social constructivist course: toward a framework for usability evaluations. *Quarterly Review of Distance Education, 17*(1), 1-10.

Pipere, A. & Micule, I. (2014). Mathematical identity for a sustainable future: an interpretative phenomenological analysis. *Journal of Teacher Education for Sustainability, 16*(1), 5-31, doi: https://doi.org/10.2478/jtes-2014-0001.

Poon, K.K. (2017). Learning fraction comparison by using dynamic mathematics software – GeoGebra. *International Journal of Mathematical Education in Science and Technology, 49*(3), 469-479, doi: 10.1080/0020739X.2017.1404649.

Pope, S. & Mayorga, P. (2019). *Enriching Mathematics in the Primary Curriculum.* SAGE. London.

Prismana, R.D.E., Kusmayadi, T.A. & Pamudya, I. (2018). Analysis of difficulties in mathematics problem solving based on revised Bloom's Taxonomy viewed from high self-efficacy. *Journal of Physics: Conference Series, 1008*(1), 12-63, doi:10.1088/1742-6596/1008/1/012063

Rahayu, C., Putri, R.I.I., Zulkardi & Hartono, Y. (2019). ICT on mathematics learning process at Pagaralam elementary school. *Journal of Physics: Conference Series, 1188*, conference 1, https://doi.org/10.1088/1742-6596/1188/1/012069. Indonesia.

Rahman, A.A., Mohd Zaid, N., Abdullah, Z., Mohamed, H. & Aris, B. (2018). Social constructivism learning through project-based learning with scaffolding in flipped classroom. In: *2018 International Conference on Learning and Teaching in Computing and Engineering, 1*(1), 50-56, doi:10.1109/LaTICE.2018.00017.

Ramaa, S. (2019). Learning difficulties and disabilities in mathematics: Indian scenario. In: Fritz, A., Haase, V., Räsänen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer. India.

Rasanen, P., Laurillard, D., Kaser, T. & von Aster, M. (2019). Perspectives to technology-enhanced learning and teaching in mathematical learning difficulties. In: Fritz, A., Haase, V., Rasanen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer, Cham.

Rao, C.H.D. & Saha, S.K. (2019). RemedialTutor: A blended learning platform for weak students and study its efficiency in social science learning of middle school students in India. *Education and Information Technologies, 24*, 1925–1941, https://doi.org/10.1007/s10639-018-9813-4

Rau, M.A. & Matthews, P.G. (2017). How to make 'more' better? Principles for effective use of multiple representations to enhance students' learning about fractions. *ZDM Mathematics Education, 49*(1), 531–544, https://doi.org/10.1007/s11858-017-0846-8.

Reddy, V. (2016). National Research coordinator: *TIMSS - South Africa*. South Africa.

Reeves, S., McMillan, S.E., Kachan, N., Paradis, E., Leslie, M. & Kitto, S. (2015). Inter-professional collaboration and family member involvement in intensive care units: Emerging Themes from a Multi-Sited Ethnography. *Journal of Interprofessional Care, 29*(3), 230- 237, doi: 10.3109/13561820.2014.955914.

Revina, S. & Leung, F.K.S. (2018). Educational borrowing and mathematics curriculum: *Realistic Mathematics Education in the Dutch and Indonesian Primary Curriculum.* Hong Kong.

Rice, R. (2018) Implementing connectivist teaching strategies in traditional K-12 classrooms. In: Nah, F.H., Xiao, B. (eds) *HCI in Business, Government, and Organisations. HCIBGO, 10923*(1), 645-655.

Richardson, F.C. & Suinn, R,M. (1972). The mathematics anxiety rating scale: psychometric data. *Journal of Counselling Psychology, 19*(6), 551-554.

Riley, N., Lubans, D.R., Holmes, K., Hansen, V., Gore, J., & Morgan, P.J. (2017). Movement-based mathematics: enjoyment and engagement without compromising learning through the EASY Minds program. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(6), 1653-1673. https://doi.org/10.12973/eurasia.2017.00690a.

Roberts, K., Dowell, A. & Nie, J. (2019). *Attempting Rigour and Replicability in thematic analysis of Qualitative Research data; a case study of codebook development.* University of Otago. New Zealand.

Robertson, S.A. & Graven, M. (2019). Exploratory mathematics talk in a second language: a sociolinguistic perspective. *Educational Studies in Mathematics, 101*(1), 215–232, https://doi.org/10.1007/s10649-018-9840-5.101: 215.

Robinson, M. (2019). *Technology not the elixir of education.* The Mail & Guardian. South Africa.

Rodriguez, C., Cuadro, A., Ruiz, C. (2019). Mathematics learning and its difficulties: The cases of Chile and Uruguay. In: Fritz, A., Haase, V., Rasanen, P. (eds) *International Handbook of Mathematical Learning Difficulties*. Springer, Cham. Switzerland.

Rosenthal, M. (2016). Qualitative research methods: *Why, when, and how to conduct interviews and focus groups in pharmacy research.* The University of Mississippi School of Pharmacy, Oxford, Mississippi.

Rumrill, P.D. and Bellini, J.L. (2018). Research in rehabilitation counselling: *A guide to Design, Methodology, and Utilisation.* USA.

Ryen, A. (2016). Qualitative Research: *Research Ethics and Qualitative Research*. UK. SAGE.

Saal, P.E., van Ryneveld, L., & Graham, M.A. (2019). The Relationship between using Information and Communication Technology in education and the mathematics achievement of students. *International Journal of Instruction, 12*(3), 405-425.

Saylan, A., Onal, N.T. & Onal, N. (2018). *Using Technology in education from the Pre-service Science and Mathematics Teachers' Perspectives*. Faculty of Education, Erciyes University, Kayseri, Turkey.

Scherer, R., Siddiq, F. & Tondeur, J. (2019). The Technology Acceptance Model (TAM): *A Meta-analytic structural equation modelling approach to explaining teachers' adoption of Digital Technology in Education.* Norway.

Segumpan, L.L.B. & Tani, D.A. (2018). Mathematics performance and anxiety of junior high school students in a flipped classroom. *European Journal of Education Studies, 4*(12), 1-33, https://oapub.org/edu/index.php/ejes/article/view/1841.

Shaikh, U.U., Karim, S. & Asif, Z. (2017). *Re-thinking Vygotsky: Applying social constructivism to asynchronous online courses utilising the power of crowdsourcing.* Pacific Asia Conference on Information Systems. 2017 Proceedings. http://aisel.aisnet.org/pacis2017/233. Karachi, Pakistan.

