The influence of Virtual Reality as an educational tool on teachers' pedagogy

by

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Submitted in partial fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR

in the Faculty of Education

at the

UNIVERSITY OF PRETORIA

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MARCH 2023

Declaration

I declare that the thesis, which I hereby submit for the degree PhD Computer-integrated Education at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.'

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Dedication

I dedicate this research to my husband, Cedric, who has stood by me, supported me and egged me on, during these many months. My beautiful daughters, who have been a support throughout this process. Thank you, I love you.

Acknowledgements

My sincere gratitude goes out to the following people for helping me achieve this milestone in my life:

- My family, who provided me with strength and perseverance to complete this study;
- Prof Johannes Cronje, research supervisor, for his invaluable advice and guidance;
- Dr Franci Cronje, for her encouragement, wise council, and nurturing inspiration;
- Dr Nicolaas Blom, who motivated me to sign up, and begin the process;
- Dr Richard Hayward, whose kind words of wisdom and care assisted me through difficult times and motivated me not to give up;
- Last, but not the least, my friend Linda, thank you.

Abstract

This study explores how does the use of Virtual Reality (VR) simulation as a technology tool influence teachers' pedagogy. VR is a relatively new technology in the primary school classroom environment. This study explored how the use of this immersive, multimodal technology influenced the teachers' pedagogy, their teaching and learning practices. The conceptual framework depicts the relationship between the teachers' planning, resource selection, learning theories and the influence of the VR resource. Eight intermediate phase teachers from four private schools within a range of socio-economic groups in South Africa participated in this qualitative instrumental case study with a constructivist-interpretivist research design. Schools were purposefully selected, and participants taught at those schools and volunteered to be part of the study. The participants communicated both opportunities and challenges during the lessons. The teachers' experiences and observations influenced their teaching pedagogy. Thematically analysed the data, using an inductive approach. More research is also needed to understand the deeper underlying reasons for the excitement of using VR, possibly by comparing the use of VR to that of high-resolution videos and/or images. This study demonstrates that technology has a positive influence as an educational tool on teachers' pedagogy; however, if the use of VR increases within the schooling sector, further investigations into educators' professional development might assist teachers to integrate technology into their teaching practices.

Key Terms:

Virtual Reality (VR), teaching practices, teacher experiences, lesson integration; teachers' pedagogy, multimodal experiential learning.

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List of abbreviations

Abbreviation	Term
3D	Three dimensional
AR	Augmented reality
CAPS	Curriculum Assessment Policy Statements
COP26	26th United Nations Climate Change conference
COP27	27th United Nations Climate Change conference
Covid-19 / Covid	Coronavirus disease
DBE	Department of Basic Education
EMS	Economic Management Sciences
Eng	English
GCD	Global Collaborative Design
GCD	Global Collaborative Design
HEI	Higher Education Institution
HOD	Head of Department
ICT	Information and Communication Technology
IP	Intermediate Phase
km	Kilometres
KZN	KwaZulu-Natal
LS	Life Skills
LSEN school	School for learners with special educational needs
NDP	National Development Plan 2030 (NDP)
NS	Natural Sciences
NST	Natural Science and Technology
OECD	Organisation for Economic Co-operation and Development
PCORI	Patient-Centred Outcomes Research Institute
PGCE	Postgraduate Certificate in Education
SA	South Africa

SACE	South African Council of Educators
SAMR	Substitution, Augmentation, Modification and Redefinition
SDG	UN Sustainable Development Goals
SP	Senior Phase
SS	Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TPACK	Technological, pedagogical, and content knowledge model
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VR	Virtual reality

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1. CHAPTER ONE: GENERAL ORIENTATION

1.1 INTRODUCTION

This thesis describes the research that was undertaken to determine how the use of virtual reality simulations as a learning resource influences primary school teachers' pedagogy. The research talks to the knowledge gap as described by Alalwan et al. (2020, p. 2) study of primary school teachers, stating that 'there is still a notable lack of research into understanding the perceptions of teachers towards Virtual Reality (VR) and Augmented Reality (AR) in school teaching and learning.' This is highlighted by Li, Liu and Chen (2022, p. 3218) who stress that 'teachers play a critical role in the successful application of VR in the classroom'.

This research is relevant because it follows up on the research by Billingsley et al. (2019), investigating VR's use in teacher training programmes in immersive VR environments. There is little information available about teachers' adoption and attitude to VR (Li, Liu & Chen, 2022). These researchers found that more research needs to be done to assess the extent to which learning through virtual learning environments was transferred to teachers' classrooms. It also aligns with Padayachee (2017) whose study aimed to explore the extent to which educators in South Africa use ICT to enhance concept acquisition. Padayachee found that the challenge lay not only in how to use technology, but also in how to integrate effectively into the curriculum (2017). Although the study was about general ICT technology, it could be related to a specific educational technology, in this instance, VR. The study also adds to the body of knowledge Graeske and Sjöberg (2021) identified when studying VR technology in teaching the Swedish language, and found that VR technology offers many opportunities, but it cannot function independently of the curriculum. VR is 'rarely implemented in primary school education' (Laine, Korhonen & Hakkarainen, 2023, p. 2). The research adds to the dimensions of the work mentioned above, but it is unique because it explores how the use of virtual reality scenarios as a learning resource for primary school teachers' classrooms in the subjects the teachers teach, could influence their teaching practices, although it adds dimensions to the work mentioned above.

The rest of this chapter will identify the research problem, paradigm, aims, and research questions of the study. Exploring previous research related to the topic. The chapter introduces the research methodology, research design, research instruments, and the process used. It concludes with descriptions about the analysis and interpretation of the data, limitations, and value of the study, and presents an outline of the thesis.

1.2 RESEARCH PROBLEM

From the literature, Stojšić et al. (2017) offer the reminder that the global economic and societal changes have also changed the role of the schoolteacher. 'Teachers in modern classrooms are more facilitators than lecturers, and the application of new technologies can help them with new roles' (Stojšić et al., 2017, p. 93). Educational technology is a tool to influence pedagogic activity and to support and improve learning (Christie & Ferdos, 2004). It is possible to force-fit VR into existing educational paradigms, but it is important to have a solid pedagogy connected with it in order for teachers to use virtual reality to its fullest potential for learning (Lege & Bonner, 2020). The value of exposing teachers to VR would reveal opportunities for inclusion in their lessons (Alhalabi, 2016; Freeman et al., 2017; Craddock, 2018; Cooper et al., 2019; Khukalenko et al., 2022), and broadening their knowledge of technology (Xiaorong, 2018; Mukasheva et al., 2023). Teachers must explore the integration of VR into the lessons they teach. There is a need to investigate teacher attitudes toward using VR technologies (Albirini, 2006). In addition, the dearth of discussion of appropriate learning and teaching theories and models to guide VR technological design and development (Chen, 2006), also shows a gap in the current knowledge. Laine et al (2023) highlights a lack of VR implementation in primary school education. The current study adds to this body of knowledge. According to Alalwan et al. (2020) – their study only focused on science teaching – this provides a limited understanding of how the integration of VR technologies covers a range of school subjects across global regions. Some authors accentuate the importance to establish meaningful lessons in VR technology that are interlinked with curriculum content (Padayachee, 2017; Billingsley et al., 2019; Graeske & Sjöberg, 2021).

Much of the existing educational VR research focuses on learners using VR devices or software (Cooper & Thong, 2018; Szabo, 2021; Laine., et al., 2023) Most research about teachers relates to preservice training of teachers (Seufert et al., 2022), and in-service training for the use or evaluation of VR technology (Billingsley et al., 2019). There is a need to add to the body of knowledge about teachers in classrooms integrating VR into their lessons.

Cooper and Thong (2018) and Asad et al. (2021) describe VR technology as a transformative tool, offering the opportunity to transform teaching pedagogy, and has the potential to act as a bridge to assist disadvantaged learners by closing the educational gap (Freeman et al., 2017; Li, Liu & Chen, 2022). Alongside this awareness is a request for further ICT research to address the educational ICT challenges in South Africa (Munje & Jita, 2020).

The knowledge gap in our current understanding of the research is that although there is much research on VR that addresses teachers teaching one subject at a time (Alalwan et al., 2020; Graeske & Sjöberg, 2021; Laine et al., 2023), there is a gap to explore a range of subjects that teachers are teaching while incorporating VR in the primary school (Alalwan et al., 2020). Hussein and Nätterdal (2015), Bonasio (2019), and Dick (2021) and Laine, Korhonen & Hakkarainen (2023) express the benefit of using VR in an educational context, as it creates an immersive, experiential, and individualised learning environment that feels real. The affordances that VR technology can contribute to lessons should also be considered.

The research problem addresses how VR technological tools influence primary school teachers' theory and practice of teaching, their pedagogy.

1.2.1 Research paradigm

My position in terms of the nature of this study is antipositivist with a focus on a constructivist-interpretivist paradigm, with the view that the world is socially constructed (Collins & Stockton, 2018); meaning must be interpreted to understand it (Schwandt, 1998). The interpretivist paradigm primarily focuses on human experience to acquire an understanding and account for an individual's actions (Fossey et al., 2002, p. 720). As an interpretivist researcher, I observed, listened to, recorded, and examined the participants' world of meaning and attempted to interpret it (Schwandt, 1998). Interpretivist researchers are encouraged to use a variety of techniques, methods, and tools to investigate the phenomenon in focus (Denzin & Lincoln, 2011).

1.3 AIM OF THE RESEARCH

The aim of this research was to investigate the extent to which VR experiences are pedagogically beneficial for primary school teachers to incorporate into their teaching practices, and to explore the influence of the use of VR simulations as a technology tool on teachers' pedagogy. The probe was to glean teachers' opinions, experiences, and views when connecting the curriculum aligned subject content with the selected VR technology in intermediate phase lessons, while delving into the influence of the VR amalgamated into their teaching practices, to understand how teachers' teaching and learning may change when VR technologies are integrated into their lessons. The research question guided the plan for this empirical research, which focused on the integrated teaching practice and experiences of the participants in VR.

1.4 RESEARCH QUESTIONS

To achieve the aim of the research, the following leading question was formulated:

How does the use of Virtual Reality simulation as a technology tool influence teachers' pedagogy?

The three sub-questions listed below aim to augment and assist in achieving the main research question:

- What are the implications of VR simulations for changed pedagogical practices?
- How does the integration of VR simulations influence primary school teachers' classroom practices?

- What are teachers’ beliefs and attitudes about the use of VR as a learning tool for teaching?

1.4.1 Objectives related to the research questions

The main objective of this study is to explore and record the findings as to how the use of VR simulations as a technology tool influences teachers’ pedagogy,

- To explore the influences of incorporating VR into lessons by Intermediate phase teachers, on themselves and their learners within the South African school context and determine whether the integration modified the teachers’ pedagogy.

- To understand the teachers’ planning, how it is aligned to the curriculum and how relevant VR resources are included in the lesson.

- To interpret the teaching strategies deployed, and the correlation to teaching theories.

- To identify the impact of the inclusion of VR directly on the individual teachers and their learners, the influences on their teaching and learning practices, and professional development.

The objectives of the three sub-questions of the study are to:

- Explore the implications of VR simulations for changing pedagogical practices of teachers by:
    - Delving into the potential connections of VR resources in lessons to teaching theories, techniques, and approaches.
    - Identifying the value of integrating VR into lessons, both opportunities and challenges that teachers may express as influencing their changed pedagogical practices.
- Explore how the integration of VR simulations incorporated into lessons might influence primary school teachers' classroom practices.

    - Discern how the teachers observe and react to their learners' interaction with the VR content, the learners' experience of the resource, their reactions to the multimodal experience, and the potential impact on their learning.
- Explore teachers' beliefs and attitudes about the use of VR as a learning tool for teaching within their classroom environment.
    - Identify influences / impact on teachers' beliefs and attitudes (positively or negatively) in relation to the integration of VR, as they experience the potential emotional and cognitive responses of their learners.

1.4.2 Rationale of the study

VR has been used to train both pre-service and in-service personnel. The effect of VR on learners has also been examined. The purpose of this study was to explore the opportunities and challenges faced by primary school teachers who integrate VR simulations into their teaching pedagogy. The study examined how the incorporation of VR resources impacted the classroom practices of eight primary school teachers in the Intermediate Phase of South Africa.

The immersiveness of VR has been shown to positively impact learners in a meaningful way, and teachers' pleasure to the learners' reaction impacts their teaching strategies. To begin using technology in the classroom, teachers need to feel comfortable and confident in it. The purpose of this case study was to investigate how VR simulations might impact teachers' pedagogy and possibly change their teaching methods by exploring how teachers react, feel, and believe about incorporating VR into their daily lessons.

The study aimed to showcase the benefits and challenges teachers experienced regarding integrating VR into their lessons. As an initial study, the findings could be used as a stepping stone for further research into effective ways to assist larger numbers of teachers to experiment with and feel confident in using technology within their teaching environments. The study intended to provide practical examples from the individual experiences of the teachers that might assist other teachers who would like to try using VR in their classroom teaching.

1.4.3 Previous research

‘VR educational experiences can provide great insights into the pedagogy driving actual use of VR’ (Lege & Bonner, 2020. p. 169). VR is a digital educational technology that provides opportunities for changing primary school teachers’ pedagogy. The adoption of mobile VR in schools is still in the early adoption stage (Tudor et al., 2018; Al-Ansi et al., 2023), particularly in primary school (Laine et al., 2023) Importantly, this ICT related topic would play a significant role within the world of educational VR, particularly within the South African context. The chances and challenges of using VR by teachers would help provide educational policymakers with measures to accommodate newer technologies and to build capacity for educational change (Alalwan et al., 2020; Munje & Jita, 2020).

Cooper and Thong (2018) and Asad et al. (2021) describe VR technology as a transformative tool that offers the opportunity to transform teaching pedagogy and assist in closing the educational gap for disadvantaged learners (Freeman et al., 2017; Li et al., 2022). The relevance of educational VR is considered immersive (Jowallah, Bennett & Bastedo, 2018), accessible (Górski et al., 2016; Rudran & Logishetty, 2018), and capable of being used in different school contexts (Craddock, 2018), within learning theories such as the theory of experience (Dewey, 1997; Parong & Mayer, 2018), experiential learning (Kolb & Kolb, 2018; Asad et al., 2021;), constructionism (Papert & Harel, 1991) and constructivism (Niţu et al., 2018). Requests for further exploration investigating teachers’ attitudes towards the use of VR technology (Albirini, 2006; Alalwan et al., 2020; Li et al., 2023). There is also a need to identify the appropriate theories and models to guide the design and development of VR technology (Chen, 2006) and to highlight the value of using VR technology in lessons (Stoddard, 2009). However, teachers' perceptions of incorporating VR into teaching and learning are not understood (Alalwan et al., 2020).

Technical training found that VR training can meaningfully assist in developing vocational skills in areas such as industrial training (Dwivedi et al., 2018), engineering and mining (Van Wyk, 2015; di Lanzo, et al., 2020), medical field

(Ekstrand et al., 2018; Alfalah, et al., 2019; Anbro, 2019), tourism (Rudran & Logishetty, 2018), sports training (Renganayagalu et al., 2021), vehicle manufacture and workplace safety training (LaPierre, 2018) to name but a few. However, the lack of teacher professional development is a barrier related to educational VR curricula implementation (Khukalenko et al., 2022).

VR scenarios for training are beneficial when situations are dangerous, expensive, or unachievable in real situations (Bailenson et al., 2008; Mellet-d'Huart, 2009; Serin, 2020). VR training is specifically context-dependent, and different activities relate to a specific context in formal and informal learning environments (Mellet-d'Huart, 2009). In education, VR has also focused on pre-service and in-service teacher training and teaching of learners (Köhler et al., 2014; Alhalabi, 2016; Chen, 2016; Zantua, 2017; Xiaorong, 2018), as well as areas such as providing student-teacher opportunities to practice teaching before being employed (Yildirim et al., 2020), caregivers of toddlers (Passig et al., 2001), and even classroom management strategies to reduce or prevent disruptive behaviour (Mouw et al., 2020).

VR technology-enabled learning initiatives are only effective if teachers embed the resource within the curriculum context (Tudor et al., 2018). This statement suggests that the potential of multimodal VR resources incorporated into teaching strategies may transform the manner of teaching and learning. Teachers need to consider the affordances that VR technology provides when incorporating it into lessons.

VR enhances existing teaching materials (Araiza-Alba et al., 2022; Dick, 2021; Madrigal et al., 2016) and in the study reported by Wästberg et al., virtual laboratory users achieved most of the intended learning outcomes (2019). Reactions of learners also demonstrate an increase in the motivation and enjoyment of the lessons, compared to traditional lessons (Dalgarno & Lee, 2010). Educators using VR also found that it improves learners' ability to recall content (Xiaorong, 2018), with the potential to change the way learners react to and remember information (Laseinde et al., 2015; Barrett et al., 2018). VR significantly affected long-term memory retention, with learners scoring higher and remembering information better

(Yildirim et al., 2019). The most important authors within this field were difficult to find. Freeman et al. (2017) suggest that the integration of VR in schools can be used to transport learners to places that are impossible or difficult to visit. They are proponents of integrating VR technology in schools as part of preservice teacher training (Cooper et al., 2019). The incorporation of VR in higher education contexts has included the use of fully immersive, high-end, and low-cost mobile application-driven headset technologies (Radianti et al., 2020).

The literature indicates that the benefit of using VR in education is supported (Bonasio, 2019; Alalwan et al., 2020; Li et al., 2022). However, there is a lack of data and peer-reviewed literature to support its use in educational contexts. The knowledge gap in the current understanding of research is that much of the primary school VR research addresses learner engagement, with a limited focus on the teacher's perspective (Garcia et al., 2023; Laine et al, 2023) Another area of required research is that one subject is studied at a time, particularly the sciences (Alalwan et al., 2020; Graeske & Sjöberg, 2021), and that there is a gap in exploring a range of subjects in which teachers are incorporating VR into lessons (Alalwan et al., 2020; Villena-Taranilla et al., 2022). Educational technology is a tool to influence pedagogic activity in order to support and improve learning (Christie & Ferdos, 2004; Jowallah et al., 2018). There is a need to investigate teacher attitudes toward using virtual reality technologies (Albirini, 2006; Kennedy-Clark, 2011; Li et al., 2022).

In addition, there is a need to identify the appropriate learning and teaching theories and models to guide VR technological design and development (Chen, 2006). It is important to research the value of meaningful lessons in VR technology interlinked with curriculum content (Padayachee, 2017; Billingsley et al., 2019; Graeske & Sjöberg, 2021). The value of exposing and training teachers about VR would reveal opportunities for inclusion in their lessons (Alhalabi, 2016; Freeman et al., 2017; Craddock, 2018; Cooper et al., 2019), thereby, broadening their knowledge of technology (Xiaorong, 2018).

1.4.4 The South African Context

The 2030 South African National Development Plan 2030 (NDP) (National Planning Commission, 2012) outlines the commitment of the South African government to build a society where poverty is eliminated, and inequality is reduced. Information and communication technologies (ICTs) are highlighted as playing an important role in facilitating the achievement of the NDP objectives of improving education (NDP, p. 30, p. 33). Alongside the NDP, the Action Plan for 2019 (DBE, 2015) provides suggestions for achieving the national plan. Goal 20 of the Action Plan states [to] 'Increase access amongst learners to a wide range of media, including computers, which enrich their education' (DBE, 2015, p 3). It emphasises the importance of eEducation and ICTs in changing schooling for all students with the potential to diversify learning, remove inequalities, and link to society (DBE, 2015, p 17). The South African government (The Presidency, 2017) committed to providing a tablet device with digital learning content to every South African learner within six years, from 2017.

The Department of Basic Education (DBE) of South Africa published a 'Professional Development Framework for Digital Learning' (2018, p. 3) which describes the 13 levels of competency that teachers should develop to demonstrate their digital skills. Competency Level 5 (p. 16) refers to teachers selecting appropriate digital tools and resources when fulfilling the role of the educator. One of the competencies states that teachers should 'design interactive learning activities' (DBE, 2018, p. 16). Virtual reality could be used as an interactive learning task. Digital learning is described as used by the teacher to strengthen the learner's learning experience, and in return results in a 'more effective achievement of curriculum learning outcomes' (DBE, 2018, p. 11). The White Paper on e-Education (DoE, 2004, p. 19) expresses that the environment where learning and teaching are taking place should involve a creative process using diverse, varied, relevant, and high-quality resources for learners. Using VR adds to the diversity of technology. When selecting a VR scenario related to the subject content being taught, the relevance of this technology is appropriate in building understanding, and developing cognitive activities (Chen, 2016) by viewing the scene in 3D.

Educational institutions in South Africa are beginning to explore 3D spaces and online virtual worlds. Higher education institutions have VR facilities. Squelch (2001) studied the use of VR in mining safety training; the University of Pretoria's Mining Engineering Department (2021) has a Virtual Reality Centre to enhance mining engineering education, training, and research; a VR Innovation Academy (University of Western Cape [UWC], 2022) has been established to train new virtual reality professionals to develop their own VR and AR companies; and a virtual and augmented reality study and teaching facility has been launched to 'accelerate innovation in the field and educate the next generation of researchers and practitioners' [online] by the University of Johannesburg [UJ] (2021) Faculty of Education Department of Science and Technology Education. However, there is insufficient research into whether VR could be used to assist teachers in impacting teaching strategies and methodologies when interacting with primary school learners.

The Western Cape Department of Education E-Learning Directorate (WCED, 2018) expressed the advantages of cellular phones in schools to help promote the use of ICT in lessons for easy access to information and resources. My study focused on the educational implications of teachers integrating curriculum-related VR content on a cellular phone, in primary school classrooms to enhance their teaching strategy in engaging learners to solve problems and to assist in knowledge building. The severe limit of ICT resources in South African schools has resulted in pedagogical, operational, and strategic challenges (Padayachee, 2017). Within this context (Munje & Jita, 2020), the need for further study related to educational ICT challenges was identified.

1.5 RESEARCH METHODOLOGY

1.5.1 Research design

The study is located within the metatheoretical paradigm of constructivist-interpretivism (Vygotsky, 1978; Cohen et al., 2000). The ontology is related to the constructivist-interpretivist paradigm, in assuming that there is no single reality (Kivunja & Kuyini, 2017). This qualitative instrumental case study intended to gain insight into the phenomenon of how the use of virtual reality simulations as a learning resource influences teaching practice. The case focused on the experiences of eight primary school teachers who incorporated VR technology into their teaching practice and explored the implications of VR simulations for changing pedagogical practices and how the integration of VR simulations influenced these primary school teachers' classroom practices. In addition, explored the beliefs and attitudes of these teachers about the use of VR as a learning tool for teaching by also using an instrumental case study method to understand the particular circumstance (Mertens, 2010). The advantages of this design are intended to:

- Understand a particular circumstance of the case (Mertens, 2010) by obtaining in-depth information about the phenomenon of interest;
- Gain insights into a particular educational phenomenon (Mertens, 2005) of how the use of virtual reality simulations as a learning resource influences teachers' pedagogy;
- Conduct an exploration of a case researched over time through in-depth data collection (Creswell, 2013);
- Be bounded within a specific and unique case (Stake, 2012; Creswell, 2013), aimed at providing insight into an educational issue (Stake, 1995) providing a rich description of teachers using VR technology in their teaching and learning environment;
- Researchers can examine the data at a detailed micro-level by utilising case studies to explore specific phenomena.

Arguments have been raised against case study research. Evaluating and establishing the quality or rigour of the study can be perceived as contentious and conflicting (Collins & Stockton, 2018).

These were addressed in the following manner:

- The lack of rigour (Yin, 1984), was addressed by setting objectives for the study (as stated above) and providing clear parameters for Intermediate Phase primary school teachers, creating curriculum-related lessons, and including VR as a resource within a given time.

- A limited sample case (Yin, 1993) or the dependency on a single case (Tellis, 1997), was addressed as this case was of eight primary school teachers within four primary schools from different socioeconomic communities and a diversity of sociocultural positions. Being bounded, specific, and unique (Stake, 2012; Creswell, 2013) are far more important in the case study method than a big sample size.
- Considering the specific phenomenon of this study means that the results would be applicable only to this specific case.

1.5.2 Research instruments

Informed consent documentation was obtained from the participants before the study began. The research instruments included interviews, a focus group, lesson observations, and a photographic analysis tool.

- Two semi-structured interview instruments

Semi-structured interviews allowed participants to answer in their own words and consisted of open-ended questions (Creswell & Plano Clark, 2017),

- The first interview (Addendum 7.4.1), focused on the nature of the research study, the roles of the participants, and issues of confidentiality, anonymity, and consent.
- The second interview (Addendum 7.4.2) was conducted after observing the VR lessons. The teachers reflected on the use of the VR technology and the possible effects and reaction the technology had on their learners. They expressed their thoughts about the success or difficulties experienced or noticed during the lesson.
- Informal conversational interview instrument: These informal conversational interviews were spontaneous discussions related to the ongoing fieldwork of the research study (Gall et al., 2003), and there was no interview instrument created for these interactions.

- Lesson observation instrument: The classroom observations of participants were an evidentiary source of data collection (Yin 2002), where the lesson detail and inspected settings were recorded as they were observed and examined, both as an observer and a participant (Kawulich, 2012).
- Focus group interview instrument: A focus group of participants was conducted so that three participants attended. In the first section (45 minutes) of the focus group, the discussion aimed to acquire the teachers' inputs, feedback, and comments about VR and their teaching strategies.

- Focus groups can also be used in the latter stage of research projects to help clarify the findings (Barbour, 2017). Therefore, the second section (20 minutes) of the focus group was used to disseminate and give feedback information to the research participants (Morgan et al., 1998).

- Photographic analysis tool: In this study, learners were not interviewed; however, permission was granted by the students and their parents for videos and photos to be taken. Anonymity was ensured for the students and photographs and videos were taken when the students were wearing VR headsets. An analysis tool (Addendum A8) was created to record the observation of body language with respect to body position when viewing VR. The researcher was aware that photographs provided an alternative observation method (Cleland & MacLeod, 2021).

1.5.3 Research process

This case aimed at providing insight into an educational issue (Stake, 1995) providing a rich description of teachers using VR technology in their teaching and learning environment. Purposeful sampling was used to identify four primary South African independent schools for the study (Patton, 1990). Qualitative enquiry calls for the selection of detailed and in-depth engagement within the research sites (Patton, 1990). The sites were selected within the South African independent school education context, making them information-rich cases in which the researcher could learn about the issues which are of central importance to the purpose of the enquiry (Patton, 2002). Furthermore, intermediate-phase teachers were interested in VR as a teaching tool (Creswell & Plano Clark, 2017). This gave the researcher the opportunity to try to understand how the affordances of VR can influence these teachers' pedagogy.

In the process of purposeful selection of schools as research sites for the study, anomalies arose as to the demographics of students and teachers in the selected schools, their differences, and similarities. The selected schools differed as they spanned a range of socio-economic contexts and followed different school calendars. The schools were similar in that they were all independent, co-educational primary schools that cater for Intermediate Phase grades, teachers, and learners for real-life contextual research. The four research sites were selected; three schools in Gauteng Province and one in the North West Province. Ridgeview Primary, Waterfall School, Damview School, and Birdsong Primary are the pseudonyms used for the four different research sites. Three of the independent schools are classified by the Department of Basic Education (DBE) as ordinary schools, and one is an LSEN school (a school for learners with special educational needs). In this case study, the unit of analysis is the teachers that are exploring the use of VR in their teaching (Faltis, 1997; Merriam, 1998). The participants are Intermediate Phase teachers teaching at the purposefully sampled sites (Patton, 1990); co-educational, independent schools. The selection criteria for the participants in this study was designed with the specific goal of collecting rich and thick data. First, the participating teachers in the research sites were using ICT or VR technology in their lessons as a teaching strategy. Second, the participants had to be Intermediate Phase teachers willing to integrate relevant VR technology within the curriculum content in their classroom practices. Teachers had to be willing to participate in the study and communicate their experiences reflectively (Palinkas et al., 2013). Initially, 12 teachers indicated their willingness to participate in the study. However, due to the Covid-19 pandemic interruptions in schools, the number of participants was reduced to eight teachers. The eight participants were all female, as all teachers at the four research sites (Intermediate Phase) were female. Seven teachers worked in ordinary[1] schools (Damview, Waterfall, and Ridgeview), while one taught in an LSEN[2] school (Birdsong School).

Lessons were observed at times convenient to the teacher. Teachers selected the lessons they used in the research study. An initial interview was conducted to get to know the teacher and describe the research. After each lesson and at a time that the teacher found suitable, an interview was conducted to discuss the lesson. In instances where teachers were willing to present more than one lesson, those were observed, and interviews related to those lessons were also conducted.

1.5.4 Analysis and interpretation of data

The data was analysed thematically (Braun & Clarke, 2012). The findings from the data were interpreted and represented (Yin, 1994) by using an inductive approach (Thomas, 2006) to code and analyse the information. Digital audio interviews were transcribed and converted to text, which constituted the main form of data analysis. The codes and themes were derived from what were in the data that were collected through observations, interviews, and the researcher's journal. The information was processed through thematic analysis (Bowen, 2009; Braun & Clarke, 2012) by identifying and recognising patterns within the data. The identified themes are intertwined and firmly linked to the data (Patton, 1990). The theme encapsulates an important aspect of the data related to the research question and represents a level of patterned meaning within the data set (Braun & Clarke, 2012). Thematic mapping, visual (Braun & Clarke, 2006) and text-based findings (Frith & Gleeson, 2004) depicted and exposed the main themes and subthemes. The interconnections within

[1] Ordinary schools in South Africa are the public schools and private (independent) schools, and comprise roughly 97% of schools in South Africa, other than schools for specialised education (Mhlanga & Moloi, 2020)

[2] LSEN schools are schools with learners with special educational needs (LSEN); these learners need additional help and support in their learning.

the codes and themes were identified and redrawn. This process led me through the following steps:

Step 1: Getting acquainted with the data: The purpose of acquainting myself with the data was to detect patterns and identify deviants and oddities, making notes on the entire data set and the individual transcripts.

Step 2: Generating initial codes: All the data was coded, ensuring that the relevant data for each code was collated. Checks were put in place to ensure all codes were relevant to answering my research question.

Step 3: Identifying themes: To answer the research question, investigated how themes might work together to tell an overall story about the data. Before beginning to review the themes, a thematic table and map was created and collated, which summarised the potential themes (Braun & Clarke, 2012).

Step 4: Reviewing Potential Themes: As in level one, coded data extracts were reviewed; reading and collating the extracts of each theme to create coherent patterns (Braun & Clarke, 2012). For example, if a theme had a coherent pattern, it had to move to the second level. If the themes were inadequate, consideration was made as to whether the theme was problematic or whether parts of the data extracted did not fit. In both cases, the themes had to be rewritten, recreated, or new homes were sourced for ill-suited extracts. With all these themes, an initial thematic representation became evident.

A similar process was conducted during Stage 2 but in relation to the entire data set. Research dissemination is evidence translation by communicating findings back to participants in a focus group (Knerr et al., 2016). The validity of individual themes in relation to the data set was assessed and the accuracy of the level one thematic map was reconsidered. The last twenty minutes of the focus group were used to spread and verify these identified themes. The interview was transcribed and used to validate existing themes. These themes were analysed by identifying potential themes. Data triangulation using individual interviews, a focus group interview, documents, photos, and videos, and the researcher's journal resulted in a broader understanding of the phenomenon of my study (Carter et al, 2014). Some codes and themes had to be identified, discarded, or reallocated to other themes. Additional themes were then created. The themes were discarded if the correlation with the data that answered the research question was not evident. Braun and Clarke emphasise that analysis should not be forced into coherence (2012). By the end of this stage, the potential themes were identified, indicating how they interlinked and showing the story that the data revealed (Braun & Clarke, 2012).

Step 5: Defining and naming themes. Each theme had to have a specific name with a clear singular focus, scope, and purpose (Braun & Clarke, 2012). Care was taken to triangulate the data by considering multiple sources and gaining various perspectives to support the analysis of the study phenomenon (Patton, 1999; Carter et al., 2014).

Step 6: Validating the conclusions and writing the report. Finally, this step validated the conclusions and findings of the data. The combined data was synthesised, and conclusions were drawn and verified. The data were then translated into a report. It provides an informed and compelling story about the data based on the analysis. The story is complex, convincing, and clear (Bowen, 2009; Turner, 2010; Braun & Clarke, 2012); while embedded in the field of education, it addressed the research question. The plans of Braun and Clarke (2012) were carefully considered to ensure that the research data is critically analysed to provide a rich answer to the research question.

1.6 LIMITATIONS OF THE STUDY

This study targeted Intermediate Phase[3] teachers, eliminating all other teachers within the school context who may have used, or had an interest in using VR within their lessons. Therefore, the study targeted the subjects that teachers were teaching at the time of their observation. Therefore, not all Intermediate Phase subjects were included in the study, nor were all topics within the one-year curriculum included in

[3] Intermediate Phase in the South African schooling system, is considered the middle years of primary school (Grade 4 - 6), between the foundation phase (Grade 1 - 3) and the senior phase (Grade 7 - 9). It should be noted that most primary Schools are from Grade 1 to Grade 7.

the lessons observed. The results are limited to the lesson topics presented during the study. This case study is limited in number to eight teachers; Intermediate Phase teachers from four schools who participated in the investigation. All participants are female, as in those schools, all Intermediate Phase teachers were females. However, there is a diversity of sociocultural positions among participants. Therefore, the study would be difficult to replicate as the experiences of the individual teachers within this study would be different from those of other teachers in a similar study.

The study focused on the teachers; however, their opinions were influenced by the learners' reactions. Some learners who had not used VR before the study were given the opportunity to familiarise themselves with the technology, which may have assisted in reducing the novelty effect.

Despite these limitations, the researcher concluded that teachers' perspectives on integrating VR resources into their teaching pedagogy were reasonable. The limitation was reduced by having teachers from different schools, adding various teaching experiences and technologies they had available to them and could relate to. Its impact was further reduced, as there were teachers who had used VR before the study and those who used it for the first time. This provided varying perspectives on the responses and discussions and therefore provided richer content. The teachers were also from various sociocultural backgrounds, and therefore drawn from a culturally diverse pool to provide wider and richer perspectives and views.

When conducting qualitative case study research, the varying views and opinions of individuals are interpreted and analysed; therefore, it is important to be aware of the limitations to establish the exceptions and limits inherent in a study (Creswell et al., 2007; Creswell, 2013). These limitations and restrictions need to be considered.

The subjective opinions of the researcher may have influenced the case study. Some teachers lacked technological confidence and knowledge. Another restriction was that the researcher demonstrated how to use VR goggles with mobile phone applications. Teachers were also shown how to search for VR applications in the application stores, select scenarios, download, and access VR scenarios for lessons. These demonstrations and discussions were necessary for teachers to know how the technology worked and was used to participate in the study and to conduct the lessons. Bracketing was used to minimise limitations by monitoring preconceptions (Ahren, 1999) throughout the cascading research process.

The timing and distribution of the technology were considered potential limitations. Covid-19 interruptions and load shedding were limitations in the number of lessons observed and viewed. Covid-19 changed the mindset of school leaders and teachers, and the pandemic made it more difficult to get access to schools. This limitation was minimised by extending the research period and increasing the geographic circle of the study.

Case study situations may be difficult to replicate and are time-consuming. Conclusions could not be generalised to the wider population, as it was a limited case study. However, suggestions can be made. I realised that when the interviews were conducted, not all the information was relevant and not all related to the study. Qualitative data analysis was influenced by the interpretation and subjective opinion of the researcher (Creswell, 2014; Mc Kinley, 2015; McLeod, 2019). A restriction was that the researcher spoke about herself, noting her choices, experiences, and actions during the research process (Mruck & Breuer, 2003). This reflective practice aims to make the researcher's decisions and choices visible to the reader during the research process, creating a constructed nature of the study results (Mruck & Breuer, 2003). Yin argues that 'most qualitative researchers not only believed that there are multiple perspectives or views of the case that needed to be represented, but that there was no way to establish, beyond contention, the best view' (2002, p. 108). He adds that, due to ethical obligations, qualitative researchers need caution 'to minimise misrepresentation and misunderstanding' (2002, p. 109) of the data.

1.7 VALUE OF THE STUDY

This study set out to explore how the use of Virtual Reality simulations as a learning resource influences intermediate phase teachers' pedagogy and adds to the body of knowledge within the primary school classroom and the impact and influences teachers experience when using VR. The implications of these experiences, in turn, influenced their teaching practices and perceptions of VR as a learning resource.

Researchers interested in VR would find the study valuable, as the teachers' personal descriptions varied. However, they all found the inclusion of the VR experiences in their lessons as having a beneficial and positive impact on their learners. The value of lesson planning and teaching strategies, integrated with VR resources, assists learners in building their content knowledge. The reflection can also be of benefit to the self-development and learning about VR resources, integration into lessons, and technical understanding of the VR technology.