Sherman, H.J., Richardson, L.I. & Yard, G.J. (2019). *Teaching Learners who Struggle with Mathematics*: Responding with systematic intervention and remediation. Waveland Press, Inc.

Shin, M. & Bryant, D.P. (2016). Improving the fraction word problem solving of students with mathematics learning disabilities: Interactive computer application. *Remedial and Special Education, 38*(2), 76-86, https://doi.org/10.1177%2F0741932516669052.

Siegler, R.S., Fazio, L.K., Bailey, D.H., & Zhou, X. (2013). *Fractions: the new frontier for theories of numerical development, 17*(1), 13–19, https://doi.org/10.1016/j.tics.2012.11.004.

Sim, J., Saunders, B., Waterfield, J. & Kingstone, T. (2018). Can sample size in qualitative research be determined a priori? *International Journal of Social Research Methodology, 21*(5), 619-634, doi: 10.1080/13645579.2018.1454643.

Simon, M.A., Placa, N., Avitzur, A. & Kara, M. (2018). Promoting a concept of fraction-as-measure: A study of the learning through activity research programme. *The Journal of Mathematical Behaviour, 52*, 122-123, https://doi.org/10.1016/j.jmathematicsb.2018.03.004.

Skosana, P.S. & Monyai, R.B. (2013). Learner-centred policies with reference to constructivism in the implementation of the curriculum. *International Journal of Humanities and Social Science Invention, 2*(9), 51-58.

Sohn, B.K., Thomas, S.P., Greenberg, K.H. & Pollio, H.R. (2017). Hearing the voices of students and teachers: A phenomenological approach to educational research. *Qualitative Research in Education, 6*(2), 121-148, doi: http://dx.doi.org/10.17583/qre.2017.2374.

Soylu, Y. & Soylu, C. (2005). Learning difficulties of 5th class in primary education at fraction: ordering, adding, subtraction, multiplication in fraction and problems related to fraction. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi, 7*(2), 101-117.

Spangenberg, E.D. (2017). Comparing the achievement goal orientation of mathematics learners with and without attention-deficit hyperactivity. *South African Journal of Education, 37*(3), 14-19, http://dx.doi.org/10.15700/saje.

Spaull, N. & Taylor, S. (2012). *"Effective enrolment" - Creating a composite measure of educational access and educational quality to accurately describe education system performance in sub-Saharan Africa.* (Stellenbosch Economic Working Papers: 21/12). University of Stellenbosch. Bureau for Economic Research.

Stafylidou, S. & Vosniadou, S. (2004). The development of students' understanding of the numerical value of fractions. *Learning and Instruction, 14*(5), 503-518, https://doi.org/10.1016/j.learninstruc.

Stando, J., Guncaga, J. & Bacova, B. (2018). *What about Mathematics with using ICT in Education*. Paper presented at The Seventh International Conference on E-Learning and E-Technologies in Education (ICEEE), Lodz University of Technology, Lodz, Poland.

Story, D.A., Leslie, K. & French, C. (2018). Feasibility and pilot studies: small steps before giant leaps. *Anaesthesia & Intensive Care, 46*(1), 11-12, doi: 10.1177/0310057x1804600103.

Strydom, H. (2011). *Research at Grassroots: For the Social Sciences and Human Service Professions.* Pretoria. Van Schaik Publishers.

Sutton, J. & Austin, Z. (2015). Qualitative research: data collection, analysis, and management. *The Canadian journal of hospital pharmacy, 68*(3), 226–231, https://doi.org/10.4212/cjhp.v68i3.1456.

Svela, A., Nouri, J., Viberg, O. & Zhang, L. (2019). *A Systematic review of Tablet Technology in mathematics education*. International Association of Online Engineering. Retrieved September 18, 2020 from https://www.learntechlib.org/p/216532.

Taufik, N.A.M. & Maat, S.M. (2017). *Perception of mathematics teachers on Cooperative learning method in the 21st century*. Presented at the AIP Conference Proceedings, Malaysia.

Taukeni, S.G. (2019). Providing remedial support to primary school learners within their zone of proximal development. *South African Journal of Childhood Education, 9*(1), 654, doi: https://doi.org/10.4102/

Tella, A. (2008). Teacher variables as predictors of academic achievement of primary school pupils mathematics. *International Electronic Journal of Elementary Education, 1*(1), 16-34.

Thanh, N.C. & Thanh, T.T.L. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science, 1*(2), 24-27.

Thompson, S., & Timmons, V. (2017). Authentic inclusion in two secondary schools: "It's the Full Meal Deal. It's Not Just in the Class. It's Everywhere.". *Exceptionality Education International, 27*(1), 62-84. Retrieved from https://ir.lib.uwo.ca/eei.

Thong, L.W., Ng, P.K., Ong, P.T. & Sun, C.C. (2018). Performance analysis of learners learning through computer-assisted tutorials and item analysis feedback learning (catiaf) in foundation mathematics. *Herald National Academy of Managerial Staff of Culture and Arts, 1*. Malaysia.

Towers, J., Takeuchi, M.A. & Martin, L.C. (2018). Examining contextual influences on students' emotional relationships with mathematics in the early years. *Research in Mathematics Education, 20*(2), 146-165, doi: 10.1080/14794802.2018.1477058.

Tracy, S.J. (2019). *Qualitative Research Methods: Collecting evidence, Crafting Analysis, Communicating Impact*. John Wiley and Sons, Inc. USA.

Tsai, T.L. & Li, H.C. (2017). Towards a framework for developing students' fraction proficiency. *International Journal of Mathematical Education in Science and Technology, 48*(2), 244-255, doi: 10.1080/0020739X.2016.1238520.

Ulusoy, F. & Incikabi, L. (2019). Incorporating representation-based instruction into mathematics teaching: Engaging middle schoolers with multiple representations of adding fractions. *Handbook of Research on Promoting Higher-Order Skills and Global Competencies in Life and Work*, doi: 10.4018/978-1-5225-6331-0.ch019

Umugiraneza, O., Bansilal, S. & North, D. (2018). Examining teachers' perceptions about improving the teaching and learning of mathematics and statistics. *Statistics Education Research Journal, 17*(2), 239–254, http://www.stat.auckland.ac.nz/serj.

Valero, P. (2010). Mathematics education as a network of social practices. In Durand-Guerrier, V., Soury-Lavergne, S. & Arzarello, F. (Eds.), *Proceedings of the Sixth Congress of the European Society for Research in Mathematics Education*, 54–80. Lyon. France.