1.8 OUTLINE OF THE THESIS

Chapter one is an overview of the thesis and what to expect as you work on the chapters.

Chapter two is the literature highlighting the existing literature on VR in education, presenting several limitations that set the foundation for the research questions addressed in this thesis, as well as gaps in the literature. Much of the focus of existing VR research is on the pre-service training of teachers (Seufert, et al., 2022) and in-service training on the use or evaluation of VR technology (Billingsley, et al., 2019). The essence of this research is to elaborate on the educational value of this immersive digital technology. Despite theoretical inferences, no study has provided empirical support for whether VR simulation creates affordances for changed pedagogical practices, specifically in South Africa.

Chapter three explains the case study methodology used within this investigation. This qualitative instrumental case study intended to gain insight into a phenomenon of how the use of VR simulations as a learning resource influences teaching practice. The qualitative case study approach was selected to conduct an exploration of a case researched over time through in-depth data collection (Creswell, 2013), through the analysis of informal semi-structured and conversational interviews, focus groups and lesson observations. This case involved eight primary school teachers within four primary schools from different socioeconomic communities; it was bounded, specific, and unique (Stake, 2012; Creswell, 2013).

The case focused on the experiences of teachers who incorporated VR technology into their teaching practice. The implications of VR simulations for changed pedagogical practices and how the integration of VR simulations influenced these primary school teachers' classroom practices. In addition, the beliefs and attitudes of these teachers about the use of VR as a learning tool for teaching were explored. An instrumental case study method to understand a particular circumstance (Mertens, 2010). The data was collected, analysed, and interpreted to understand, describe, and predict this educational phenomenon (Mertens, 2005). This case aimed at providing insight into an educational issue (Stake, 1995) providing a rich description of teachers using VR technology in their teaching and learning environment.

Chapter four presents in-depth findings on the phenomenon of how the use of VR simulations influences the teacher’s pedagogy. This study examined the experiences and perceptions of eight primary school teachers who have used virtual reality as a teaching resource to understand how VR affects their pedagogy. The researcher also observed and commented on how VR impacts learners' learning and engagement and discussed with teachers the challenges and limitations they encounter with VR. To gather data, in-depth lesson observations and interviews were conducted with primary school teachers using VR as a teaching resource. In general, the findings suggest that teachers who have used VR in their classrooms had positive experiences and believed that it could improve their teaching and the engagement of learners.

Chapter five places the conclusions into a broader educational context and reflects the implications of methodological (theoretical) and substantive (practical) findings for the main question and three sub-questions explored in this thesis to address how the use of Virtual Reality simulation as a technology tool influence teachers’ pedagogy. Using a case study approach and a comprehensive qualitative research methodology, the study is of eight primary school teachers who integrated VR into their lessons.

2. CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Recently, Forbes described virtual reality as 'THE learning aid of the 21st century' (Rogers, 2019). Digital technology is a wide field of many devices, applications, and websites. These technologies are now part of our schooling system. Teachers have used technological resources as part of learning since they have been teaching. This study focuses on one type of technology that is beginning to enter the school system, that is, virtual reality (VR), and enquiries about its influence on teachers' pedagogy.

Virtual reality is different from other technologies. 'Virtual reality (VR) is a fake world that feels absolutely authentic' (Kelly, 2016, p. 211). It offers a learning situation where the user is immersed in an interactive learning space, with sensory interactions and experiences (Parong & Mayer, 2018; Qiu et al. 2023). This chapter explores the influences of VR on education, in particular on R-12 teaching experiences.

VR as a digital educational technology, creates affordances for changing the teaching practices of primary school teachers. Highlighting the importance that this topic would play a significant role within the world of educational VR, particularly within the South African context. Evidence of the educational value of VR related to teachers practising in their classrooms. Addressing how VR scenarios influence the changing pedagogical practices of teachers. Illustrating how VR is integrated into various curriculum subjects and aligned with lesson-related outcomes. The study contributes to the limited knowledge areas of technology research in the South African context. Teachers are catalysts for educational change.

Teachers must think critically about ways to include VR by integrating pedagogy and technology within a balanced framework for lessons (Jowallah et al., 2018; Lege & Bonner, 2020). Teachers make pedagogical decisions within their own subject area, about the method of teaching, content knowledge, and the learning related to what they believe the purpose for teaching the content to be, what learning learners should develop, and what technological resources and materials would be required (Hughes, 2005).

The relevance of VR is considered immersive, accessible, and capable of being used in different school contexts (Craddock, 2018), within learning theories such as the theory of experience (Dewey, 1997), experiential learning (Kolb & Kolb, 2018), constructionism (Papert & Harel, 1991) and constructivism (Niţu et al., 2018). The literature questioned the correlation between the pedagogical and technological affordances related to VR in teaching and learning (Jowallah et al., 2018; Szabo; 2021). VR provides interactive environments and authentic learning situations (Al Farsi et al., 2021; Philippe et al., 2020). The importance of establishing effective technology integration and classroom teaching practices (Billingsley et al., 2019). Not insulation, but meaningfully interlinked content of the curriculum lesson (Padayachee, 2017; Graeske & Sjöberg, 2021). The question arose as to whether current learning outcomes developed from traditional pedagogy could be transferred into a virtual space (Billingsley et al., 2019; Graeske & Sjöberg, 2021). There is a lack of understanding of integrating VR technologies to improve teaching and learning within a range of subjects (Alalwan, et al., 2020). The majority of the studies are in areas of science and maths, research in areas such as history and music would be beneficial (Villena-Taranilla et al., 2022). The inclusion of VR into lessons seems to have a positive effect in all subjects (Villena-Taranilla et al., 2022).

Much of the existing research focus is on pre-service training of teachers (Seufert et al., 2022) and in-service training of the use or evaluation of VR technology (Billingsley et al., 2019). There is a literature gap on how the incorporation of VR into lessons impacts teachers' pedagogy. Billingsley et al. (2019) suggested research on the transferability of VR training to the classroom by teachers. Asad et al. (2021) deduced that virtual reality is a beneficial educational pedagogical tool, and useful in teaching and learning. The significance of this study is to gain insight into the educational value of VR related to practising primary school teachers in their classrooms. Another study suggested a larger sample size from different regions to better understand the challenges and prospects of VR (Alalwana et al., 2020). Aligned to that is the request from South African researchers (Munje & Jita, 2020) for further research related to ICT to address educational ICT challenges in the country. Researchers (Bonasio, 2019; Alalwan et al., 2020; Laine et al., 2023) continued to see the benefit of using VR in education, especially in primary schools; however, there is a lack of data and peer-reviewed literature to support its use in educational contexts. The need to investigate teachers' attitudes and perspectives toward the use of VR technology (Albirini, 2006; Khukalenko et al., 2022), or identify the appropriate theories and/or models to guide the design and development of VR technologies (Chen, 2006; Qiu et al., 2023) is not new. However, there is limited understanding of how VR technologies could be used to improve learning and teaching in a variety of school subjects (Alalwan et al., 2020; Khukalenko et al., 2022). The findings of this literature present a critical analysis of VR being explored in school contexts and to better understand the nature of the current uses of VR technologies in knowledge areas and subjects for teachers to use in their environments.

The debate extends to the practice of integrating VR into the classroom, addressing the successes and challenges of technological influences across subject areas. Educational technology is a tool to assist pedagogy and influence pedagogic activity, as 'the sound use of any technology to support and improve learning' (Christie & Ferdos, 2004, p.15). The affordances considered by teachers to integrate VR technology into lessons. The severe limit of ICT resources in South African schools has resulted in pedagogical, operational, and strategic challenges (Padayachee, 2017). The value of exposing and training teachers about VR would reveal opportunities for inclusion in their lessons (Alhalabi, 2016; Freeman et al., 2017; Craddock, 2018; Cooper et al., 2019; Alalwan et al., 2020), broadening their technology knowledge (Xiaorong, 2018).

Virtual reality (VR) is a computer-generated sensory experience that is widely used in social and gaming settings. It has educational applications available to teachers. VR, however, is not readily found in the primary school classroom. Revealing a gap in existing research to explore the influences of VR resources on the teaching practice of primary school teachers. Teachers must think critically about how to include VR technology, while considering pedagogy when planning lessons

(Jowallah et al., 2018). In integrating VR resources into their lessons, teachers' beliefs, attitudes, and teaching practices will be influenced by the opportunities and challenges VR may evoke. The evidence gap highlights the challenge of achieving effective integration of technology into classroom teaching practices (Billingsley et al., 2019) related to curriculum content (Padayachee, 2017) and specific learning outcomes (Graeske & Sjöberg, 2021). In realising the valuable link between technology, content and pedagogy, VR developers should provide teachers with authentic contexts for VR integration (Qiu et al., 2023). The resulting implication of these recommendations for this study is the exploration of the use of VR in the classroom as an integration of teaching practices within curriculum subjects aligned with relevant outcomes (Billingsley et al., 2019). The significance of this study is to gain insight into the educational value of VR related to practising teachers in their classrooms. A research gap exists regarding the potential implications of integrating this multimodal technology in a range of primary school subjects.

This study would advance this body of knowledge by exploring whether VR scenarios create affordances for the changed pedagogical practices of the teachers. This study would add to these areas of knowledge about technology research in the South African context. This study explores the attitudes and perceptions of teachers when integrating VR technology. The findings of this literature aim to highlight the importance of teaching practices and the implications of VR related lessons for teachers, and to better understand the nature of the current uses of VR technologies across different subjects by teachers in their learning environments.

The purpose of the study was to highlight the ways in which virtual reality can be used as a learning resource to influence teachers' pedagogy. The key characteristics of the study are to highlight the beliefs and attitudes of teachers when integrating technologies that align with the content of the subject being taught, as well as the teaching practices they showcased when planning, conducting, and reflecting on the lessons. The implications of professional development when integrating technology. Finally, establishing whether a planning model would be relevant to add to the existing literature. Ultimately, the researcher's aspiration is to encourage research into VR in schooling, to establish validation of the affordances the teachers identified. To inspire developers to develop VR content in a wide range of content topics suitable for teachers to link both pedagogically and technologically into lessons. The branching tree of this literature review (Figure 1) illustrates the flow of this chapter.

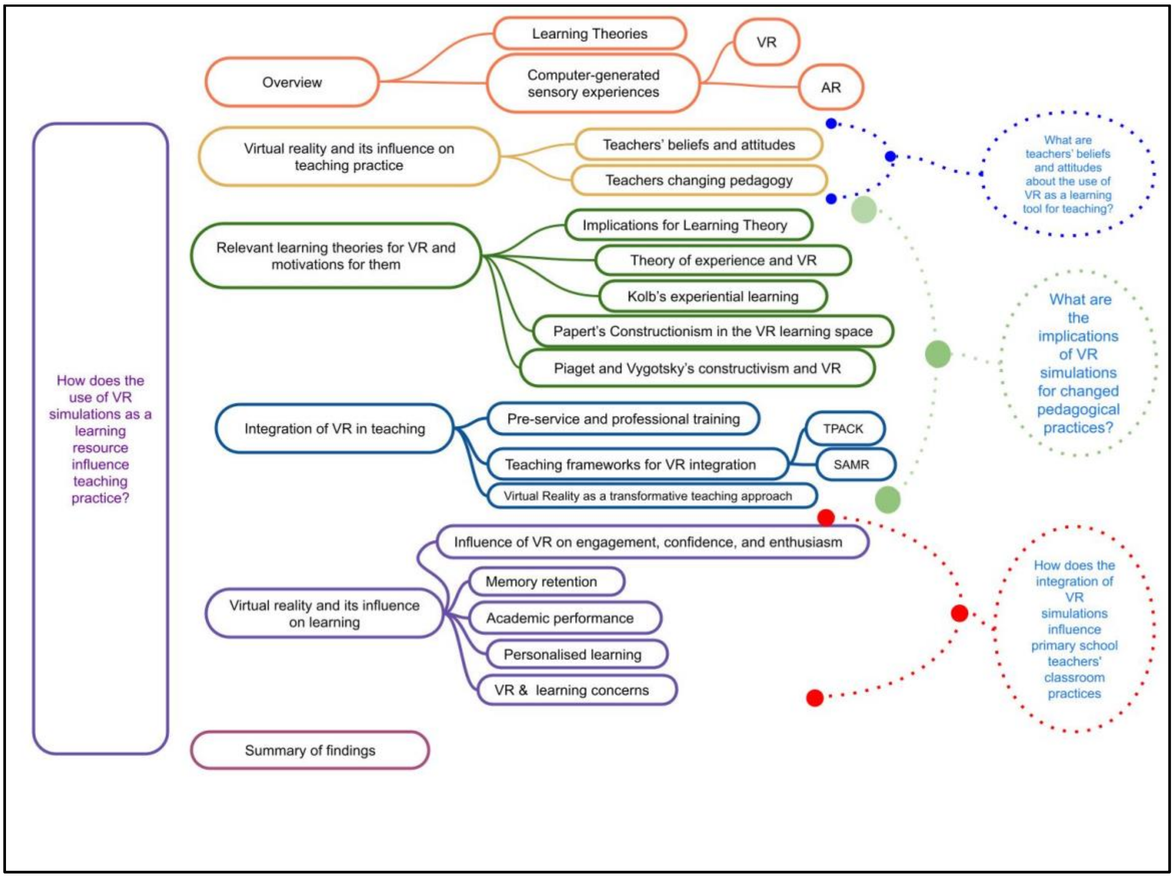

Figure 1: Branching tree of Literature review

This review of the literature begins with an overview of the related learning theories, the theory of learning, experiential learning, constructionism, and constructivism. Thereafter, introducing the reader to computer generated sensory experiences and then describe how VR experiences influence teaching practices. This leaves the question of how teachers react to VR integration and theories that they find useful. The discussion of how VR has been integrated into the professional development of educators, what tools are used, and then look at VR and the positive influence of VR on learning. This leads then to the question as to whether the use of VR simulations as a learning resource influences teachers' pedagogy. After perusing this literature, the conceptual framework was created.

2.2 LEARNING THEORIES

'Learning theories aim to help teachers understand how people learn' (Harasim 2017, p. 4), providing a framework or lens for teachers to understand a phenomenon in a particular way (Harasim, 2017). Teachers must grasp learning theories and how they support 21st century teaching approaches to teach their learners how to learn effectively. Theories provide teachers with guidance on how to interpret their teaching strategies. The descriptions in this section address the tenets of learning theory that describe how learners acquire, process, and retain knowledge during a learning activity. There are a wide range of learning theories; in this review, the learning theories relate to five foci: theory of experience, experiential learning, constructionism, constructivism, and behaviourism. Experiential or real-life learning is related to a specific context, with the 'theory of experience' (Dewey, 1997), the experiential learning cycle (Kolb, 1984), and building towards constructionism (Papert & Harel, 1991). Constructivism was discussed from two viewpoints; such as constructing knowledge from perception as an individual (Paiget, 1964), and social constructivism, working with others to understand and build knowledge (Vygotsky, 1962), and finally, the Behaviourist theory of learning (Skinner, 2003). Most of the learning theories were developed before the 21st century digital age; however, these theories are explored in relation to the impact of modern technologies on educational change, and the challenges teachers face in this digital climate (Niţu et al., 2018).

Learning experiences encompass learners' need to interact directly with the world to understand it (Dewey, 1910). Therefore, the promotion of a theory of experience was encouraged where one actively engages directly with their environment (Dewey, 1997). According to Dewey (1910, p. 96), 'the ultimate educative value of all deductive processes is measured by the degree to which they become working tools in the creation and development of new experiences.' Dewey (1966) expressed how learners should be provided with an 'educative medium' (Dewey, 1966, p. 18) to enable their interest, describing how the stimuli around them would impact how they operate. Teachers should facilitate and guide learners to opportunities to discover for themselves (Dewey, 1910). He advocated that learners should be encouraged to become independent and active learners.

Similar to Dewey's (1910) thinking, experiential learning endeavours to place experience at the centre of the learning process (Kolb & Kolb, 2012). Experiential education is where experience influences the individual's continuous learning, as with the experiential learning cycle (Kolb & Kolb, 2009). Experiential learning assumes that learning is a tense and conflict-filled process where ideas and new knowledge are formed and reformed. Skills and attitudes are achieved through the confrontation of modes of experiential learning of concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Kolb & Kolb, 2018). The 'recursive learning circle' (Kolb, 1984, p. 907) is where learners acquire information through concrete experiences. Learner knowledge continues to grow as students discuss, debate, and experience the learning in which they participate. They develop and transform their learning through conceptualisation and reflection.

Pedagogically strong teachers consciously encourage learners to reflect on what they have seen and experienced during a VR lesson by asking inquisitive and reflective questions; reflect on lessons with their learners, asking questions (Jowallah et al., 2018). Kolb (1984) suggested that learners are encouraged to change the information they receive into a new experience. Kolb's (1984, 2015) group teaching strategy is an experiential learning cycle that encourages learners to share their experiences (experience), reflect, and share the meaning of their experiences (reflect). Then they are encouraged to think about the implications of the experiences for the group (think). Reflections and discussions after VR sessions are beneficial to both learners and teachers (Loke, 2015). Finally, the learners create together, using the knowledge acquired from the learning implications (Kolb, 1984, p. 878). The emphasis is placed on experiencing mode of the learning cycle driving and initiating learning due to the 'here-and-now' experiences (Kolb & Kolb, 2018, p. 9).

Similarly, allowing learners to experiment, experience, and explore learning is how Papert (1980) investigated and researched the use of computers. In the Logo computer coding environment, learners developed a better understanding of mathematics, which is where constructionism developed. Constructionism supports constructivism as learner knowledge is constructed and reconstructed through personal experience (Ackermann, 2001). Using Logo, constructionism provides the learner with a resource and a coding language to think about thinking. Activities are described as promoting the development of higher-order thinking and problem-solving skills (Parmaxi et al., 2017).

Constructionism emphasises that learners construct knowledge by using technology as individuals or groups through practical, real-world tasks and experiences (Harel & Papert, 1991). Constructionists view learning as 'building knowledge structures' through the progressive internalisation of actions within the context where learners are actively and consciously constructing information (Harel & Papert, 1991, p. 1). The e-textile study (Shaw et al., 2020) was associated with their student-centred approach of building knowledge on a tangible digital artefact approach to constructionism. Papert (1980) proposed using procedural thinking to build concrete knowledge and small aspects of knowledge. Papert (1980) expressed that the learning environment should be stress-free, creating conditions for effective and joyful learning. Papert saw the teachers' role as creating a 'productive context for learning' with the key focus being the learners (Stager, 2009). Although the learners were working on the computer, the constructionists saw learning as taking place. Papert highlights the fact that 'diving into' situations and connecting with content are powerful means of gaining understanding (Ackermann, 2001).