Vajravelu, K. (2018). Innovative Strategies for learning and teaching of large differential equations classes. *International Electronic Journal of Mathematics Education, 13*(2), 90-95, https://doi.org/10.12973/iejme/2699.

Van Ryzin, M.J., Roseth, C.J. & Biglan, A. (2020). Mediators of effects of cooperative learning on prosocial behavior in middle school. *International Journal of Applied Positive Psychology*, https://doi.org/10.1007/s41042-020-00026-8.

Vencie, A. & Dhliwayo, A. (2018). Integrating technology with pedagogy in the classroom through the smart phone: a content analysis. *Baraton Interdisciplinary Research Journal, 8*(Special Issue), 1-7.

Villamizar, L.J. (2017). The effects of Vygotsky's socio-cultural theory on second language acquisition and language input. *Espiral, Revista de Docencia e Investigacion, 7*(1), 91-102.

Visser, M., Juan, A. & Feza, N. (2015). Home and school resources as predictors of mathematics performance in South Africa. *South African Journal of Education, 35*(1), 1-10, http://dx.doi.org/10.15700/201503062354.

Visser, M.M., Juan, A.L. & Hannan, S.M. (2019). Early learning experiences, school entry skills and later mathematics achievement in South Africa. *South African Journal of Childhood Education, 9*(1), 597, http://dx.doi.org/10.4102/sjce.

Vithal, R., & Volmink, J. (2005). This is a chapter. In Vithal, R., Adler, J. & Keitel, C. (Eds.), *Researching Mathematics Education in South Africa: Perspectives, Practices and Possibilities*, 3-27, HSRC Press. South Africa.

Volta, E., Alborno, P., Gori, M., Ghisio, S., Piana, S. & Volpe, G. (2018). *Enhancing learners' understanding of mathematics with multisensory technology.* Proceedings of the 5th International Conference on Movement and Computing. Article 50, 1–4, https://doi.org/10.1145/3212721.3212889.

Vululleh, P. (2018). Determinants of students' e-learning acceptance in developing countries: An approach based on Structural Equation Modelling (SEM). *International Journal of Education and Development using ICT, 14*(1), 141-151, doi: https://www.learntechlib.org/p/183560/.

Vygotsky, L.S. (1978). *Mind in Society: The development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Waller, P.P. & Kori L.H. (2017). Mathematics teachers' perceptions of resources and curriculum availability in post-apartheid schooling. *International Journal of Science and Mathematics Education, 15*(1), 741–757, https://doi.org/10.1007/s10763-016-9713-2.

Wangler, T.G. & Ziliak, E.M. (2018). Increasing student engagement and extending the walls of the classroom with emerging technologies. In Keengwe, J. (Ed.), *Research Perspectives and Best Practices in Educational Technology Integration,* 44-60, Hershey, PA: IGI Global. doi:10.4018/978-1-4666-2988-2.ch003.

Wassie, Y.A. & Zergaw, G.A. (2019). Some of the potential affordances, challenges and limitations of using GeoGebra in mathematics education. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(8), em1734 https://doi.org/10.29333.

Waterman, A.S. (2013). The humanistic psychology-positive psychology divide: contrasts in philosophical foundations. *American Psychologist, 68*(3), 124–133, https://doi.org/10.1037/a0032168.

West, A., Swanson, J. & Lipscomb, L. (2017). Scaffolding. In: Lombardi, P. (Ed.), *Instructional Methods, Strategies and Technologies to meet the needs of all learners: Scaffolding,* 185-202, Pressbooks Publishing.

Westwood, P. (2018). *Inclusive and Adaptive Teaching: Meeting the Challenge of Diversity in the Classroom.* London: Routledge.

Widodo, S. & Ikhwanudin, T. (2018). *Analysing Students' errors on Fractions in the Number Line.* Paper presented at the 4th International Seminar of Mathematics, Science and Computer Science Education 14 October 2017. Bandung. Indonesia.

Wijaya, A. (2017). The relationships between Indonesian fourth graders' difficulties in fractions and the opportunity to learn fractions: a snapshot of TIMSS results. *International Journal of Instruction, 10*(4), 221-236, https://doi.org/10.12973/iji.2017.10413a.

Wijaya, T., Ying, Z., & Purnama, A. (2020). The empirical research of Hawgent dynamic mathematics technology integrated into teaching fraction in primary school. *Jurnal Cendekia: Jurnal Pendidikan Matematika, 4*(1), 144-150, https://doi.org/10.31004/cendekia.v4i1.174

Wilkerson, T. L., Cooper, S., Gupta, D., Montgomery, M., Mechell, S., Arterbury, K., Moore, S., Baker, B.R. & Sharp, P.T. (2015). An investigation of fraction models in early elementary grades: a mixed-methods approach. *Journal of Research in Childhood Education, 29*(1), 1-25, doi:10.1080/02568543.2014.945020.

Wilkie, K. J., & Sullivan, P. (2018). Exploring intrinsic and extrinsic motivational aspects of middle school students' aspirations for their mathematics learning. *Educational Studies in Mathematics, 97*(3), 235-254, https://doi.org/10.1007/s10649-017-9795-y.

Wilkins, J.L.M. & Norton, A. (2018). Learning progression toward a measurement concept of fractions. *International Journal of STEM Education, 5*(27), 1-11, https://doi.org/10.1186/s40594-018-0119-2.

Wilkinson, D.J. & Jones, T. (2017). An exploration of 'scaffolded' and 'experiential' learning environment's impact upon students' experiences of a challenging level 6 topic in forensic psychology. *Psychology Teaching Review, 23*(1), 41-48.

Willingham, D.T. (2017). Ask the cognitive scientist: Do manipulatives help students learn? *American Educator*, 25-40.

Wood, D., Bruner, J.S. & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100, https://doi.org/10.1111/j.1469-7610.1976.tb00381.x.

World Economic Forum Annual Meeting 2016: Mastering the Fourth Industrial Revolution.

Wright, V. (2018). Vygotsky and a global perspective on scaffolding in learning mathematics. In: Zajda, J. (eds) Globalisation and Education Reforms. *Globalisation, Comparative Education and Policy Research, 19*(10), 123-136.

Yang, S. & Kwok, D. (2017). A study of students' attitudes towards using ICT in a Social Constructivist Environment. *Australasian Journal of Educational Technology, 33*(5), 50-62, https://doi.org/10.14742/ajet.2890.

Yearley, S. & Bruce, C.D. (2014). A Canadian effort to address fractions teaching and learning challenges. *Australian Primary Mathematics Classroom, 19*(4), 34-39.

Yilmaz, K., Gizem, F., Ozdemir, B.G. & Yasar, Z. (2018). Using digital stories to reduce misconceptions and mistakes about fractions: an action study. *International Journal of Mathematical Education in Science and Technology, 49*(6), 867-898, doi: 10.1080/0020739X.2017.1418919

Zahle, J. (2018). Values and data collection in social research. *Philosophy of Science, 85*(1), 144-163, doi:10.1086/694770.

Zakaria, N.A. & Khalid, F. (2016). The benefits and constraints of the use of information and Communication Technology (ICT) in teaching mathematics. *Creative Education, 7*(1), 1537-1544, doi:10.4236/ce.2016.711158.

Zaranis, N. (2019). Comparing the effectiveness of using tablet computers for teaching addition and subtraction. *Early Childhood Development: Concepts, Methodologies, Tools, and Applications*, 820-840, doi:10.4018/978-1-5225-7507-8.ch040.

APPENDIX A

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

26 October 2018

Mrs Shamilla Hajaree (214584645)
School of Education
Edgewood Campus

Dear Mrs Hajaree,

Protocol reference number: HSS/1848/018D
Project title: Exploring Grade 5 learners' perceptions on the use of Technology when learning fractions in one grade five class in the Ilembe district of KwaZulu-Natal, South Africa

Approval Notification – Expedited Application

In response to your application received 11 October 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**

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

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

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

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

Yours faithfully

....
Professor Shenuka Singh (Chair)

/ms

Cc Supervisor: Dr Jayaluxmi Naidoo
Cc Academic Leader Research: Dr SB Khoza
Cc School Administrator: Ms Sheryl Jeenarain

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma | Tel: 033 392 1063 | Ref.:2/4/8/1722

Mrs S Hajaree
PO Box 1510
Stanger
4450

Dear Mrs Hajaree

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"EXPLORING GRADE 5 LEARNERS' PERCEPTIONS ON THE USE OF TECHNOLOGY WHEN LEARNING FRACTIONS IN ONE GRADE FIVE CLASS IN THE ILEMBE DISTRICT OF KWAZULU-NATAL, SOUTH AFRICA"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 11 February 2019 to 01 July 2021.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

Dr. EV Nzama
Head of Department: Education
Date: 15 February 2019

..Championing Quality Education - Creating and Securing a Brighter Future

KWAZULU-NATAL DEPARTMENT OF EDUCATION
Postal Address: Private Bag X9137 • Pietermaritzburg • 3200 • Republic of South Africa
Physical Address: 247 Burger Street • Anton Lembede Building • Pietermaritzburg • 3201
Tel.: +27 33 392 1063 • **Fax.:** +27 033 392 1203• **Email:** Phindile.Duma@kzndoe.gov.za •**Web:** www.kzneducation.gov.za
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Kristine Melville-Rossouw
Editor
8 Kingston Terrace East
North Adelaide 5006
South Australia

+61(0)448 236320
krissie999@gmail.com

This is to confirm that during February 2020, I Kristine Melville-Rossouw, (B. Journalism & Media Studies, Rhodes University) a professional editor, reviewed and edited the thesis of Shamilla Hajaree, student number 214584645, titled: 'Exploring Grade 5 learners' perceptions on the use of technology when learning fractions in one Grade 5 class in the Ilembe district of KwaZulu-Natal, South Africa.'

If you have any queries please don't hesitate to contact me.

Signed...

Date.....10-2-2020.....

Exploring Grade 5 learners' perceptions on the use of technology when learning fractions in one class within the ILembe district of KwaZulu-Natal, So

ORIGINALITY REPORT

17%	12%	7%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Embury Institute for Teacher Education Student Paper	<1%
2	journals.sbmu.ac.ir Internet Source	<1%
3	"Globalisation and Education Reforms", Springer Science and Business Media LLC, 2018 Publication	<1%
4	Barohny Eun. "The zone of proximal development as an overarching concept: A framework for synthesizing Vygotsky's theories", Educational Philosophy and Theory, 2017 Publication	<1%
5	"Second Handbook of Information Technology in Primary and Secondary Education", Springer Science and Business Media LLC, 2018 Publication	<1%

LETTER TO THE PRINCIPAL OF THE SCHOOL

School of Education, College of Humanities,

University of KwaZulu-Natal,

Edgewood Campus,

The Principal

KwaDukuza Primary School

Dear Mr P.B.Pillay

Re: **Permission to conduct a research study at the school**

My name is Shamilla Hajaree. I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. I am interested in exploring the way in which learners learn fractions in Grade 5. I am writing to request your permission to conduct a study of the ways in which Grade 5 learners learn fractions. This current study 'Exploring the learning of fractions with the use of technology in one Grade 5 class in the Ilembe district of KwaZulu-Natal' seeks to investigate how learners experience the learning of fractions. The main questions that this study asks are: What are Grade 5 learners' perceptions on the use of technology when learning fractions in mathematics? How do Grade 5 learners use technology when learning fractions in mathematics? Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics? Such research is particularly relevant in South Africa given the importance placed on the improvement of mathematics results by the Department of Education. Recent reports of unsatisfactory mathematics results at South African schools are a cause for concern.

The research study aims to investigate the experiences of learners who are learning fractions in Grade 5. The study will involve engaging learners in task-based worksheets, showing them video clips and interviews with learners. All participants in the school and the names of the school will be anonymised. In the various publications that will result from this study I will not use participants' real names or the name of their school. Participants are free to withdraw from the project at any time during or after data collection, without penalty.

To generate the information, I am interested in asking the Grade 5 learners some questions, and I will engage the learners in task-based worksheets.

Please note that:

- The learners' confidentiality is guaranteed as their inputs will not be attributed to them in person, but reported only as a population member opinion.
- The interview and worksheet activity may last for about 45 minutes to 1 hour.
- Any information given by the learners cannot be used against them, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- Learners have a choice to participate, not participate or stop participating in the research. They will not be penalized for taking such an action.
- Their involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to allow learners to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

Equipment	**Willing**	**Not willing**
Audio equipment		

I can be contacted at: Email: shajaree8@gmail.com Cell: 0723227113

My supervisor is Dr. Jayaluxmi Naidoo who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: naidooj2@ukzn.ac.za Phone number: +27312601127.

You may also contact the Research Office through:

Ms P Ximba (HSSREC Research Office)

Tel: 031 260 3587

Email: ximbap@ukzn.ac.za)

Thank you for your contribution to this research.