Constructivists encourage active learning, like Dewey's (2016, p. 372) view that 'learning is active.' The constructivist philosophy of learning is founded on the premise that individuals construct their knowledge and understanding of the world they live in by reflecting on their experiences. The individual generates new knowledge and comprehension (Vygotsky, 1962; Piaget, 1964; Bruner, 1997). Piaget and Vygotsky are founding researchers of constructivist thinking. They were both dedicated to studying how humans construct knowledge, each proposing different epistemologies about the cognitive constructions of the growing child. Piaget's constructivism suggests that knowledge develops as conceptual changes emerge due to experience (Ackermann, 2001), through active assimilation (Piaget, 1964) of learning. Vygotsky (1978) assumed that a child's development process is independent and separate from that of learning. Putting emphasis on educational activities is more impactful when learning involves social interaction, because social constructivism (Vygotsky, 1986), Vygotsky's Zone of Proximal Development (ZPD) incorporates types of activities that are beyond the learner's independent capacity, but are achievable with assistance (Aleven, et al., 2003). Learners construct their knowledge with the assistance of another in relation to their individual learning development (Chaiklin, 2003) or own their own (Piaget, 1964). In contrast, the behaviourist sees the learner as acquiring knowledge through repetition (Skinner, 2003).

The Behaviourist theory of learning (Skinner, 2003) interprets human behaviour as a stimulus-response interaction. Respondents react and behave due to stimuli; the behaviour may change or be modified by means of conditioning. Learning occurs because of the practice of a behaviour from individual stimuli to the response (Shuell, 1986). The teacher is seen to play an active role as a transmitter. The teacher provides information and shared experiences, and the learner takes (Skinner, 2003). Theories need to be assessed exploring the merits and 'examination for the benefit of learners' (Masethe et al., 2017, p. 231).

Theories are criticised. Kolb's experiential learning cycle is criticised for not addressing the impact of non-reflective experiences on the learning process within larger social groups (Cherry, 2020). The need to examine and consider how an individual's interaction within the larger group influences the experiential learning process (Cherry, 2020).

Constructionism and experiential learning are related to various concepts of constructivism, which grew from Dewey's learning experiences. However, a limitation of constructivism is that a central tenet is that learning occurs inside a person, even from a social constructivist view (Siemens, 2005). The theory does not address learning that occurs outside of people, such as learning that is manipulated or stored by technology (Siemens, 2005). Constructionists see learners as blank slates that teachers need to design instructions to guide them in how to learn and engage (Alanazi, 2016). A criticism of Piaget's learning theory is that it does not notice the role of context, media, and the importance of personal preferences in human learning and development (Ackermann, 2001). Vygotsky's theories have been criticised for their focus on observation, rather than experimental tests, due to their view of social interaction for learning. A further criticism is the concept of social interaction being central to learning; therefore, assumptions need to be made that all societies are the same (Kurt, 2020).

Learning theories inform teachers' teaching practices on how learners learn (Maj, 2022). It is most important for teachers to focus on pedagogy, learning outcomes, and potential VR experiences when planning lessons, so VR is not used as a distraction or diversion (Lege & Bonner, 2020), but used beneficially and meaningfully. Teaching practices are practical interpretations of each individual teacher that incorporate the teacher's views on learning theory (pedagogy) and affordances (practice), both positive and negative, for incorporating technology into lessons. VR is one form of technology that teachers might use.

As one progresses through this review, exploring the affordances of integrating virtual experiences into teaching practice. Exploring the potential bridge between learning theory and the implications of computer-generated VR sensory experiences for changed pedagogical practices.

2.3 COMPUTER-GENERATED SENSORY EXPERIENCES

Sensory learning experiences are encouraged to develop cognitive thinking from a very young age (Goodwin, 2008). Sensory learning includes all our senses of touch, sight, hearing, taste, and smell, building, and encouraging creative and problem-solving skills. Just as in the early years, teachers needed to be made aware of sensory play (Goodwin, 2008), so teachers in older grades might be exposed to computer-generated sensory experiences (Murray, 2019; Radianti et al., 2020) for their lessons.

2.3.1 Virtual reality

Before exploring existing research on how VR is used in the classroom setting, the concept of VR should be explained. VR is a computer-created sensory experience that allows users to believe they are in a 'virtual' experience (Franchi, 1994). In the VR experience, users have difficulty distinguishing the difference from the scene and a real context (Fuchs et al., 2011; Tokel & İsler, 2015; Sternig et al., 2017). VR uses multisensory inputs, such as computer graphics, images, and sound, to recreate and reproduce digital versions of real-life situations (Cochrane, 2016; Fuchs et al., 2011). VR arose due to the development of head-mounted displays with two tiny stereoscopic screens positioned close together in front of the eyes (Franchi, 1994; Woodford, 2007; Massis, 2015).

Generally, VR is interpreted as using software to allow someone to experience a scenario different from the environment, which may be an aspect of the world or an imaginary world (Lee & Wong, 2014). In the virtual world, the individual is absorbed and immersed in an artificial, sensory, digital environment (Massis, 2015; Woodford, 2007). These virtual worlds became more accessible as technology companies developed VR products. Oculus VR is Facebook's VR headset and controls, named Oculus Rift (Oculus, 2016). Palmer Luckey invented it in 2012 (Koles, 2018). In 2014, Google launched Google Cardboard (Nartker, 2014) and Samsung Gear VR (Samsung Newsroom, 2015) as a cost-effective VR product powered by applications on a mobile phone. Based on the stereoscope principle (Virtual Reality Society, 2017) as a semi-immersive head-mounted device (HMD). The educational mobile phone application, Google Expeditions (Howard 2016), contained a wide range (more than 900) of virtual educational field trips. As VR technologies developed, their impact on education continued (Jowallah et al., 2018; Rudran & Logishetty, 2018). VR combines technology and real-life experiences (Schott & Marshall, 2018; Hamilton et al., 2020), the user's headset creates a responsive virtual environment experience that incorporates visual and auditory stimuli. The virtual world (Savin-Baden, 2010; Jowallah et al., 2018) provided an engaging and immersive environment in which students collaborated and worked.

The VR technology used in this study is VR goggles (McAdam, 2019), an alternative to Google cardboard (Nartker, 2014). Inexpensive, easy-to-use VR hardware headsets (Brown & Green, 2016; Peltekova & Stefanova, 2016) and cost-effective software application options are available to teachers. Low-cost VR technology provides greater access for schools and students to VR as a learning tool (Zantua, 2017; Xiaorong, 2018). Google Cardboard is a smartphone-based headset device that makes VR accessible through Google Play or Apple App Store applications on the individual's mobile phone (Nicas & Seetharaman, 2016). Google cardboard was based on the principles of the stereoscope (Virtual Reality Society, 2017). Cardboard uses stereoscopic imaging that tricks the eyes into seeing 3-D by showing two offset images separately to each eye. The brain combines the two images and creates a single whole image with added depth, thereby creating a third dimension. This is not a new technology; stereoscopes from the 1830s already used stereoscopic imaging (Boehlert, 2015; Virtual Reality Society, 2017). Google Cardboard is a relatively inexpensive way to expose students to VR experiences. The top picture in Figure 2 shows a Google Expeditions screenshot, depicting the split stereoscopic images. The bottom left is an example of Google Cardboard (Google VR, 2014), and the bottom right is an image of goggles VR[4] by The Virtual Space (2019), which was used in the current study's research.

[4] Image: The Goggles VR are produced by The Virtual Space (2019) in South Africa https://thevirtualspace.co.za/branded-goggles-vr-headsets/

Figure 2: Top: Google Expeditions screenshot of stereoscopic imaging. Bottom Left, Google Cardboard (Google VR, 2014); Bottom Right, Goggles VR by The Virtual Space

VR has been expensive for school budgets, with the development of low-cost VR headsets for cell phones makes it more affordable (Jowallah et al., 2018). The VR lens in this chapter is wide and an amalgamation of research from VR 3D simulations to VR head-mounted devices. VR is different from augmented reality. VR replaces your reality using the headset, while AR bridges the gap between the physical and virtual worlds (Rogers, 2017).

2.3.2 Augmented Reality

Augmented reality (AR) and virtual reality (VR) are computer-generated context representations (Johnson, 2019), both immersive sensual experiences. These technologies may be on a continuum of a sliding scale of mixed reality (Nielsen et al., 2016). AR combines real and virtual objects in the natural environment (Azuma et al., 2001). It is characterised as a technological perceptual concept, which includes technological, perceptual, and information components, adding visual, sound, and other virtual elements to an existing environment (Jeřábek et al., 2014), augmenting the user's perception of the world (Heim, 1998; Nielsen et al., 2016; Johnson, 2019). AR activates computer-generated images on a mobile phone screen using mobile applications (Sinha, 2021).

The computer-generated sensory experiences of AR incorporate visual and auditory sensations. These computerised environments affect the user's world. Enabling the teacher to demonstrate concepts using virtual images, in a more interactive manner, while enhancing the textbook material (Sinha, 2021). The development of learner independence was shown to be achieved with the use of AR (Baragash et al., 2022). Incorporating AR and VR into the classroom (Sapp, 2015; Donally, 2018) provides teachers with additional ideas to explore and discover.

Human imagination continues to be pushed when using VR (Jowallah et al., 2018). The purpose of VR creates a possible sensorimotor and cognitive activity for people in a digitally constructed artificial world, which may be an imaginary, symbolic, or a simulation of an aspect of the real world (Fuchs et al., 2011). The growth of VR in education provides an opportunity to explore technological affordances where learners experience virtual tours of simulated environments (Murray, 2019). For these experiences to be incorporated into learning, teachers must see the value within their own teaching environments.

2.4 VIRTUAL REALITY AND ITS INFLUENCE ON TEACHERS' CLASSROOM PRACTICE

Integration and inclusion of technology in lessons is complex. Teachers must explore and experience various technologies to realise that some technologies are better suited for particular learning tasks as they have their tendencies, and limitations (Koehler & Mishra, 2009). Conceptualising how best to integrate VR technology into the curriculum (Dahlstrom et al., 2015), allowing them to act as facilitators in the classroom (Yildirim et al., 2020). For instance, VRMath (Yeh, 2010) provided learners (8 and 10 years of age) with new ways of creating and thinking about 3D geometry. While online education providers are beginning to offer VR experiences, therefore, increasing opportunities to align with the curriculum (Fransson et al., 2020), such as Thinglink (2020) and Nearpod (2020) have VR offerings on their platforms.

Teaching is a multifaceted problem-solving task of decision making regarding many variables during a lesson (Ke et al., 2020). Teaching practices include classroom management, a set of procedures, strategies, physical and digital resources, pedagogy, learning activities, and instructional methods that teachers use to create a classroom environment that promotes learning (UNESCO, 2020). The way teachers and learners interact with each other works towards knowledge acquisition, highlighting active learning, cognitive activation, and teacher-directed instruction as key teaching strategies (OECD, 2016; Molina et al., 2018). Instructional techniques and strategies enable learning to occur, including the interaction between teacher and student (Siraj-Blatchford et al., 2002).

Teachers' teaching practices vary from teacher to teacher and from country to country (OECD, 2009). VR technology provides a variety of opportunities but cannot exist on its own. It must be aligned with the curriculum and educational outcomes (Graeske & Sjöberg, 2021). Teacher classroom practices are influenced by the teacher's perceptions and views. Student teachers found their classroom management problematic when using VR as a teaching resource (Huang, Richter, Kleickmann, Wiepke et al., 2021). Therefore, Seufert et al. (2022) researched a VR classroom management tool for pre-service teacher students, which showed an improvement in student-teacher classroom management skills. When using VR as a whole class activity, teachers could more easily monitor learner involvement, which assisted the teachers with their classroom organisation (Li et al, 2022). An affordance is defined as the way in which a user interacts or communicates with an object or an environment in this instance technology, such as a 'like' button on a social media application affords users the ability to express their approval of a post with a single click, or a VR headset affords a 3D, immersive experience. Affordances can also constrain (Hammond, 2010) user behaviour. For example, the length of a tweet on Twitter is limited to 280 characters, which constrains the amount of information a user can express in a single message. Teacher's teaching practice translated into their classroom environment. When incorporating VR into the classroom, the teacher should not view VR as a holistic solution.

Nesenbergs et al. (2021) highlighted that the VR scenario was not a solution to all educational requirements but was beneficial as a teaching resource. VR (Lee & Wong, 2014) is a way of digitally simulating or replicating an environment

(Makransky & Lilleholt, 2018). These virtual environments enable scenario-based learning and experiential learning. Integrating VR as an inquiry-based learning environment (Peltekova & Stefanova, 2016) or as a problem-based learning experience (Abdullah et al., 2019) provided virtual field trips for learners to investigate and explore while remaining within the classroom. These virtual field trips may serve as a gateway to engage those teachers who are less prone to using technology to develop skills and become more comfortable teaching with VR (Stoddard, 2009; Garcia, Nadelson, & Yeh, 2023). VR was integrated into the lessons to deepen the learner's understanding of the concept being taught (Craddock, 2018). Teachers identified opportunities to visualise complex processes and scenarios to make teaching and learning more interesting, varied, and experience-based pedagogical possibilities when integrating head-mounted VR devices into lessons (Fransson et al., 2020).

A systematic literature review (Billingsley et al., 2019; Laine, Korhonen & Hakkarainen, 2023) explored the enhanced learning experiences of pre- and in-service teachers when using Immersive VR technology in teacher education, recommending further investigation to address transferability and generalisability of VR training to teachers' actual classrooms. An additional research request was to investigate whether current learning outcomes targeted by traditional pedagogy can be transferred to a virtual space. Technology integration is not achieved by providing teachers with devices, rather addressing the incorporation of teaching practices and technology within the curriculum (Padayachee, 2017). The implications of this study are the exploration of the influence of the use of VR in teaching practices applicable to the content of the curriculum and the related outcomes.

2.4.1 Teachers' beliefs and attitudes about the use of VR as a learning tool

'The task of creating learning environments conducive to the development of cognitive skills rests heavily on the talents and self-efficacy of teachers' (Bandura, 1989, p. 66). The difference between beliefs and practice is shaped by pedagogical and cultural traditions, representing different parts of the pedagogical context for learning by learners (OECD, 2009). Teachers' beliefs are influenced by training courses, learning experiences, professional development, teaching experiences, and teaching practices (Gilakjani & Sabouriit, 2017). The beliefs teachers have had in the past shaped how they teach and learn (Gilakjani & Sabouriit, 2017). How teachers structure their lessons, promote discussions, and ask questions about the learners' interactions with VR content would impact the quality of the learning.

The level of confidence and comfort of incorporating technology into teaching practices is affected by teachers' attitudes (Yildirim et al., 2020). Those familiar with technology integration coped with the change in teaching practices during the Covid-19 pandemic, found virtual tours valuable (Squire, 2021), and showed learner-directed interactions using VR, Google cardboard (Tudor et al., 2018). However, teachers who did not feel comfortable using the technology could reject the use of new technologies in the lessons (Yildirim, et al., 2020). The absence of relevant teacher training was evident where there was a lack of adoption of VR technology (Fernandez, 2017; Santamaría-Bonfil et al., 2020; Gao & Zhang, 2020).

The positive attitudes of teachers extended further; a group of teachers who had participated in a VR study perceived their participation as an opportunity to bring increased acknowledgement and statuses to their roles by promoting the incorporation of high technology into the profession (Fransson et al., 2020). Even within the teaching profession, high school history teachers discussed the integration of VR into their lessons as having the potential of gaining them acknowledgement and support, which was often reserved for other teachers, such as maths teachers (Fransson et al., 2020). Librarians described themselves as master teachers and subject area generalists teaching across a range of subjects (such as geometry, biology, language arts, and American history classes), therefore, being able to promote and integrate VR technology effectively within their flexible schedule (Craddock, 2018).

Teachers saw VR tours as adding value by offering 'flipped' technology experiences, where learners interacted and engaged in immersive technology (Al-Ansi et al., 2023) and used virtual classroom occurrence for learning activities that leveraged face-to-face interactions during quarantine (Squire, 2021; Gracia et al., 2023). The attitude of teachers in schools that already use technology meant that they quickly adapted to the new lockdown context. This was evident in schools who already had digital materials and structural capital designed to prepare learners for knowledge work (Squire, 2021). Simultaneously, the new generation of learners was depicted as easily and naturally learning, connecting, and interacting within the digital environment (Sanchez-Cabrero et al., 2019; Asad et al., 2021). Teachers who used less technology needed to adapt and consider adding relevant and educationally sound technology to their teaching practices.

The challenge of using VR devices in education is that many teachers lack technical skills or knowledge to source content related to their learners or improve their teaching practices (Fransson et al., 2020; Khukalenko et al., 2022). Teachers' perception of their knowledge and skillset to use VR as a pedagogical tool was assessed as lower than when using other digital technologies (Cooper et al., 2019). As VR became more popular and less expensive, devices and content were more easily accessible to be included in the lessons (Jung et al., 2016). Teachers may be afraid to use technology in teaching (Graeske & Sjöberg, 2021) due to their own beliefs and attitudes. Teachers showed the intention to use VR in lessons from questionnaire results; however, they needed to see the value and perceive the usefulness of VR to integrate it into lessons (Majid & Shamsudin, 2019). Teachers who were not technologically trained found that managing hardware, software, and content issues (purchases, updates, and profile logins) was problematic when VR equipment was within the classroom environment (Fransson et al., 2020). On the other hand, teachers who had attended VR professional development were willing to create lesson plans that incorporate VR on different topics (Yildirim, et al., 2020).