Yours Sincerely

…………………

Mrs S. Hajaree

INFORMED CONSENT FORM FOR PARENTS OF THE PARTICIPATING LEARNERS

School of Education, College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus,

Dear Parent

My name is Shamilla Hajaree. I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. This current study 'Exploring the learning of fractions with the use of technology in one Grade 5 class in the Ilembe district of KwaZulu-Natal' seeks to investigate how learners experience the learning of fractions. The main questions that this study asks are: What are Grade 5 learners' perceptions on the use of technology when learning fractions in mathematics? How do Grade 5 learners use technology when learning fractions in mathematics? Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics? Such research is particularly relevant in South Africa given the importance placed on the improvement of mathematics results by the Department of Education. Recent reports of unsatisfactory mathematics results at South African schools are a cause for concern.

The research study will involve engaging learners in task-based worksheets, showing them video clips and interviews with the learners. All participants in the school and the names of the school will be anonymised. In the various publications that will result from this study I will not use participants' real names or the name of their school. Participants are free to withdraw from the project at any time during or after data collection, without penalty.

To generate the information, I am interested in asking your learner/ward some questions and engaging you in task-based worksheets.

Please note that:

- Your learner's /ward's confidentiality is guaranteed as his/her inputs will not be attributed to him/her in person, but reported only as a population member opinion.
- The interview and worksheet activity may last for about 45 minutes to 1 hour.
- Any information given by your learner/ward cannot be used against your learner/ward, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- Your learner/ward has a choice to participate, not participate or stop participating in the research. Your learner/ward will not be penalized for taking such an action.

- Your learner's/ward's involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to allow your learner/ward to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

Equipment	**Willing**	**Not willing**
Audio equipment		

I can be contacted at: Email: shajaree8@gmail.com Cell: 0723227113

My supervisor is Dr. Jayaluxmi Naidoo who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: naidooj2@ukzn.ac.za Phone number: +27312601127.

You may also contact the Research Office through:

Ms P Ximba (HSSREC Research Office)

Tel: 031 260 3587

Email: ximbap@ukzn.ac.za)

Thank you for your contribution to this research.

DECLARATION

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

I understand that my learner/ward is at liberty to withdraw from the project at any time, should he/she so desire.

…………………………………….. ……………………

SIGNATURE OF PARENT DATE

INFORMED CONSENT FORM FOR PARTICIPANTS

School of Education, College of Humanities, University of KwaZulu-Natal,

Edgewood Campus,

Dear Participant

My name is Shamilla Hajaree. I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. I am interested in exploring the way in which learners learn fractions in Grade 5. The main questions that this study asks are: How do Grade 5 learners use technology when learning fractions in mathematics? Why do Grade 5 learners use technology in the way that they do when learning fractions in mathematics? Such research is particularly relevant in South Africa given the importance placed on the improvement of mathematics results by the Department of Education. Recent reports of unsatisfactory mathematics results at South African schools are a cause for concern.

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Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- The interview and worksheet activity may last for about 45 minutes to 1 hour.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

Equipment	**Willing**	**Not willing**
Audio equipment		

I can be contacted at: Email: shajaree8@gmail.com Cell: 0723227113

My supervisor is Dr. Jayaluxmi Naidoo who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: naidooj2@ukzn.ac.za Phone number: +27312601127.

You may also contact the Research Office through:

Ms P Ximba (HSSREC Research Office)

Tel: 031 260 3587

Email: ximbap@ukzn.ac.za)

Thank you for your contribution to this research.

DECLARATION

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

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

……………………………………… ……………

SIGNATURE OF PARTICIPANT DATE

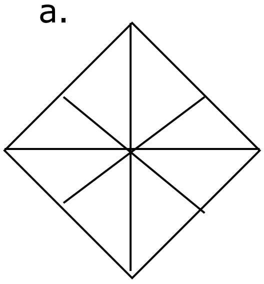
………………………………….. ……………………….

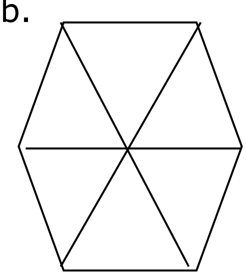
SIGNATURE OF PARENT DATE

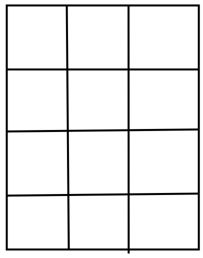
APPENDIX B

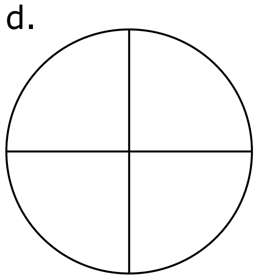
FIRST TASK-BASED WORKSHEET: FRACTIONS

1. ORDERING AND COMPARING COMMON FRACTIONS:

a. 

b. 

c. 

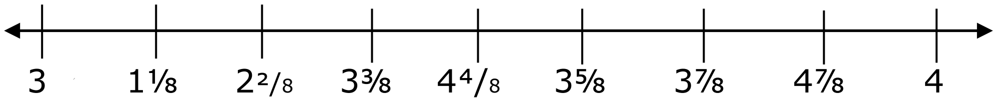
d. 

1.1. Identify the fractions represented by the parts in each shape:

a. ________________________ b. ________________________

c. ________________________ d. ________________________

1.2. Circle the mistakes on this number line and write the correct answer underneath.



2. EQUIVALENT FRACTIONS.

Use the diagram below to write the equivalent fraction for.

<table>
<tr><td colspan="8">1 WHOLE</td></tr>
<tr><td colspan="4">½</td><td colspan="4">½</td></tr>
<tr><td colspan="2">¼</td><td colspan="2">¼</td><td colspan="2">¼</td><td colspan="2">¼</td></tr>
<tr><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td><td>⅛</td></tr>
</table>

2.1. ¼ = ___________ 2.2. $^4/_8$ = ___________

2.3. Use the above diagram and fill in <, > or =.

a. $\frac{1}{2}$ ☐ $\frac{3}{8}$

b. $\frac{1}{4}$ ☐ $\frac{4}{8}$

3. ADDITION AND SUBTRACTION OF FRACTIONS

3.1. $8\frac{5}{8} + 2\frac{1}{8} =$ __________

3.2. $11\frac{7}{8} - 5\frac{3}{8} =$ ____________

3.3. Dad brings home $5\frac{3}{8}$ chocolate from work. Mum eats $2\frac{1}{8}$. How much is left? ______________________________________

4. FRACTIONS OF WHOLE NUMBERS.

4.1. $\frac{1}{4}$ of 20 = _________

4.2. $\frac{1}{8}$ of 16 = ____________

4.3. There are 20 desks in our classroom. $\frac{2}{5}$ of them are broken. How many desks are broken?

____

____

____

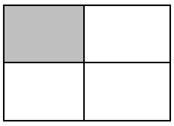
SECOND TASK-BASED WORKSHEET: FRACTIONS

Ordering and comparing common fractions.

Question 1: What fraction of the pictures below have been shaded?

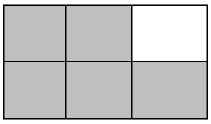
1.1.

a.



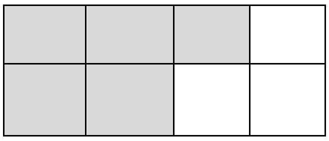
a. [ ]

b.



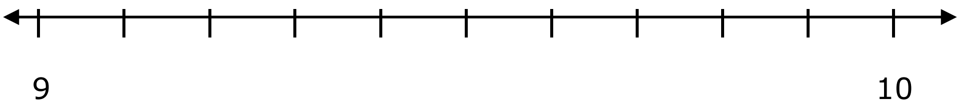
b. [ ]

c.



c. [ ]

1.2. Complete labelling the number line below by filling in the fractions



Question 2: Equivalent Fractions.

2.1. Use the diagram below to write the equivalent fraction for.

<table>
<tr><td colspan="8">1 WHOLE</td></tr>
<tr><td colspan="4">$\frac{1}{2}$</td><td colspan="4">$\frac{1}{2}$</td></tr>
<tr><td colspan="2">$\frac{1}{4}$</td><td colspan="2">$\frac{1}{4}$</td><td colspan="2">$\frac{1}{4}$</td><td colspan="2">$\frac{1}{4}$</td></tr>
<tr><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td><td>$\frac{1}{8}$</td></tr>
</table>

a. $\frac{1}{2}$ = _______ b. $\frac{3}{4}$ = ________

2.2. Use the above diagram and fill in <, >or =.

a. $\frac{4}{8}$ [ ] $\frac{2}{4}$ b. $\frac{4}{4}$ [ ] $\frac{7}{8}$

Questio[ ] Addition and Subtraction of Mixed Numb[ ]

3.1. $5\frac{4}{9} + 7\frac{3}{9}$ = __________ 3.2. $24\frac{7}{8} - 13\frac{5}{8}$ = ___________

3.3. Our family goes out for pizza. My brother brings home $\frac{3}{8}$ of his pizza, my sister $\frac{4}{8}$, and I bring home $\frac{5}{8}$. How much pizza did we bring home altogether?____

Question4: Fractions of Whole Numbers.

4.1. Solve the following.

a. $\frac{1}{4}$ of 44 = ________

b. $\frac{1}{8}$ of 48 = ________

c. There are 100 learners in grade 5. Three quarters of them come to school by bus. How many children come by bus?

____

____

____

____

APPENDIX C

<u>TRANSCRIPTIONS: FOCUS GROUP 1</u>

Researcher	S.HAJAREE
Interviewee	JANE, SUSAN, SALLY, AMANDA, SBAHLE
Date	12 November 2018
Time	08H20

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Jane: *YES. IT IS MUCH EASIER NOW ….AFTER WATCHING THE VIDEO. THE PICTURES MAKE IT LOOK SO EASY.*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Sbahle: *YES.*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Susan: *YES….I ALWAYS REMEMBER THE STORIES THAT I WATCH IN THE MOVIES. THIS MATHS PERIOD WAS LIKE WATCHING A MOVIE, SO I WON'T FORGET.*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Sally: *IT IS EASIER TO UNDERSTAND NOW…I USED TO GET VERY CONFUSED BEFORE.*

5. Which aspects of fractions do you find easy to understand?

Jane: *I FIND THE NUMBER LINE EASY TO UNDERSTAND.*

Amanda: *I FIND THE PLUS AND MINUS EASY TO UNDERSTAND.*

6. Which aspects do you find challenging, i.e. More difficult?

Jane: *IT HAS TO BE THE FRACTIONS AND WHOLE NUMBERS TOGETHER*

Susan: *WHEN YOU HAVE THE WHOLE NUMBERS AND THE FRACTIONS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

Sally: *YES….IT WAS SO MUCH FUN TO WATCH THE VIDEO.*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

All: *YES IT WAS*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Ann: *YES….IT ALWAYS HELPS*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 3 and 3 quarters

Amanda: *YES*

Jane: *NO, I DON'T FIND THAT DIFFICULT*

11. Are you able to solve the word problems without drawings and diagrams?

Sally: *I HAVE TO DRAW A DIAGRAM.*

Susan: *IT DEPENDS ON THE QUESTION.*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

Sbahle: *YES*

13. Is there anything else you would like to say with regards to these worksheets?

Susan: *2.2. IS DIFFICULT*

Jane: *MAYBE IF THERE IS A DIAGRAM…*

Susan: *I DON'T KNOW THE SIGNS…WHICH IS WHICH - THE BIGGER THAN AND SMALLER THAN*

15. What would you like to say about the video that you watched about fractions?

Susan: *AT FIRST I THOUGHT THAT FRACTIONS WERE HARD, BUT THEN OUR TEACHER SHOWED US THIS MOVIE ABOUT FRACTIONS. NOW I THINK THAT FRACTIONS ARE EASY. I UNDERSTAND WHAT A NUMERATOR AND DENOMINATOR ARE AFTER THE POWERPOINT PRESENTATION.*

TRANSCRIPTIONS: FOCUS GROUP 2

Researcher	S.HAJAREE
Interviewee	KIM, JOHN, MARK, ALICE, ABBY
Date	12 November 2018
Time	08H40

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

John: *YEAH…….I LOVED WATCHING HOW ALL THE FRACTIONS WERE EXPLAINED. IT WAS DIFFERENT FROM HOW WE DID FRACTIONS BEFORE.*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Kim: *YES. IT IS EASY WHEN YOU SHOWED US HOW IT WORKS OUT*

3. You think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Mark: *YES… IT IS EASY TO REMEMBER IT NOW.*

Abby: *THIS WAS THE BEST MATHS LESSON, SO I WILL TELL MY FRIENDS WHAT I SAW ON THE VIDEO.*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Alice: *WHEN YOU BREAK IT DOWN YOU UNDERSTAND WHAT TO DO*