The impact of the Covid-19 pandemic on the world affected individual lives, with schools and higher education institutions having to transition from face-to-face lessons to online learning. Teachers had to reconsider their teaching methods and pedagogy to ensure that their students continued with their learning even with imposed lockdown restrictions (Cleophas, 2020). Teachers struggled to continue to provide education, and many schools returned to traditional teaching methods, teaching through pre-recorded lessons, or conducting live video lessons (Mateen & Kan, 2020). Some teachers were inspired and began planning, creating, and designing effective and meaningful learning scenarios with the incorporation and installation of online technological resources (McKenney et al., 2015; Rapanta et al., 2020). During Covid-19, some educational environments promoted learning about information science technology from passive to active use of VR (Xu & Tang, 2021). Gamified virtual field trips allowed learners to learn from home using the same virtual reality technology as school and engaged them in thinking and experiencing learning (Squire, 2021). VR was used to train students when face-to-face teaching was impossible, the creation of VR-adopted courses affected the availability of knowledge. The technology provided students with the ability to use the technology when it suited them, well-designed VR courses showed an increase in performance or participation. This kept their learning course on track (Mateen & Kan, 2020; Nesenbergs et al., 2021). Using VR technology during the pandemic helped some institutions reach their students, keep them on track, and provide opportunities to rethink the way teaching was conducted.

The range of attitudes and beliefs within the school context of the teacher is very wide. Teacher implementation of new technologies was hindered by barriers related to the lack of technological knowledge, safety and security, and learner access (Yildirim, et al., 2020). Teachers' perceptions on incorporating VR into teaching and learning were not understood (Alalwan et al., 2020). Concerning the challenges and risks of VR use, teachers seem to notice only a few of them (Graeske & Sjöberg, 2021). Three areas were shown to significantly affect the use of digital technologies by teachers, and they should consider integrating technology into their teaching and learning. 1) First, the principal or the leadership prioritised digital technologies, addressing the learner teacher. 2) Second, teachers who felt valued and included in the 'shared vision' of the school were more likely to invest in the use of technology. 3) Third, teachers who had access to both technical and pedagogical support experimented and explored the use of technology in their lessons (Howard & Mozejko, 2015). For teachers' values and beliefs in VR to be established, they need to purposefully sanction core teaching practices in realistic scenarios; the call for more practical teacher training opportunities is regularly raised (Huang, Richter, Kleickmann & Richter, 2021). Similarly, Taxén and Naeve (2002, p. 594) expressed that there is little evidence of 'how the presence of a teacher or facilitator influences learning in VR applications, providing an opportunity for research into this area. A VR professional development resource was created to assist school leaders to provide meaningful assistance to teachers to assist in improving their teaching practices to ensure high-quality learning for learners (Militello et al., 2021). The pedagogical understanding of teachers underpins their beliefs and attitudes towards their classroom practices.

2.4.2 Teachers changing teaching practices

Teaching practice is ‘any conscious activity by one person designed to enhance learning in another’ (Watkins & Mortimore, 1999, p. 3). In schools, VR can be recognised as a mature technology appropriate for pedagogical use (Mikropoulos & Natsis, 2011). Teachers were aware of the range of pedagogical affordances that impacted and affected the use of VR by learners in the school context (Xiaorong, 2018; Craddock, 2018; Allison & Hodges, 2000), and this helped validate VR integration by teachers. In contrast, the adoption of mobile VR in schools was still in an early stage of adoption (Tudor, et al., 2018). Technological inclusion develops as evidence of effective teaching practices becomes apparent. Teaching is a complex problem-solving task within a highly situated context, requiring decision making and adaptive implementation of the principles of instruction, communication, and content representation (Ke et al., 2020). Teachers considered incorporating technology into lessons influenced by their pedagogy. Using the classroom teaching practices of teachers, they designed and created learning environments and improved their learners' learning. The pedagogy incorporated the philosophical concepts of teaching methods and practical action (Wang & Huang, 2018).

The learning theories of Dewey (1916), Piaget (1964), Vygotsky (1978), Papert (1992), and Kolb and Kolb (2018) resonate with various VR studies, applied to learning and teaching practices, strategies for children (pedagogy) and adult learners (andragogy). Studies about VR technology showed that VR is being used in schools (Cheng & Tsai, 2019; Tudor, Minocha & Tilling, 2018; Vishwanath et al., 2017), and higher educational institutions (Barrett et al., 2018; di Lanzo et al., 2020). From this position and point of view, VR could be defined as an educational technology to change teaching practices.

When introducing new technology into a school or subject, it should be pedagogically beneficial for the teacher to see a positive impact on the engagement and learning of her learners (Nesenbergs et al., 2021). The inclusion of VR technology (Cooper et al. 2019) for training qualified teachers and pre-service teacher training could positively impact teaching practices. It is recommended that VR is used as a teacher training experience. This will assist teachers in learning to cope with classroom behaviour, with a focus on how to identify and handle common classroom disruptive situations (Huang, Richter, Kleickmann, Wiepke et al., 2021). Therefore, preparing teachers to navigate, contribute, and participate effectively in virtual environments, developing their skill set and knowledge (Xiaorong, 2018), could motivate teachers to incorporate VR into their pedagogy.

The fusion of pedagogy and technology when educators are using VR systems (Jowallah et al., 2018) will create a meaningful union to include VR in R-12[5] education. The affordances in education are the relationships between the properties of a learning experience and the characteristics of the learner that enables certain kinds of learning to occur (Kirschner, 2015). Incorporation of virtual environments consisted of a selection of educationally desirable features, including opportunities related to specific learning outcomes, easily repeated experiences that enabled deeper learning, and provided feedback in context (Schott & Marshall, 2018). The type of immersive VR technology deployed, and the teaching methods varied. Both the sophisticated VR technology and the instructional VR design versions produced effective teaching strategies and positive results in learner performance, learning outcomes, and motivation (Pellas et al., 2020).

[5] R-12 is South Africa's schooling range, Grade R is equivalent to K (Kindergarten) and Grade 12 is the exit year of schooling, before higher education.

Teachers developed lessons by deciding on the pedagogy and how the information would be taught (Merriam-Webster, 2022). Understanding how VR-based teaching can be integrated into the existing curriculum (Radianti et al., 2020) would be beneficial. Encouraging teachers to use technology, such as VR, would benefit the learning context since VR has been a teaching and learning tool for various subject areas to encourage participation (Asad et al., 2021).

The technological affordances of smartphone VR educational applications support pedagogical approaches of experiential learning, bridging virtual fieldwork with physical field trips; and inquiry-based learning (Minocha et al., 2017). Educational technology, including AR and VR (Dick, 2021), helped learners to improve their learning capabilities. VR helped to build the confidence of the learner in the knowledge of the content (Madrigal et al., 2016; Pieterse et al., 2018), improved the results of the evaluation and the ability of the learner to understand (Lee & Wong, 2014; Alhalabi, 2016). VR studies indicated better memory retention (Sinha et al., 2012; Xiaorong, 2018; Yildirim et al., 2019). Learning engagement was enhanced using VR (Nesenbergs et al., 2021; Araiza-Alba et al., 2022). VR technologies contributed to creating tangible understandings of abstract concepts for learners and increased their success rate (Fernandez, 2017).

The teacher's classroom practice was 'directed toward the positive modification of a learner's knowledge and behaviour' (Wang & Huang, 2018, p. 261). Incorporation of VR educational technologies into lessons indicated that the positive impact of VR integration on learner interaction and knowledge retention could drive pedagogical change (Hamilton et al., 2020). Affordances the teachers observed were learners who were motivated (Freina & Ott, 2015), experienced enhanced creativity (Fowler, 2015; Huang & Chang, 2023), and proactively constructed their own meaning, assessing it against reality (Vargas-Hernández, 2015). VR scenarios evoked immersive (Makransky & Lilleholt, 2018), experiential (Tudor et al., 2018), and multisensory experiences (Cooper et al., 2019) providing more realistic encounters (Makransky & Lilleholt, 2018) in a stimulating learning context (Chen, 2016) context. The virtual experience created an educational entertainment learning process (Makransky & Lilleholt, 2018). Primary school learners benefit from VR physical education activities for improving their physical fitness (Bae, 2023). Teachers could digitally transport learners to unusual or difficult spaces or environments (Hussein & Nätterdal, 2015). VR use was seen as an important learning tool that benefited the user experience of the learner (Schott & Marshall, 2018), as teachers understood the extensive pedagogical knowledge and saw how the learner acquired skills, formed habits, and constructed their understanding and knowledge (Mishra & Koehler, 2006).

Teachers' attitudes towards VR often depend on the results observed by their learners' reactions. Participants working within the VR environment had their learning performance effectively improved (Li, Liu & Chen, 2022).

A teacher in a high school VR study described how she was previously afraid to use VR technology as she had not mastered it, but had changed her mind, and realised that she could learn with learners, finding that the incorporation of VR in the lesson had positive results (Graeske & Sjöberg, 2021). The teaching practice improved the user experiences of the learners (Schott & Marshall, 2018), providing more realistic learning scenarios for the learners (Madrigal et al., 2016). Virtual platforms were considered potentially transformative educational tools (Cooper et al., 2019; Dick, 2021). In contrast, teacher participants who were not confident in their knowledge and skills to use VR as a learning tool used it less than other technologies (Cooper et al., 2019). Although other teachers felt that learners needed to be trained in technology for it to be effective in lessons (Alalwan et al., 2020). Integrating VR into the learning experience could add value (Peltekova & Stefanova, 2016).

Teachers may consider potential challenges when using VR, such as the amount of input required by them when learners use VR in a lesson. The practical use of VR headsets and VR applications on mobile phones (Peltekova & Stefanova, 2016) and how it is integrated in the lesson. Teachers must find the balance between pedagogy and technology when planning, understanding that the VR technology will not and should not replace physical experience in real life. The consideration of the teaching strategy for the effective inclusion of VR as a teaching resource (Alalwana et al., 2020) by the teacher needs to be carefully considered. Professional development of teachers about technical requirements (Lugrin et al., 2018) would assist teachers in alleviating challenges, and finding the balance between the technology and the pedagogy within a lesson. The absence of pedagogical and technological balance will limit the validity and legitimacy of VR in schooling (Jowallah et al., 2018). The effectiveness of virtual technology for learning is determined by the correlation between the pedagogical and technological affordances related to VR (Baceviciute, 2021). On the other hand, fundamental concepts in VR, contributing to knowledge retention and providing engaging sessions, are limited when teaching in an old-fashioned manner or using non-interactive modes (Szabo, 2021). In this sense, teachers' knowledge and skills must be developed through professional development to demonstrate the balance between pedagogy and technology selection for the effective incorporation of VR into their teaching practices.

Teachers may lack confidence in implementing and using technology (Cooper et al., 2019) in lessons, which may be due to the technological divide (Jowallah et al., 2018). Implementing VR resources requires specific technical expertise (Graeske & Sjöberg, 2021). Within the South African context, there is an ongoing challenge of the lack of support for schools with ICT resources. Support is lacking in all areas of implementation, namely, technical, financial, and administrative support (Munje & Jita, 2020). Other obstacles to the integration of VR to be considered are equipment costs, potential health and safety risks to users, and logistics implementation of using the technology (Jowallah et al., 2018; Philippe, et al., 2020).

Teachers may be wary of adding new technologies to their teaching, such as VR, in lessons due to a lack of professional development (Liberman, 2015). Therefore, there is value in providing professional development for teachers who may not be comfortable using new technologies with their students (Stoddard, 2009).

From a South African perspective, Munje and Jita (2020) expressed the need for more research on ICT-related challenges to help provide a holistic picture of technology problems within education. The idea is to provide more data to the government, so action can be taken to address the needs and problems; VR is one form of ICT as an alternative technology. Identifying the learning requirements with teaching practices and pedagogical models, and then to seek evidence of sources of technology resources to support the lesson (Fowler, 2015). Learning theory influences teacher practice.

2.5 RELEVANT LEARNING THEORIES FOR VR AND MOTIVATIONS FOR THEM

An effective learning environment requires a pedagogical approach that leads to learning theory to achieve educational goals and learning outcomes (Mikropoulos & Natsis, 2011). Learning theories aim to help teachers understand both how knowledge was created and how people learned (Harasim, 2017). Teachers want their learners to learn, so understanding the learning theory may enhance their teaching practices. This study draws on the works of several renowned scholars, namely Dewey's theory of experience (1916), Piaget's (1964) and Vygotsky's (1978) constructivism, Papert's (1992) constructionism, and Kolb's (2015) experiential learning cycle. Connections are drawn between learning theory and the use of technology, in particular VR, for teaching and learning.

2.5.1 Implications for Learning Theory

Learning theory influences teachers' viewpoints when they are creating a learning space. Learning involves the interaction between a person and an environment. 'Learning is the process whereby knowledge is created through the transformation of experience' (Kolb, 1984, p. 38). The use of VR in educational settings supports constructivist learning (Huang et al., 2010; Katz & Halpern, 2015; Bani-Salameh et al., 2017) and positively impacts inquiry-based learning (Peltekova & Stefanova, 2016). In a classroom setting, when integrating VR, affordances may address experiential learning; bridge virtual fieldwork with physical field trips; and inquiry-based learning (Minocha et al., 2017). As Piaget's constructivism suggests, knowledge develops as conceptual changes emerge from experience (Ackermann, 2001). Simultaneously, the incorporation of VR reinforces Papert's constructionism by providing learners with a greater opportunity to learn and better understand the content through experiential learning (Dewey, 2016a). This feeds into Kolb's concept of learners acquiring information through concrete experiences (1984) and

Vygotsky's (1978) ZPD with VR as 'the more knowledgeable other.' It is also reinforced with VR research using 3D design, which highlighted that VR could positively impact students' learning results (Allcoat & von-Mühlenen, 2018; Meyer et al., 2019; Radianti et al., 2020; Niu et al., 2021). VR was described as a useful teaching tool, as students were interested as they saw it as a new technology and were engaged (Smith et al., 2018).

The learning theory that teachers employ (consciously or not) determines what they see, what they consider to be important, and therefore how they will design and implement their teaching practice (Harasim, 2017, p. 4). Teachers' affordances regarding the learning theories they would use would be different depending on the preferences of each. When teachers understand learning theories, they can reflect on their teaching practices, improve, reshape, and refine their lessons (Harasim, 2017, p. 4). The teacher decides when and where to use VR. The implications of the study would be for teachers to determine and decide when to use VR in a lesson, as Pantelidis (2009, p. 66) states that for teachers 'deciding when to use VR leads to decisions on where to use VR.'

2.5.2 Theory of experience and virtual reality

Dewey (1966) contended that learning occurs when learners are curious, exploring, eager to experience new and varied contexts, and are active learners. Therefore, VR could provide a natural experience for learners of places they are learning about but cannot get to, such as remote places within human anatomy (Hussein & Nätterdal, 2015), remote places, or exploring a Fijian island (Schott & Marshall, 2018). They could express their thoughts in a deductive manner about the experiences. Bukhari et al. (2017) findings can be translated into a classroom situation by allowing learners to explore, gain knowledge, and develop an understanding of a concept or context without the pressure of time frames or limiting the number of attempts to do an activity; thus, developing knowledge from impressions made in VR experiences rather than by natural objects.

Learner-directed interactions (Tudor et al., 2018) using Google Expeditions VR, where the teacher managed the learning process by leading students through the various VR experiences in an immediate and personal way. If exploring Dewey's stimuli and response (1966), the VR experience would be the stimuli and the reaction of the learners would be the response. Teachers would source relevant and beneficial learning experiences for their learners. VR being a tool in assisting the learner to become an active learner, interacting with the virtual environment. If the teacher allowed the learners to explore VR contexts related to the topic being taught, they were inspired to learn. In these cases, experiences were found to be beneficial when used as stimuli in the learning situation (Bukhari; et al., 2017) to motivate learning (Freina & Ott, 2015). This was also reinforced by Thomas and Hooper (1991), who noted that using VR simulation in lessons to be more effective in the application, understanding, and transfer of knowledge to real-world contexts instead of memorising information and facts. Results indicated that adding segmentation or summarisation to an immersive VR lesson improved the transfer of knowledge of Grade 6 and 7 learners, but that they did not acquire more factual knowledge (Klingenberg et al., 2023). VR motivated and stimulated learning among learners (Niţu et al., 2018) studying software engineering who participated in VR and consumer device demonstrations. Virtual learning simulations changed education into a gamification or entertainment learning process (Dimitropoulos et al., 2007; Makransky & Lilleholt, 2018). Dewey's participatory learning encouraged the learner to exercise their imagination in constructing an experience of greater value than the child has yet mastered (Dewey, 1916a). The engagement with VR is different from other types of human-computer interfaces, as people are active participants in virtual experiences rather than simply using it (Slater & Sanchez-Vives, 2016). A most important connection between Dewey's (1913) theory of learning and immersive VR was that Makransky and Lilleholt (2018), found that immersive VR could promote generative processing by providing a more realistic experience for the learner, due to the practical nature of the experience and the learners actively interacting with the environment during tasks.

Because learning is an active process, according to Dewey (1916a), the implications for the study would be to observe if teachers are seeing an impact on their learners with the selected VR scenarios and if that influences their teaching practices.

Teachers identifying with the theory of experiential learning might lead to Kolb's experiential learning cycle as learners move from concrete to virtual interactions, reflecting on their own experiences.

2.5.3 Kolb's experiential learning

Providing the potential to allow learners to experience objects and learn in ways they cannot do so in real life is what VR offers (Taxén & Naeve, 2002; Niţu et al., 2018). As students are encouraged to view VR scenarios and then debate and discuss their findings, a greater user experience with the potential for learning is encouraged.

Kolb and Kolb (2018) emphasise that the experiencing mode of the learning cycle drives and initiates learning due to the 'here-and-now' (p. 9) experiences. The learners exploring the rainforest scenes of the Borneo Google Expedition (Google, 2015) using VR felt that they had experienced and visualised the actual rainforest. This sparked their learning as they connected their understanding and related the environmental changes in Borneo rain forests to their local nature reserve, exploring and reflecting on the impact of technological development on the natural environment (Tudor et al., 2018), and gaining new knowledge. Schott and Marshall (2018) reported in their findings that participants felt a 'strong sense of immersion' (p. 848), feeling as if they were really on the island. VR created an authentic and experiential learning experience. All the modes of the learning cycle are experienced (Kolb, 1984), learners related to the subject topic as being relevant.

By aligning the information of the study with the Kolb learning cycle, the learners begin by moving from a concrete experience of doing and experiencing the virtual interaction. They progress to the second stage of reflective observation, by reviewing and reflecting on the content and information they have experienced. The third stage is abstract conceptualisation, where the learners draw conclusions and discuss what they learned from the experience. Finally, learners actively experiment with further planning or testing what they have learned. Learners developed better confidence in understanding conceptual relativity and enjoyed the VR simulation learning experience (McGrath et al., 2010). Tudor et al. (2018, p. 31) noted that students were asked to ‘reflect on how the virtual field trip made them feel differently about the large-scale development planned near the local nature reserve.’ The interaction and reflection of the learners during and after viewing VR scenarios allowed for a more effective learning experience. Taking a lesson from the Tudor et al. (2018) study, using immersive experiential education in the classroom is beneficial to many subject curricula, as learners are exposed to complex real-world problems as part of everyday lessons. Kolb provides a comprehensive theory built on philosophy, cognitive, and social psychology, which offers a lifelong learning approach to education (Zuber-Skerritt, 1992). The experiential learning theory correlates from a technological viewpoint with constructionism of using a computer to assist in learning.

2.5.4 Papert’s Constructionism in the virtual reality learning space

Papert (1992) described how when computers were introduced into schools, teachers allowed students to control their learning, giving their students autonomy to learn as having a 'radically different theory of knowledge' compared to traditional teaching (Papert, 1992, p. 61). These teachers discovered ways to use technology to structure their lessons, which built their students’ knowledge, occasionally providing advice to the students. Papert described this teaching action as learning-in-use. He perceived it to be both beneficial and liberating for the learner, learning in a more personal manner than traditional classroom teaching (Papert, 1992). Teachers described their learners as being engaged, excited and having fun participating in the VR mathematics game. A slight improvement in the mathematics results was evident (Akman & Çakır, 2023). Similarly, immersive VR technology creates the impression of being in another place, tricking the student or participant’s brain into believing the scenario (Hsu, 2017). Immersive VR creates and enables the learner to be embodied in the learning due to the visible and tangible experience, and the mentally embedded experience (Mellet-d'Huart, 2009) of learning reinforces the belief of being in another environment. In a scaffolded literacy lesson, the concept was expanded using VR with an experiential learning virtual field trip (Pilgrim & Pilgrim, 2016). Chen’s (2016) VR study aligns with this constructionist thinking by showing that virtual experiences provide a stimulating, realistic and immersive learning environment, improving the student's understanding of the language and greater student concentration while learning. To use an educationally powerful computational environment, VR, as an alternative to traditional classroom instruction and teaching (Papert, 1980). This is substantiated by the findings from Li et al. (2022, p.3238) where teachers found that the use of the VR resource assisted them in improving their ‘instructional effectiveness’ when explaining complex information, as the learners understood the lesson’s content better after completing the VR activity. Makransky and Lilleholt (2018) identified that VR experiences affected learners' satisfaction by being enjoyable and motivated to play, with a high level of VR usability features, giving students a sense of presence. Learners using VR claimed that the technology improved their problem-solving skills and increased their motivation to learn (Zhao & Yang, 2023). Various studies described VR as pleasant learning experiences (Tokel & İsler, 2015; Makransky & Lilleholt, 2018), providing fun edutainment[6] opportunities (Sternig et al., 2017; Fransson et al., 2020). Virtual technology is described as a learning facilitator that provides learners with contextual and innovative learning (Chen, 2016). VR is proposed as an effective resource for teachers looking for remarkable long-term results for learners in high-motivational and entertaining lessons (Yildirim et al., 2019). Papert's ideas can be translated into virtual learning experiences, where students explore and discover in a relaxed learning environment (Anderson, 2019; Cheng & Tsai, 2019). Learners explore a partial aspect of content in single VR scenarios, then discuss and reflect on what information has been observed and engaged with. The study by Zantua (2017) showed that learners learn by doing, involving a small group of Grade 6 Social Studies using affordable VR technology (Google Cardboard), and found that the use of VR applications benefited the performance scores of the learners. Their scores were better compared to the group of learners who did not use VR technology (Zantua, 2017). Comparably, Papert saw teachers being liberated (Papert, 1992) as they provided their learners with a more personal learning experience.

[6] Edutainment - digital or other materials which provide both educational and enjoyment value.

2.5.5 Piaget and Vygotsky's constructivism and VR

A constructivist approach was implemented within a teaching and learning context for research using a VR-based application (Nițu et al., 2018). VR scenarios incorporated into educational settings indicated the support of constructivist learning (Huang et al., 2010; Bani-Salameh et al., 2017). Individuals construct meaning, testing it against reality, not just memorising and regurgitating someone else's meaning (Vargas-Hernández, 2015). Katz and Halpern (2015) followed a constructivist-based learning approach to exploring immersive 3D environments for museum visitors. The study suggested that participants may increase their reasoning process and become more interested in cultural content, illustrating the effectiveness of learners involved in an active learning process, learning through exploration. This aligns with Piaget's active assimilation (Piaget, 1964) of learning, student learning was also provoked by external situations (Gauvain & Cole, 1993). In this case, through the VR experience, the memory retention and understanding of the learners improved. This is reiterated by Niţu et al., (2018), who described the impact of the VR experience as an effective, immersive, and interactive learning tool.

The lecturers at an HEI used VR in academic settings, creating virtual environments that encourage learners to learn through experience, action, discovery, and exploration (Niţu et al., 2018), applying a constructivist teaching and learning approach. The 'more knowledgeable other' of the Zone of Proximal Development (ZPD) (Vygotsky, 1978) could be the VR experience. During VR lessons, the teacher, group members, and the VR experience could all be described as the 'more knowledgeable other.' The learners gained information from the VR content while asking questions to the teacher and group members. VR was considered immersive, mobile, and capable of being used in different school contexts (Craddock, 2018), as well as constructivist, providing interactive environments and authentic learning situations (Niţu et al., 2018; Philippe et al., 2020; Al Farsi et al., 2021).

The value of VR in assisting in constructing knowledge is reinforced by the research conducted by Winn et al. (2005), showing that the virtual content provided greater context to a learning situation when comparing the learning of students who used VR and those students who had the actual learning experience. Therefore, it was found that the learners who used VR gained greater knowledge and understanding of the content taught in class. The study showed the benefit of using digital learning, providing broader knowledge of a particular concept. Virtual experience could be said to substantiate Vygotsky (1962) and Bruner's beliefs (Bruner et al., 1966) that learning depends on social interaction and 'social learning', leading to cognitive development.

Vygotsky (1978) assumed that a child’s development process is independent and separate from that of learning. Zaretskii (2009) expands on Vygotsky’s theory, suggesting that knowledge is acquired and understood due to the expanding zone of actual development. The correlation that VR expanded the actual development zone of actual development was evident when they expressed the experience as pleasant, felt motivated to learn, and mentioned the good quality graphics of the virtual environment and the ease of the user interface (Niţu et al., 2018). Zantua (2017) stated that the learning experiences of Russian Gr 6 learners were improved when VR was used as a learning tool. Furthermore, learners using 3D models on mobile phones (Xiaorong, 2018) demonstrated better understanding and memory retention. Philippe et al. (2020) suggest that there is a consensus that VR may promote activity-based and student-centred learning, as in constructivism, while achieving learner motivation, self-regulation, and self-assessment. The experiential and constructionist theories correlate with constructivist theories of active learning and knowledge construction, as learners experience content through their senses. Further research into the impact of the teaching models used by the teacher when incorporating VR, may reveal more about pedagogical knowledge and decisions (Szabo, 2021).

The learning theories of experiential learning, constructionism, and constructivism interlink with each other, as they describe learning as experiences with the learner as the focus of the interaction. It is often the case that different learning theories prescribe the same instructional methods for the same situations, but with different terminology and possibly with different goals (Harasim, 2017). The teacher incorporates the concepts of theory into teaching practice, which influences how learning occurs. The teacher is the support and guide to learning. VR is one type of resource teachers might consider when designing their teaching experiences for learners.

2.6 VIRTUAL REALITY: INTEGRATION OF VR IN TEACHING

Teachers consider incorporating technology into lessons influenced by their pedagogy. The teachers are influenced by their individual contexts. They identify affordances that are directly related and are very specific to their teaching context and what they want to do with their learners within a lesson (Haines, 2015). They recognise both positive and negative impacts and influences within a lesson. If one translates that into the classroom, the teacher recognises and creates an awareness of opportunities and constraints. The mind map (Figure 3) illustrates the range of positive and negative influences that might be considered when integrating VR into a lesson. The list is not exhaustive as teachers react and decide on the benefits and disadvantages of each learning situation.

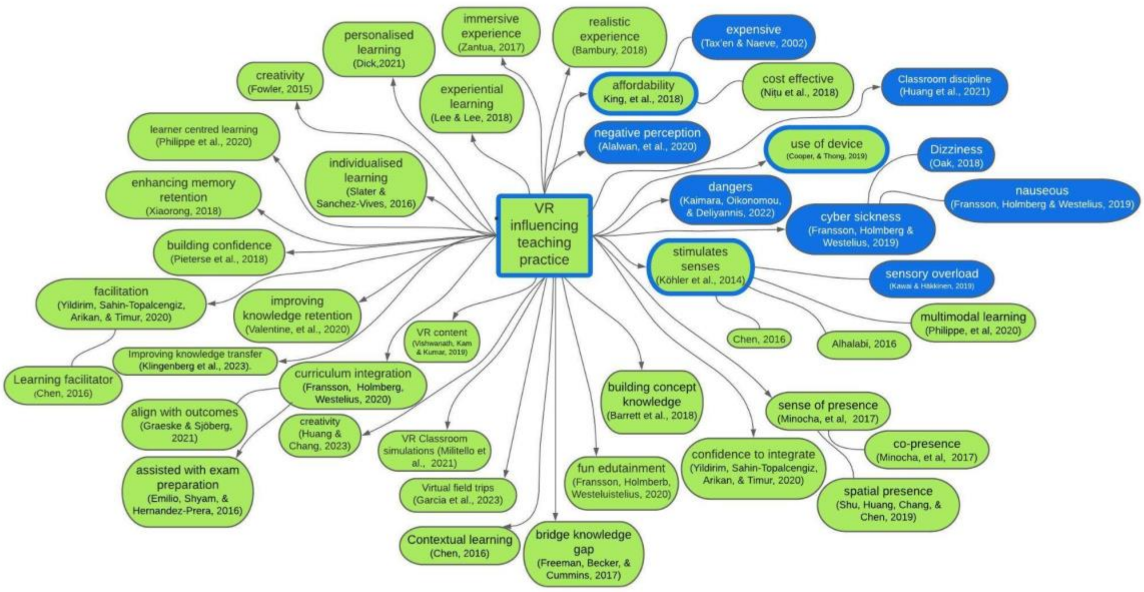

Figure 3: VR influencing teaching practice

Professional development recommendations (Stoddard, 2009; Lugrin et al., 2018) would impact the study by exploring the understanding of a teacher's confidence when implementing new technology, as well as the influence of teacher training on the teacher's behaviour. 'Beliefs play a key role in teachers' classroom practices and their professional development' (Gilakjani & Sabouri, 2017, p. 78). Teachers' perceptions about VR in relation to other teaching resources.

2.6.1 Pre-service and professional training

VR research has spread throughout the training spectrum, from technical training to vocational skills. The benefits of using VR simulations in training situations are when instances are too dangerous, too expensive, or simply unachievable to set in real situations (Mellet-d'Huart, 2009). Integrating sensory prompts into training provides an interactive and more realistic learning experience (Psotka, 1996). VR in industrial training allows learning and performing with simulated hands-on activities in a controlled, safe environment (Renganayagalu et al., 2021). Mellet-d'Huart et al. (2004) conducted a study on vocational training for adults in metal machining where virtual environments were developed, indicating the benefits of learning technical skills virtually. Virtual technologies in training have been validated in medical education in areas such as pain management, neuropsychological assessment, rehabilitation, and therapy due to being accessible, scalable, and affordable (Rudran & Logishetty, 2018). These studies demonstrated the range of skill development training for difficult situations where people's lives are at stake. VR training is also found in industries such as construction (LaPierre, 2018); tourism (Rudran & Logishetty, 2018;) and gaming (King et al., 2018; Renganayagalu et al., 2021). VR is even present in sports training (Renganayagalu et al., 2021). VR training for American football found two significant benefits. Trainees were given the opportunity to continue practising their mental preparedness which effectively and proactively simultaneously, reduced the possibility of injury (Huang et al., 2015). The international interest in virtual technologies for teaching, training, and learning has been ongoing for a few years. These environments empowered students, providing them with simulated environments to practise and learn before progressing to real-life applications, building student confidence in completing the learned skill when performing it in reality. VR training is highly context-dependent, and different activities relate to a specific context in formal and informal learning environments (Mellet-d'Huart, 2009).

Pre-service VR training in education has also been tried. Passig et al. (2001) used a VR simulation for caregivers on a toddler's cognitive and visual viewpoint in the first days of day-care. The findings indicated a better understanding and awareness of the perspective of a toddler by caregivers. Cooper et al. (2019) assessed a VR tool with student teachers to determine whether it would be an effective teaching and learning tool. Pre-service teachers often have difficulty selecting and applying effective classroom management strategies to reduce or prevent disruptive behaviour (Mouw et al., 2020). The VR environment was used to develop classroom management skills and promote teacher resilience (Mouw et al., 2020). Another VR orientation module allowed student-teachers opportunities to learn, practice, and apply their VR skills before being employed as teachers (Yildirim et al., 2020). The pre-service VR training benefited student teachers during their educational studies.

The effectiveness of VR training was reviewed (Renganayagalu et al., 2021) indicating a lack of rigour and experimental robustness, suggesting the need for further studies using VR head-mounted displays in authentic training contexts. Similar scenarios for school education could help to develop a concrete understanding of a concept, investigate the impact of VR on school education, and train educators. Whether students self-learn by using VR technology to re-teach information when it suits them, or to easily focus on areas of concern, exploring the features of virtual environments to either aid or inhibit learning (Chen, 2006). Exploration could investigate teachers' attitudes towards the use of VR technology (Albirini, 2006). Identify the appropriate theories and models to guide the design and development of VR technology (Chen, 2006). A review about VR specifically for teacher development found most of the studies reported positive results regarding the intended programme outcomes, implementation, and measuring effectiveness (Huang, Richter, Kleickmann & Richter, 2021). Virtual field trips may serve as a gateway to engage teachers who are less prone to using technology to develop skills and become more comfortable teaching with it (Stoddard, 2009). Teachers could be inspired and stimulated to try new, creative ideas and explore other teaching and learning options when they begin planning, creating, and designing effective and meaningful learning scenarios with the incorporation and instillation of online technological resources (Goodyear, 2015; McKenney et al., 2015; Rapanta et al., 2020).

A further complexity is that because many teachers taught in pre-internet days (Crouch, 2014), their integration with technology and the technological changes teachers faced (Niţu et al., 2018) were compounded. The impact of modern technologies on educational progress was fundamental for educational change. Technological changes and development meant that 'teachers were faced with an enormous challenge to change' (Niţu et al., 2018, p. 5). During Covid-19, educational environments promoted the use of information technology, which changed learning from passive to active use (Mateen & Kan, 2020; Nesenbergs et al., 2021; Squire, 2021; Xu & Tang, 2021). Many years earlier, Henriques (2002) noted that as teachers saw the value and became comfortable infusing technology to enhance lessons, technology use would become more prevalent across all grades. With this in mind, trained teachers potentially saw the educational value of integrating VR into their lessons (Irwin, 2012; Zantua 2017) and conceptualised the integration of VR into the curriculum (Dahlstrom et al., 2015).

The South African Professional Development Framework for Digital Learning (Digital Learning Framework) document (DBE, 2018, p. 14) identified the collective roles of teachers in schools, including being learning mediators and lifelong learners. The DBE addressed professional development for teachers and suggested transformative pedagogy as one of the premises for the transformation of practice toward digital learning, which focused on learning-centred knowledge building and higher-order thinking skills (DBE, 2018). The impact of successful teacher development was demonstrated by a Myanmar start-up that introduced VR into schools and found that teachers could 'visit' places they had never visited and experience complex scenarios (Xiaorong, 2018). Teachers benefited from using VR as they learned about other places. Their teaching practices changed as they became more learner-centred. This demonstrated that there was value in providing professional development for teachers who may not be comfortable using new technologies with their learners (Stoddard, 2009). The Myanmar project was described as successful because the teachers were willing to learn. Therefore, if teachers are encouraged to be lifelong learners, it is for the benefit of their learners.

Educational technology, such as VR, affects learners by the way technology is used in lessons. Therefore, the value of encouraging teachers to attend educational technology training makes sense and the integration of VR technology into schools in areas (Freeman et al., 2017; Cooper et al., 2019) such as pre-service teacher training and educating learners (Köhler et al., 2014; Alhalabi, 2016; Chen, 2016; Zantua, 2017; Xiaorong, 2018). If teachers were not ahead of the curve in skills and knowledge development to navigate through technologies or technoscapes, it would become increasingly difficult for them to understand and direct learners' learning (Crouch, 2014). Therefore, continuous professional development seemed pertinent. Annually, large sums of money are spent on technology in schools; however, professional development for teachers needs to be included for them to learn how to use the new technologies (Stoddard, 2009). VR professional development for teachers was considered advantageous (Freeman et al., 2017; Xiaorong, 2018; Cooper et al., 2019) for both pre-service and in-service training, especially when they tested and learned how to use technology learning tools (Roy et al., 2017; Lugrin et al., 2018; Seufert et al., 2022). Niţu et al. (2018) expressed that VR technology represented the future of the learning process in terms of learning through experience. Teachers could train themselves or refer to a technology coordinator at the school (Ke et al., 2020). It is important to note that the VR teacher training was not only about professional training, but also about individual teacher growth and learning (Zantua, 2017).

The barrier to implementing VR in lessons illustrates the need for teacher development to use VR technology. Research on the professional development of teachers in VR would be beneficial, as these sessions help reduce negative preconceived perceptions (Alalwan et al., 2020) and highlight the value of using VR technology in lessons (Stoddard, 2009). Teachers' perceptions of incorporating VR into teaching and learning are not understood (Alalwan et al., 2020). Renganayagalu et al. (2021) proposed that the pedagogical and interaction aspects between users and the VR application should be carefully considered when adapting training. Any technology-enabled learning initiative, including VR-based resources, can be effective only if educators justify its use to learners and embed the resource within the curriculum context (Tudor et al., 2018). Mikropoulos and Natsis (2011) observed that few of the reviewed studies had a clear pedagogical model to inform the use and design of virtual educational environments. Additionally, there is a limited understanding of how VR technologies might be used to improve learning and teaching in a variety of school subjects. This limited understanding makes it difficult for education policymakers to implement additional measures to address the difficulties associated with the availability of VR equipment and the lack of trained educators (Alalwan et al., 2020). A chicken-and-egg scenario is evident, as an underlying assumption is that if the use of VR by educators across all education sectors grew, then examining how in-service and post-training could be implemented by integrating this technology into their pedagogy would likely interest various stakeholders (Cooper, et al., 2019). The need for teacher development identified the research gap in teachers showing how to use and encourage them to integrate VR technology into their teaching pedagogy.