Mark: *I KNOW IT NOW….YOU PLUS THE TOP AND THE BOTTOM STAYS THE SAME*

5. Which aspects of fractions do you find easy to understand?

Mark: *I FIND PLUS AND MINUS EASY.*

John: *I LIKE THE MIXED NUMBERS AND IT'S EASY TO UNDERSTAND.... ALSO THE NUMBER LINE.*

6. Which aspects do you find challenging, i.e. More difficult?

John: *QUESTION 2 EQUIVALENT FRACTIONS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES. THE VIDEO WAS VERY HELPFUL.*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

Mark/John: *YES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

John: *YES WE LOVE IT*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 3 and 3 quarters

Mark/John: *YES*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO WE HAVE TO DRAW SO WE CAN SEE AND UNDERSTAND BETTER*

John/Alice: *WE CAN JUST LOOK AT THE DRAWING AND GET THE ANSWER*

Mark: *I CAN UNDERSTAND PROPERLY*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

Kim: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

All: *AFTER IT WAS EXPLAINED IN THE VIDEO...NOW IT'S EASY*

14. What would you like to say about the video that you watched about fractions?

Mark: *FRACTIONS ARE EASY AFTER WE WATCHED THE VIDEO. THE VIDEO ACTUALLY HELPED US… SO WE CAN REMEMBER OUR WORK.*

TRANSCRIPTIONS: FOCUS GROUP 3

Researcher	S.HAJAREE
Interviewee	AKHONA, NANCY, PAM, AMELIA, AMBER
Date	12 November 2018
Time	08H55

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Akhona: *YES IT MADE ME LEARN TOO MUCH OF THINGS….AND IT WAS FUN TOO*

Nancy: *IT MADE ME LEARN FROM MY MISTAKES*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Nancy: *YES. I DO UNDERSTAND*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Pam: *YES I WILL NOT FORGET NOW.*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Amber: *IT IS EASY*

5. Which aspects of fractions do you find easy to understand?

Amelia: *QUESTION 1.2......WHAT FRACTION HAS BEEN SHADED*

Akhona: *ADDITION AND SUBTRACTION*

6. Which aspects do you find challenging, i.e. More difficult?

Nancy: *QUESTION 1.1. THE NUMBER LINE*

Pam: *WORD PROBLEMS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES. THE VIDEO GAVE US A LOT OF INFORMATION THAT HELPED US.*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

ALL: *YES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Amber: *YES. BECAUSE IT WILL HELP YOU TO UNDERSTAND HOW TO DO THINGS*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 4 and 3 quarters

All: *YES*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO*

Nancy: *BECAUSE WE CAN'T SEE HOW MANY ARE LEFT AND WE HAVE TO COUNT*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

Akhona: *BECAUSE IT SHOWS US A LOT OF THINGS THAT WE DIDNT KNOW. NOW WE KNOW*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

All: *IT IS EASY NOW*

Amber: *I THINK THE SECOND WORKSHEET WAS BETTER…..I COULD ANSWER MORE*

14. What would you like to say about the video that you watched about fractions?

Akhona: *THIS WAS THE FIRST TIME I SAW A MATHS MOVIE…. I REALLY ENJOYED IT AND I LEARNT A LOT*

TRANSCRIPTIONS: FOCUS GROUP 4

Researcher	S.HAJAREE
Interviewee	LARRY, BEN, SAM, ALLAN, LUKE
Date	12 November 2018
Time	09H20

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Larry: *IT'S NICE.*

Luke: *IT'S MUCH BETTER THAN DOING MATHS IN CLASS LIKE WE DO EVERY TIME*.

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Sam: *NO…. I STILL GET CONFUSED*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Allan: *YES….IT' EASY TO WORK IT OUT AFTER WATCHING THE VIDEO*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Larry: *IT'S MUCH EASIER…. I CAN SEE THAT YOU ONLY ADD THE TOP (numerator) NOT THE DOWN NUMBER (denominator)*

5. Which aspects of fractions do you find easy to understand?

Larry: *NUMBER LINE*

Ben: *ADDITION AND SUBTRACTION OF FRACTIONS*

6. Which aspects do you find challenging, i.e. More difficult?

Sam: *THE QUESTION WHERE THE FRACTION IS BIGGER THAN OR SMALLER THAN*

Larry: *MIXED NUMBERS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES ………BECAUSE IT EXPLAINED TO US HOW TO DO FRACTIONS.*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

All: *YES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Allan: *YES..... THEY CAN HELP US*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 4 and 3 quarters

Larry: *YES*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

Sam: *NO….BUT THE SECOND WORKSHEET WAS A LOT NICER.*

Larry: *I ALSO LIKE THE SECOND WORKSHEET*

14. What would you like to say about the video that you watched about fractions?

Larry: *THIS WAS THE FIRST TIME WE USED A COMPUTER (laptop) FOR MATHS. IT WILL BE FUN TO DO OUR OTHER SUBJECTS LIKE THIS TOO.*

TRANSCRIPTIONS: FOCUS GROUP 5

Researcher	S.HAJAREE
Interviewee	SIBA, JESS, SARA, NONHLE, ALEXA
Date	12 November 2018
Time	09H45

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Siba: *YES….IT REMINDS ME ABOUT THE MOVIES WE WATCH….IT MAKES YOU LEARN A LOT OF THINGS*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Alexa: *YES…IT'S SO MUCH EASIER*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Siba: *YES….I WAS A BIT CONFUSED BEFORE BUT NOW I UNDERSTAND*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Jess: *IT'S EASY NOW*

5. Which aspects of fractions do you find easy to understand?

Sara: *WHAT FRACTIONS ARE SHADED……*

6. Which aspects do you find challenging, i.e. More difficult?

Nonhle: *THE QUESTION WHERE THE FRACTION IS BIGGER THAN OR SMALLER THAN*

Siba: *THE NUMBER LINE QUESTION*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES*

Jess: *IT HELPED US TOO MUCH*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

All: *YES*

Sara: *BECAUSE WE COULD SEE THE SIZE OF THE FRACTION*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Nonhle: *YES ….IT'S NICE TO HAVE….*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 4 and 3 quarters

Alexa: *NO*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

Siba: *IT IS EASIER NOW*

14. What would you like to say about the video that you watched about fractions?

Siba: *I LIKE TO SEE THE SUMS ON THE SCREEN… I ENJOYED WATCHING….*

TRANSCRIPTIONS: FOCUS GROUP 6

Researcher	S.HAJAREE
Interviewee	TIM, SIHLE, LEON,SIFISO, SAKHILE,
Date	12 November 2018
Time	10H00

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Tim: *YES.*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Tim: YES

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Sihle: *YES….IT WAS HARD BEFORE….BUT I CAN DO IT NOW…..*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Sakhile: *IT'S EASIER NOW*

5. Which aspects of fractions do you find easy to understand?

Leon: *WHAT FRACTIONS ARE SHADED*

6. Which aspects do you find challenging, i.e. More difficult?

Sifiso: *EQUIVALENT FRACTIONS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

All: *YES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Tim: *YES IT'S A LOT EASIER.*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 4 and 3 quarters…is it hard?

Sakhile: *SOMETIMES I FEEL IT'S HARD*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

Leon: *NO…..BUT THE SECOND ONE WAS BETTER.*

14. What would you like to say about the video that you watched about fractions?

Sifiso: *THIS WAS THE FIRST TIME WE DID MATHS LIKE THIS…..MOST OF THE TIME I FEEL MATHS IS HARD, BUT THIS HELPED ME.*

TRANSCRIPTIONS: FOCUS GROUP 7

Researcher	S.HAJAREE
Interviewee	KYLE, PETER, OSCAR, NKOSI, BRIAN
Date	12 November 2018
Time	10H15

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Peter: *YES*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Kyle: *YES…IT'S MUCH BETTER NOW*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

Brian: *YES…I WILL REMEMBER*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Oscar: *ITS MUCH EASIER*

5. Which aspects of fractions do you find easy to understand?

Nkosi: *WHAT FRACTIONS ARE SHADED*

6. Which aspects do you find challenging, i.e. More difficult?

Peter: *EQUIVALENT FRACTIONS*

Kyle: *WORD PROBLEMS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES…..IT HELPED A LOT*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

All: *YES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Nkosi: *YES…..I LIKE TO USE DIAGRAMS*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect? E.g. 2 and a half or 4 and 3 quarters. Is it difficult?

Kyle: *YES*

Oscar: *I DON'T THINK IT'S DIFFICULT*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO…. WE HAVE TO DRAW*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

Nkosi: *NO*

Brian: *I LIKED THE SECOND ONE… THE FIRST WORKSHEET WAS A BIT HARD.*

14. What would you like to say about the video that you watched about fractions?

Brian: *IT WAS A VERY GOOD VIDEO….IT HELPED US IN OUR WORKSHEET*

TRANSCRIPTIONS: FOCUS GROUP 8

Researcher	S.HAJAREE
Interviewee	ANN, LIHLE, THABO, SIPHO, APHIWE
Date	12 November 2018
Time	11H00

1. Do you think fractions are easier to understand after you have watched the video presentation? Why do you say this?

Lihle: *YES, I THINK IT IS EASY BECAUSE THEY EXPLAINED HOW TO DO THE SUMS LIKE IF IT IS MIXED NUMBERS YOU CAN UNDERSTAND HOW TO DO IT*

Ann: *I HAVE THE SAME ANSWER AS HER*

Thabo: *I COULD UNDERSTAND IT BEFORE WATCHING THE VIDEO*

2. Do you find it easier to understand the terms numerator and denominator now that you have watched it being explained in the video?

Ann: *YES, SO I DONT GET CONFUSED WHEN WE JUST SAY FRACTIONS*

Lihle: *I DO GET CONFUSED A LITTLE, BUT THE VIDEO HELPED ME*

3. Do you think that in future fraction problems you will remember that the numerator and denominator are not 2 separate numbers but one rational number?

All: *YES*

4. How do you feel about addition and subtraction of fractions now that you were able to see it being explained in the video? Was it a section that you found difficult before and easier to understand now?

Aphiwe: *IT'S EASIER BECAUSE WE KNOW HOW TO BREAK IT UP NOW*

Lihle: *NOW I UNDERSTAND WHICH ONES TO ADD AND WHICH ONES NOT TO ADD*

5. Which aspects of fractions do you find easy to understand?

Lihle: *I UNDERSTAND ALL OF IT NOW THAT I WATCHED THE VIDEO*

Ann : *I ALSO UNDERSTAND ALL, BUT NOT THE PROBLEM SOLVING (WORD PROBLEMS).*

6. Which aspects do you find challenging, i.e. More difficult?

Ann: *WORD PROBLEMS*

Lihle: *FRACTIONS OF WHOLE NUMBERS*

7. Do you think the video that you watched helped you to answer the questions in the worksheet?

All: *YES*

Ann: *THEY EXPLAINED AND MADE IT MUCH MORE EASY*

8. Do you think that the diagram in question 2 was helpful in answering the questions on equivalent fractions?

Sipho: *YES*

Lihle: *IT HELPED A LOT*

Ann & Lihle: *NO, I WOULDNT*

Lihle: *I NEED IT BECAUSE I GET CONFUSED*

Ann: *I NEED THE DIAGRAM BECAUSE I WILL ALSO GET CONFUSED.... BECAUSE OF THE SIZES. I WONT BE ABLE TO SEE THE SIZES*

9. Would you prefer to have real life objects like diagrams, drawings or other resources to help to understand fractions better?

Lihle: *YES, BECAUSE IT MAKES YOU UNDERSTAND*

Thabo: *IT HELPS BECAUSE IF YOU HAVE AN OBJECT YOU CAN SHADE IT IN HALVES OR QUARTERS*

Ann: *IT'S ALSO EASIER BECAUSE WITHOUT ANY OBJECTS OR DRAWINGS YOU WONT UNDERSTAND IT AND YOU MAY GET CONFUSED.*

10. Do you find the combination of whole numbers and fractions (mixed numbers) a challenging aspect ? E.g. 2 and a half or 4 and 3 quarters

Lihle: *I DONT FIND IT HARD NOW BECAUSE THE VIDEO MADE ME UNDERSTAND IT*

11. Are you able to solve the word problems without drawings and diagrams?

All: *NO*

12. Are you able to solve the questions on number lines more successfully now that you have watched it being explained in the video?

All: *YES*

13. Is there anything else you would like to say with regards to these worksheets & fractions?

Ann: *THE VIDEOS MADE ME MORE RELIEVED THAT I DONT HAVE TO WORRY. IT TAUGHT ME MORE*

Thabo: *IT MADE FRACTIONS FEEL EASIER.*

14. What would you like to say about the video that you watched about fractions?

Lihle: *IT MADE ME UNDERSTAND MORE ABOUT FRACTIONS AND IT MADE ME SEE THAT IT'S EASIER THAN WHAT PEOPLE THINK IT IS.*

Sipho: *IT WAS VERY HELPFUL TO ANSWER THE WORKSHEET QUESTIONS*