- Participants working on a VR teaching and learning platform experienced technological and pedagogical difficulties. The scheduled assignments driven by VR were postponed one after another. This was due to the steep learning curve experienced by teachers using the new teaching platform (Melo et al., 2019).
- The Virtual Field Trip Model for the Social Studies study found the need for more teacher education around Virtual Field Trips to help make student learning more authentic and aligned with subject content and disciplines (Stoddard, 2009).
- Tudor et al. (2018) noted that the adoption of mobile VR in schools was still in an early adoption stage. Technological inclusion developed evidence of pedagogical effectiveness.
- Militello et al. (2021) developed a VR tool to assist school leaders in conducting meaningful professional development for teaching staff members.

Alalwana et al. (2020) provided evidence that teachers required training on various educational technology practices, that education departments and schools should offer courses to refine teachers' VR skills and knowledge. Furthermore, information about technology should be presented in a manner that benefits teachers and learners (Alalwana et al., 2020). Peltekova and Stefanova (2016) suggested that teachers should include VR resources in lesson planning rather than just in informal use. There is limited research on the impact of VR on teacher practice and teaching pedagogy. The need for relevant VR professional development to build teacher confidence and to promote the usage of VR technology, teacher development seems necessary.

2.6.2 Teaching frameworks for VR integration

Teaching frameworks help teachers consider 'the emergent and changing nature of digital technologies and their influence on the practice of learning and teaching' (DBE, 2018). Therefore, exploring the potential connections that teaching theories provide for technology integration, particularly VR, is advantageous. Classroom practices of teachers are also influenced by affordances (Gibson, 2013). The DBE (2017) Professional Development Framework for Digital Learning[7], in alignment with the National Development Plan, promotes the United Nations Sustainable Development Goal (SDG) Four to 'Ensure inclusive and quality education for all and promote lifelong learning' (United Nations Development Programme [UNDP], 2022).

The affordances recognised and created an awareness of opportunities and constraints (Hammond, 2010). Integrating technological resources into lessons requires an understanding of technology and the knowledge of the subject. Exploration and knowledge of technological resources by teachers to establish which VR scenarios are better suited for particular learning tasks was valuable, as each technology contained differing foci, tendencies, and constraints (Mishra & Koehler, 2006). The Digital Learning Framework (DBE, 2018) described the digital

[7] In 2017 the South African Department of Education, released the Professional Development Framework for Digital Learning (Digital Learning Framework) to assist organisations conducting teacher professional development, and individual teachers on their own learning paths.

learning competencies teachers should acquire, related to professional growth, curriculum focus and leadership. Teachers are expected to apply digital literacy skills and integrate it into the curriculum developing specific educational knowledge (DBE, 2018). The benefits of professional development were highlighted by Irwin (2012), where teachers participated in 2D simulation professional development courses to improve their ability to incorporate technology into their lessons. The findings suggested that the participants significantly improved their ability to incorporate technology into their lesson plans (Irwin 2012). Stoddard (2009) found the need for continuous professional development of teachers around virtual resources to help make student learning more authentic and aligned with subject content and disciplines. This demonstrated the benefit of professional development sessions as a combination of pedagogical (how I will teach), content (what I will teach) and technological (digital resources I will use) knowledge (Mishra & Koehler, 2006). This is reiterated in the DBE's (2018) professional development framework. Renganayagalu et al. (2021) proposed that pedagogical and interaction aspects between users and the VR application should be carefully considered when planning. Any technology-enabled learning initiative, including VR-based resources, can be effective only if educators justify the use to learners and embed the resource within the curriculum context (Tudor et al., 2018). Mikropoulos and Natsis (2011) observed that few reviewed studies had a clear pedagogical model to inform the use and design of virtual educational environments. Detail planning and thoughtful consideration should be considered when planning a lesson using VR. Two frameworks are considered for possible VR integration interventions:

- TPACK framework (Mishra & Koehler, 2006)
- SAMR (Puentedura, 2006)

Empowering teachers to think holistically when planning, conducting lessons, and incorporating VR-placed experiential education (Cheng & Tsai, 2019), is beneficial to learners who could be exposed to complex, real-world problems as part of everyday lessons. The implication of the study would be to identify if there is a correlation between the professional development of teachers and the implementation of the lesson.

2.6.2.1 TPACK

The technological, pedagogical, and content knowledge model (TPACK) (Koehler & Mishra, 2009) provided a framework to integrate technology, pedagogy, and content knowledge into teaching practice. Effectively integrating technology into educational environments, teachers need to become proficient in each of the knowledge areas of the TPACK model (Mishra & Koehler, 2006), and in the areas interconnected when teaching and integrating VR into lessons (Crouch, 2014). Teachers needed to know their subject material and understand technology when developing learning materials to benefit their learners (Meyer et al., 2019). Teachers explored new technologies using TPACK as a self-development tool (Asad et al., 2021), where VR was considered advantageous as a pedagogical tool in teaching and learning. Teachers who led through innovation demonstrated ways VR could impact pedagogy (Cooper et al., 2019). Integration and inclusion of technology in the lessons is complex. Teachers must explore and experience various technologies to realise that some technologies are better suited for specific learning tasks as they have their affordances, tendencies, and constraints (Mishra & Koehler, 2006).

The merging of pedagogy and technology within lesson planning would provide solid reasoning for including VR in the school education system (Jowallah et al., 2018). The TPACK framework (Koehler & Mishra, 2009) addressed these queries. Within the study, teachers would need to consider their teaching context, which models would best suit their learning environment, and the content of the lesson when planning lessons that integrate technology.

2.6.2.2 SAMR

‘My fear would be that I am inexperienced in using VR, and I think it would be hard to manage or control in a classroom,’ a teacher participant in the VR classroom research (Cooper et al., 2019, p. 7). Puentedura’s Substitution, Augmentation, Modification and Redefinition (SAMR) model (Hamilton et al., 2016) provides a framework for teachers to investigate and incorporate technology into their learning practices to eliminate fear.

This model (Puentedura, 2006) is represented as a model of teacher learning and professional development, encouraging teachers to integrate technology as a learning tool (Hamilton et al., 2016). Johnson (2019) explains how her learners moved from the substitution stage of viewing VR experiences all through to the modification stage of SAMR, as they developed and created their own VR resources related to the subject content. Teachers explored the integration of technology into their teaching using Puentedura's (2006) SAMR model. Salakas (2017) highlights the fact that VR technology does not produce a quality lesson, although it rates well with the SAMR model of tech integration, rather the pedagogy makes the difference. In relation to the study, the observed lessons will be interpreted to determine whether VR inclusion improved the lesson, which helped to produce a quality lesson as Salakas (2017).

Evidence that teachers lack practice in mastering VR technology reflects that teachers should be updated and trained on various educational technology practices. Additionally, this implies that education departments and schools must offer more related professional development to inform and refine VR skills and teacher knowledge (Alalwan et al., 2020). Providing instructional design guidelines in VR is the most important to ensure their usability in the education system (Alalwan et al., 2020). The study would add information on how VR is implemented by teachers within their teaching contexts.

The teaching frameworks of TPACK and SAMR provide teachers with guidance. The relevance of teaching frameworks provides teachers with the link uniting and connecting the appreciation that teachers have about teaching and their teaching behaviour (Béchard & Grégoire, 2005). Teachers' behaviours are influenced by the affordances (Gibson, 2013) that they take into their classrooms and teaching environments. These behaviours are used when teachers are integrating technology and establishing whether the technology is beneficial to use in a lesson.

2.6.3 Virtual Reality as a transformative teaching approach

'Transformational teaching involves creating dynamic relationships between teachers, students, and a shared body of knowledge to promote student learning and personal growth' (Slavich & Zimbardo, 2012, p. 1). VR has been described as having the potential to revolutionise education (Gadelha, 2018). As a transformative resource (Cooper & Thong, 2018; Asad et al, 2021), VR was highlighted as a technology likely to be included in the general education system as a bridge to close the gap for learners from disadvantaged social circumstances (Freeman et al., 2017). Therefore, developing an understanding of and creating awareness of situations learners would not normally have had the opportunity to experience or perhaps not understand due to limited background knowledge. Madrigal et al. (2016) found that VR technology benefited learners in their examination preparation. Dreimane (2020) expressed that introducing VR into the learning process was beneficial, as learning objectives and strategies need not be changed while assisting learners to achieve objectives, deepen understanding, and speed up the learning process. Cooper et al. (2019) described how VR scenarios and platforms could potentially act as transformative educational tools by bridging learning gaps.

Mobile VR devices regularly involve different inputs to interact with and explore the virtual environment (Cooper & Thong, 2018). The four walls of the classroom disappeared, and the students entered a multisensory, immersion VR learning space (Cooper et al., 2019). VR transformed learning into a fun and interesting task (Zantua, 2017). In a maths lesson, students were transported to the interactive geometrical entities activity in VR where they manipulated, rotated, and translated the shapes' entities (Taxén & Naeve, 2002). These VR activities increased cognitive contact with mathematical formulae (Taxén & Naeve, 2002). VR dental simulators are considered an 'essential part of modern education' (Roy et al., 2017, p. 46) and should be used to augment and enhance teaching strategies within the pre-clinical dental education framework. Lessons integrating VR, thereby impacting both teaching and learning.

Teaching strategies that incorporate multimodal VR scenarios as a learning resource were suggested to transform the way teaching and learning was conducted (Philippe et al., 2020). The VR tools allowed learning to progress beyond the standard forms of written and spoken language (Jewitt, 2008; Philippe et al., 2020). Immersive VR systems had the potential to create a lived experience (Sinha et al.,

2012) within a lesson as a teaching resource. Studies on learning about empathy using VR technology saw a benefit for learners (Bertrand et al., 2018). Virtual materials provided opportunities for teachers to expose learners to a ‘variety of simulations and scenarios from different perspectives’ (Bonasio, 2019). VR technology could transform teaching pedagogy in an unimaginable way (Cooper et al., 2019). Papert (1980) and Rautiainen, Head of Innovation Unit at the Finnish National Agency for Education (Google for Education, 2019) suggested that educational change required a review of the pedagogy and teaching strategies of how technology was used in learning. Lessons incorporating pedagogical possibilities when integrating VR as a learning tool were described as encouraging (Anderson & Rainie, 2018; Sanchez-Cabrero et al., 2019; Yildirim et al., 2019).

Teachers select resources and ask questions when planning their lessons, VR enhances existing teaching material (Madrigal et al., 2016; Dick, 2021); users of virtual laboratories (Wästberg et al., 2019) achieved most of the intended learning outcomes. Teachers should recognise that virtual tools might require an explanation and support materials. The incorporation and training of VR has been validated in medical education, in areas such as pain management, neuropsychological assessment, rehabilitation, and therapy because it is accessible, scalable, and affordable (Górski et al., 2016; Rudran & Logishetty, 2018). These studies emphasised the use of virtual technologies to improve the quality of existing teaching methods and strategies by providing an additional resource to what is being used.

The transformative teaching approach (Slavich & Zimbardo, 2012) was described as a combination of Paiget's constructivism, in which learning took place when learners were actively engaged in a discovery process (Piaget, 1964), as well as Vygotsky’s social constructivism, in which educational activities were more impactful when learning involved social interaction (Vygotsky, 1986). The outlined approach created dynamic relationships between teachers, learners, and content knowledge (Madrigal et al., 2016) to promote learning and personal growth of the learner (Slavich & Zimbardo, 2012). The DBE Professional Development Framework for Digital Learning (2018) described the lifelong learning journey of professional development for teachers. It suggested transformative pedagogy as one of the premises regarding the transformation of practice toward digital learning, which focused on learner-centred knowledge building and higher order thinking skills (DBE, 2018). The intention was to enhance the opportunities offered by digital tools and resources to support and have an impact on learning (Ng'ambi, 2013). Exploring and investing in technologies around us, many schools want to be on the cutting edge of technological advantage (Dean & Forray, 2018) for their learners. Papert (1980) believed that using technology in the learning environment assisted in modifying teaching and learning and was adapted by transformation. Teachers' attitudes change when their learners succeed. The VR excursions related to classroom lessons for Gr. R-12 learners that were observed while engaging and interacting with the VR content (Roussou, 2004; Loke, 2015; Vishwanath et al., 2017; Craddock, 2018). Traditional teaching changed as learners using VR in lessons outperformed those who did not access VR content (Zantua, 2017). Learners were more motivated than in a traditional teaching setting when VR was incorporated into VR lessons (Makransky & Lilleholt, 2018; Shi et al., 2019; di Lanzo et al., 2020). The VR integrated in the lessons showed evidence of building the context knowledge of the learners through exposure to real-world situations (Kersten et al., 2017; Lee & Lee, 2018). Incorporating VR material into lessons in a manner that is pedagogically impactful continues to be challenging (Jowallah et al., 2018). VR is a beneficial teaching resource (Nesenbergs et al., 2021), which should be included in lesson plans, instead of just using it informally (Peltekova & Stefanova, 2016). Teachers must lead innovative ways VR could impact pedagogy (Cooper et al., 2019).

VR is a pedagogical tool for strengthening students' experiential learning (Asad, et al., 2021). Incorporating new technologies, including VR, should be pedagogically beneficial, related to lesson plans and learning outcomes, and provide a positive learning experience for learners (Nesenbergs et al., 2021).

The influence of VR on teaching practices, exploring how best VR has been conceptualised into a lesson (Dahlstrom et al., 2015). The exploration journey begins. The teachers' affordances with VR and their beliefs and attitudes to integrate

VR into lessons demonstrate the opportunities and challenges to consider in the teaching environment. Researchers (Bonasio, 2019; Alalwan et al., 2020) continued to see the benefit of using VR in education; however, a lack of data and peer-reviewed literature supports its use in educational contexts. The need to investigate teachers' attitudes toward the use of VR technology (Albirini, 2006), or identify the appropriate theories and/or models to guide the design and development of VR technologies (Chen, 2006) is not new. However, there is limited understanding of how VR technologies could be used to improve learning and teaching in a variety of school subjects (Alalwan et al., 2020). This study would contribute to existing knowledge on how teachers integrate VR resources in a range of primary school subjects.

2.7 VIRTUAL REALITY AND ITS INFLUENCE ON LEARNING

VR is slowly infiltrating teaching and learning. Numerous studies illustrate how VR is used in many training and education fields; engineering education (di Lanzo et al., 2020), mining safety (Squelch, 2001), military training (Youngblut, 1998), medical school and health care interventions (Pieterse et al., 2018), tourism (Yung & Khoo-Lattimore, 2017), geosciences and oceanography (Winn et al., 2005). VR was used to enhance teaching and learning. These studies identified benefits, limitations, and suggested improvements. The value of exposing and training teachers in VR would reveal opportunities for inclusion in their lessons (Alhalabi, 2016; Freeman et al., 2017; Cooper et al., 2019) and broadening the general knowledge of teachers (Xiaorong, 2018).

The boom of education technology (Pommerening, 2021), increased incorporation of digital technologies within education, with VR as one of the technologies (Aji & Khan, 2021). Increased access to mobile devices and the growth of VR technology have globally resulted in the incorporation of VR educational technology in various fields (Gadelha, 2018; Cooper et al., 2019). Learners are surrounded by technology. Rothwell (2008) described people born from the mid-1990s to the present as having grown up on the World Wide Web in a digital age. Pollock and Pollock (2011) saw these people as being shaped by technology from birth. The learners now have greater access to VR technology (Alexander, 2018). Studies across the educational spectrum have indicated the value of using VR in educational scenarios from primary school (Pilgrim & Pilgrim, 2016) to university training courses (Tanner et al., 2016; di Lanzo et al., 2020). Teachers decide whether technology is included (or not) in their teaching practices (Shaw et al., 2020). The incorporation of educational technology in the form of VR in lessons was identified to impact the learning experience of learners. Investigations of the impact and effect of VR on learners in the school context are prevalent (Pilgrim & Pilgrim, 2016; Vishwanath et al., 2017; Craddock, 2018). Xiaorong (2018) showed the benefit of 3D learning applications for learners with a shortage of teachers, such as those who live in remote areas.

Virtual classroom experiences were effective in building conceptual knowledge and improving student knowledge retention (Laseinde et al., 2015; Barrett et al., 2018; di Lanzo et al., 2020). Virtual technology could be a tool to increase the understanding of information, creating awareness and realistic experience in situations or context learners (Ozdemir & Ozturk, 2022) may not know of or cannot experience, for instance, being on a battlefield (Craddock, 2018), exploring internal organs (Lee & Wong, 2014), or investigating parts of the world they cannot visit (Tudor et al., 2018). A benefit of VR for learners is that it improves the understanding of abstract or complex concepts (Hwang & Hu, 2013; Fernandez, 2017; Yang et al., 2020). VR stimulates students' senses (Alhalabi, 2016; Chen, 2016) assisting in building their knowledge, improving memory retention (Sinha et al., 2012; Xiaorong, 2018), increasing their transfer of knowledge (Klingenberg et al., 2023) and bolstering confidence (Madrigal et al., 2016; Pieterse et al., 2018). Learners using VR tools learn by means of 'reflection, verbal interactions, mental operations (e.g., decision-making), and vicarious experiences' (Loke, 2015, p. 119), knowing this would assist teachers when deciding which VR resources to use in their lessons (Loke, 2015). These studies demonstrate the potential value of using VR in the classroom from the learner's point of view while also having the potential to benefit the teacher's teaching practice.

VR is considered an educational technology that drives learning to be immersive (Zantua, 2017), with greater experiential and equitable learning (Zantua, 2017; Dick, 2021). It helps to increase the motivation and enjoyment of learners in lessons, compared to traditional lessons (Dalgarno & Lee, 2009; Akman & Çakır, 2023). However, VR has been found to be an essential pedagogical tool to strengthen student experiential learning (Asad, et al., 2021). The VR experiential learning bridged virtual fieldwork with physical field trips (Minocha et al., 2017). Creating the potential to change the way people react to and remember information (Laseinde et al., 2015; Barrett et al., 2018). Having the prospect of helping teachers provide personalised and individualised learning (Dick, 2021) for each student. Investigations of the impact and effect of VR on learners in the school context are prevalent (Köhler et al., 2014; Alhalabi, 2016; Xiaorong, 2018; Cheng & Tsai, 2019). Therefore, VR is seen to influence change as a transformative educational tool (Cooper & Thong, 2019; Asad et al., 2021). Revealing the affect VR has on the learning of learners (Laseinde et al., 2015; Tanner et al., 2016; Barrett et al., 2018; di Lanzo et al., 2020).

Incorporation of VR in problem-solving contexts effectively improved the group work skills of learners and encouraged self-regulated learning (Abdullah et al. 2019). VR provides opportunities for differentiated learning to occur, taking learners beyond the classroom, experiencing, and travelling to unknown places and around the world (Johnson, 2019). Assisted learners to engage in virtual environments, experiencing the sense of presence (Shu et al., 2019) and enhancing experiential learning.

Teachers with limited technology resources or favouring a group work approach were able to integrate the technology as a group rotation model (Horn & Staker, 2017). This small group model would be useful with limited VR devices, when investigating the pedagogical teaching and learning strategy. The configuration consisted of four stations or areas of learning. VR was shown to be an effective learning tool to improve group work and self-regulated learning within a problem-based scenario (Abdullah et al., 2019). The effective use of limited resources and the demonstration of the benefits of using VR collaboratively in a pair or small group (Craddock, 2018), encouraging a deeper learning experience (Craddock, 2018; Schott & Marshall, 2020). In pairs, learners took turns using the VR headset and engaging with the partner who was wearing and using the headset. The learner who used the headset described what they saw. The peer would record notes and observations. The benefit was that more learners had the opportunity to use VR, and notes could be taken while using the device. Sharing the headset encouraged the person within the VR space to be more observant and to engage with the details with more care, which could deepen their learning experience. Encouraging learners to think about the task at hand and ask relevant questions is easily made possible by this approach to learning. The use of technology is a tool, the questions teachers ask, and the questions students ask, have an impact on learning. Jurik et al. (2014) investigated the cognitive learning activity of students and intrinsic learning motivation and showed that students' learning, participation, and motivation were positively impacted by teachers using deep reasoning questions and providing regular feedback. When using technology, this needs to be considered; it is not just using the technology, but asking questions related to content or context, which makes the activity a meaningful learning experience. The small group learning task (Craddock, 2018) sharing VR could be used to encourage analytical questioning.

The introduction and investments of visual technology into the school environment are ongoing (Reedy, 2008), beginning with overhead projectors and data projectors. Education and schooling are on the cusp of evolving exponentially, as learners can be more realistically immersed in a learning experience with VR than with any other technology (Gadelha, 2018). Despite the evidence of the value of educational technology, South African schools still make limited use of the technology (Munje & Jita, 2020; Torres & Giddy, 2020). This lack of ICT resources causes frustration among learners, preventing them from benefiting from introducing ICT into the classroom (Munje & Jita, 2020). On top of that, professional development for teachers is often lacking, especially in educational technology (Torres & Giddy, 2020).

The challenges when considering VR in educational contexts are numerous; with complicated logistics, budgets, time constraints, and planning (Graeske & Sjöberg, 2021). The affordability of virtual technology has been questioned; however, taking learners on excursions is often considered costly. The replacement of physical activity with a VR experience has been described as affordable. In the early 2000s, fully immersive VR systems were found to be unsuitable and difficult to use for many learners due to their being expensive and cumbersome (Taxèn & Naeve, 2002), while the technology may not be implemented due to budget constraints (Jowallah et al., 2018). Technological developments in commercially available VR headsets made it more affordable, scalable, and accessible in medical education (Rudran & Logishetty, 2018). As the technology developed, these VR disadvantages (Yildirim et al., 2019) were overcome in the 2010s, becoming less expensive, creating an environment for VR to be implemented in classrooms (Jung et al., 2016). These low-cost VR systems assisted in the integration of virtual resources into schools (Seufert et al., 2022). In recent years, the attitude has changed as teachers and universities involved in using VR interactions found it cost-effective and more affordable (Niţu et al., 2018) than taking students to real situations. The feasibility of VR in educational settings has been driven by the increased affordability of headsets and applications (Brown & Green, 2016; King et al., 2018). Google Cardboard was a low-cost accessible version of VR (Parmaxi et al., 2017; Niţu et al., 2018) to use in the classroom, enabling learners and teachers to extend the borders of the classroom by making virtual walkthroughs in places that would normally be unreachable.

The dangers and risks associated with VR use (Kaimara et al., 2022), and the negative perception of teachers about the use of VR in lessons (Alalwan et al., 2020) are observed. There is also a security risk associated with mobile phones and charging stations. Primary schools encourage parents to allow learners to bring their mobile phones to school for learning. Learners who do not have devices or whose parents disagree would be at a disadvantage. School leadership could inform parents about the advantages (Alalwan et al., 2020). Then it is time-consuming to find the relevant VR experience or scenario the teacher requires for the topic. These negative influences may deter the teacher from wanting to investigate using VR even with the knowledge of the potential positive impacts on the teacher's students.

The feasibility and easier access to VR experiences in educational settings has been driven by the greater affordability of mobile phone headsets and applications (Brown & Green, 2016; King et al., 2018). However, there are limitations compared to the head-tracking capabilities of higher-end devices such as the HTC Vive or

Oculus Rift (Melo et al., 2019). This may also cause teachers to be cautious and not use technology. From another point of view, these low-cost VR devices can be used to bring an immersive and realistic learning environment to learners in traditional classrooms (Ray & Deb, 2016).

The adoption of VR technology in schools is still in its infancy (Alalwan et al., 2020). There are many varying types of virtual technologies that could be incorporated into a school. Teachers should consider the positive and negative impacts and effects of a resource before including it in lessons. 'The development will progress and mature as the evidence based on the pedagogical effectiveness of these technologies grows' (Tudor et al., 2018, p. 34). While Li et al. (2020) are asking for further exploration into how one delivers the necessary knowledge in virtual environments so that the learners further develop their own intercultural skills.

2.7.1 Influence of VR on engagement, confidence, and enthusiasm

Effective lesson integration of VR in lessons has the potential to empower students and improve their confidence in performing a task when performing in real life. This is demonstrated by the research of Madrigal et al. (2016) and Li et al. (2022), which showed that the students gained greater confidence and knowledge while expressing enthusiasm for content knowledge when using 3D technology. Roussou (2004) reports that VR can positively stimulate interaction when virtual environments are used for learning and doing. Learners had a sense of presence in the VR context and paid more attention to the task (Shu et al., 2019). They were engaged. Pieterse et al. (2018) substantiated the evidence of building learner confidence when using VR technology in the interactive VR operating theatre, via the surgeon's transplantation headcam. In pilot studies, medical students, and surgical residents self-reported that watching 360° videos was an inspiring experience and that self-efficacy improved. They felt better prepared for entering the operating theatre in real life. Learners exposed to a VR earthquake helped prepare them to cope, as they were immersed and felt a spatial presence in the context (Shu et al., 2019).

Virtual spaces effectively support decision-making, interaction, experiential learning (Loke, 2015), and building learners' confidence. Madrigal et al. (2016) reported that medical students felt more engaged than while watching a normal video and were confident that it improved their learning outcomes. The students were not disengaged; they were involved and felt their confidence developed. Although these were university students, this was also demonstrated in schools. The reviewed studies of courses that incorporated VR showed an increase in student engagement or performance, especially in the courses that were well designed (Nesenbergs et al., 2021). The teachers had an accurate understanding of how to use the benefits of VR for learning and as an effective resource and tool within the learning area (Niţu et al., 2018; Nesenbergs, et al., 2021). The key learning features of the VR experience were seen as the interactivity and immersion of the learners (Niţu et al., 2018). These studies demonstrate the influence of VR in building learners' confidence, enthusiasm, and active engagement in learning.

2.7.2 Memory retention

The ability to remember or recall information over a period is called memory retention (Macmillan Dictionary, n.d.). Educational studies indicated that VR improved skill proficiency, assessment results, and memory retention within teaching and learning contexts (Krokos et al., 2018). It was observed to improve learners' ability to remember and recall content (Xiaorong, 2018). VR significantly affected long-term memory retention, with learners scoring higher and remembering information better (Yildirim et al., 2019). Learners participating in a cognitive learning activity showed intrinsic learning motivation and involvement by teachers using deep reasoning questions and providing regular feedback (Jurik et al., 2014). Research conducted using an immersive VR system for earthquake disaster simulation (Sinha et al., 2012) demonstrated how the technology enhanced traditional training because the VR 'live' experience created a lasting impact on the viewers' minds. There is value in incorporating VR into lessons with evidence of improved memory retention and content proficiency (Lee & Lee, 2018). The positive investigation of VR surgical simulation training promoted mentor-free self-learning, illustrated the use of virtual mentoring to help trainees improve task performance, and reduced the number of repeated errors (Lee & Lee, 2018). When teaching, assisting learners remember the information being taught and reducing the number of errors is valuable. However, evidence of improved memory retention has been demonstrated when using VR devices, but this is not evident in all cases.

Varying results have been deduced. The benefits of incorporating VR as an active learning technology are supported by the findings of the interaction and active learning of learners (Markant et al., 2016). Suggesting the experience can lead to better learning outcomes than relatively passive forms of instruction. Yildirim et al. (2019) observed that VR and 2D video technologies had similar effects and results on short-term retention but found VR to be a highly motivating and entertaining learning experience which produced significant positive effects on learning performance in long-term memory retention. Conversely, the inclusion of VR in the act of learning, significantly affected short-term memory retention and did not affect long-term retention (Smith et al., 2016). Incorporating immersive VR into lessons led to a higher cognitive load (measured using EEG), noting higher levels of presence but less learning (Makransky et al., 2018).

Jensen and Konradsen (2018) found limited effectiveness of head mounted VR devices in acquiring cognitive, psychomotor, and affective skills compared to non-immersive technologies. Research using ‘Virtual Technical Trainer’ (VTT) on vocational training for adults in the field of Metal Machining identified a pedagogical problem in that the simulators were not designed to assist learners to critically think to solve complex problems, nor to support learners who had learning difficulties. (Mellet-d’Huart et al., 2004). The VTT was not designed to solve pedagogical problems to support learners. The study showed the benefit of learning technical skills virtually but highlighted the need to incorporate more complex thinking tasks to extend learners, as well as tasks to assist learners who had difficulty understanding a task. A similar virtual training programme in the South African mining sector explored methods for teaching mining safety by applying and evaluating the learned safety principles in dangerous mining conditions (Squelch, 2001). The educational VR technology should not just have been a tool for consuming content and information, by asking deep reasoning questions and providing regular feedback, to students could be extended, and the learning could have a greater impact.

Conclusive evidence is still required as to whether VR improves memory retention. However, numerous findings demonstrated a positive effect on learners on their results and attitude toward studies. As illustrated by the no significant difference phenomenon (Russell, 2001), which addresses the idea that the educational focus should not only be on the results, but also on the other enhancements which the incorporation of technology allows. Meyer et al. (2019) suggested that the specific affordances of VR media and the factors that influence learning should be considered when designing learning content for immersive VR.

2.7.3 Academic performance

The effectiveness of VR on academic performance is varied; some describe it as making learning more effective (Li et al., 2020) or not showing academic improvement (Smith et al., 2016; Klingenberg et al., 2022). Bricken (1990) described how the future of virtual experiences can positively impact learning, encourage individualised learning, affective education, active construction of learning, and the use of constructivism. An example of this is the study in which two groups of learners were taught the same content using a VR experience or a textbook. The VR learners remembered the information better, however, there was no difference regarding understanding the work between the two groups (Allcoat & von Mühlenen, 2018). The oceanography study compared the impact of learning by students who used the Virtual Puget Sound (VPS) with those who had the actual learning experience at sea (Winn et al., 2005). It was found that learners who used the virtual experience gained greater knowledge of the content and developed a better understanding of the physical processes of the entire tidal cycle (Winn et al., 2005). VR was identified by preservice teachers as assisting in building scientific knowledge and concepts (Lin & Sumardani, 2023). In this case, the study showed the benefit of using virtual technology, providing a wider knowledge base of a particular concept within the classroom.

When introducing new technology into a school or subject, it should be pedagogically beneficial for the teacher to see a positive impact on student engagement and learning (Savin-Baden 2010; Nesenbergs et al., 2021) to conceptualise how best to integrate technology into the curriculum (Dahlstrom et al., 2015); thus, helping teachers see the value of incorporating this technology into their lessons. Academic performance is influenced by the learning environment. Evidence suggested that shorter VR resource activities are more effective (Villena-Taranilla et al., 2022). Teachers expose learners to unusual learning contexts using virtual experiences (Karlsson, 2017; Makransky & Lilleholt, 2018; Anderson, 2019; Cheng & Tsai, 2019), providing fun and enjoyable edutainment opportunities (Tokel & İsler, 2015; Sternig et al., 2017; Fransson, et al., 2020; Akman & Çakır, 2023). Virtual scenarios take students to difficult (Quaid, 2015; Freeman et al., 2017) or dangerous places to visit. Learners would be able to experience a fully immersive sensory experience in almost any space imaginable, which may encourage them to engage in deeper learning (Parong & Mayer, 2018). Reducing errors when performing learning tasks (Lee & Lee, 2018), with students appearing more motivated than in traditional lessons (Crouch, 2014; Freina & Ott, 2015; Garris et al., 2002; Ott & Tavella, 2009; Shi et al., 2019; di Lanzo et al., 2020).

VR provided problem solving contexts (Abdullah et al., 2019; Fransson et al., 2020) for lessons. VR experiential affordances are described as more interesting (Dede, 2010) and enjoyable learning experiences (Tokel & İsler, 2015; Sterni et al., 2017; Makransky & Lilleholt, 2018; Burdea & Coiffet, 2003; Fransson et al., 2020) improving the understanding of abstract or complex concepts being taught (Hwang & Hu, 2013). Beneficial for learners in their preparation for exams (Madrigal et al., 2016) by digitally replicating an environment (Lee & Wong, 2014; Makransky & Lilleholt, 2018). VR exposed learners to virtual worlds that they may not normally experience in a classroom (Gadelha, 2018; Quaid, 2015; Anderson, 2019; Cheng & Tsai, 2019) by providing immersive, 'real' experiences based on scenarios (Peltekova & Stefanova, 2016; Zantua, 2017; Ekstrand et al., 2018; Makransky & Lilleholt, 2018; Bonasio, 2019; Fransson et al., 2020). Virtual field trips to real-world contexts (Madrigal et al., 2016; Niţu et al., 2018) or museums (Freeman et al., 2017; Kersten et al., 2017) allowed learners to investigate and explore while developing group work skills.

Integration of technology indicated the building of conceptual knowledge of learners and improved knowledge retention (Laseinde et al., 2015; Tanner et al., 2016; Barrett et al., 2018; Contero et al., 2018; Alison & Hodges, 2000; di Lanzo et al., 2020) and enhanced learner engagement (Zantua, 2017; Craddock, 2018; Parong & Mayer, 2018; Vishwanath et al. 2019). Learners made fewer mistakes (Lee & Lee, 2018) as participants gain knowledge in a virtual rather than an actual physical environment. VR technologies provide teachers with opportunities to share easy and intuitive ways to interact with multimedia lessons with their learners and motivated learning (Garris, et al., 2002; Ott & Tavella, 2009; Crouch, 2014; Shi et al., 2019; di Lanzo et al., 2020). The findings of the Narrative, Immersive, Constructionist, and Collaborative Environments for Learning (NICE) project showed that VR experiences could not substitute real-world experiences. However, it provided beneficial and rewarding learning environments for unusual or difficult learning situations and experiences, such as watching the roots of a plant grow (Roussou, 2004). Providing students with opportunities to build knowledge in a realistic environment helps to develop greater understanding. However, there is still a gap between claims of the usefulness of VR in academic learning and scientific research that tests these claims (Parong & Mayer, 2018).

The results and proficiency outcomes, the formulation of quality learning outcomes, are the foundation of a quality learning experience that incorporates the use of technology (Jowallah et al., 2018). The improved results of the students using VR were not evident in all studies. It was found that learners who used the VR experience gained greater knowledge of the content taught and developed a better understanding of the physical processes (Winn et al., 2005) and improved memory recall (Krokos et al., 2008). Brom et al. (2017) and Li et al. (2020) indicated that the motivation of learners for the virtual experience may positively affect learning outcomes, while simultaneously perceived enjoyment can negatively affect learning outcomes. As positive feelings can increase cognitive activation, at the same time, they can be a distraction (Brom et al., 2017) in lessons.

Contero et al. (2018) found that high school learners who had used immersive VR performed better on both the multichoice questionnaire (MCQ) and a knowledge retention quiz when conducted a week later than learners who used tablets to learn content. The technical graphic images used in the engineering education course's VR content created greater accuracy in transferring technical information to students (Alhalabi, 2016). While the Samsung Electronics and GfK survey conducted in 2016 showed the value of VR and AR in education (Dick, 2021), in which 1,000 US teachers participated. Teachers indicated that these technologies could improve learning outcomes (83%) and that their students would be excited about AR and VR in lessons (93%).

Using VR experiences led to greatly improved student results in the engineering course (Alhalabi, 2016). Additional involvement by students in the virtual environment was exhibited as they achieved academic success. VR in surgical simulation training promoted mentor-free self-learning (Lee & Lee, 2018), assisted trainees in improving task performance and reduced the number of repeated errors. The students developed proficiency in skills using technology. Many factors influence how immersive VR leads to educational outcomes (Makransky & Lilleholt, 2018). In these studies, learners using VR simulations showed greater confidence and improved proficiency and results. Krokos et al. (2008) and Winn et al. (2005) support that using VR experiences in education can improve student achievement and performance, helping to support the educational process, including clarifying abstract symbols.

Not all studies showed positive results. Smith et al. (2018) stated that the use of VR did not indicate a difference in test scores, nor was it found to be a more effective teaching medium. Although Parong and Mayer (2018) found that VR may not be as effective as a teaching and learning tool compared to a conventional PowerPoint lesson if students are cognitively loaded with additional information rather than just focusing on the specific information being taught. Hamilton et al. (2020) found that the adoption of immersive VR as a pedagogical method had learning benefits in around half of the 29 cognitive studies reviewed, especially where 'highly complex or conceptual problems required spatial understanding and visualisation' (p. 26). Klingenberg et al. (2023) found learners in their study did not acquire more factual knowledge, but there was better knowledge transfer. Ostrander et al. (2018) found that immersive VR was no more effective teaching medium than an interactive lecture lesson when teaching introductory concepts of additive manufacturing.

An interesting observation was noted by Greenwald et al. (2018) when comparing the students' results in the 2D and VR experiments. The baseline results were better, while the test scores between the two modalities were not different. However, 'although behavioural metrics in completing exercises gave insight into the learning that took place' (p. 241), Greenwald et al. (2018) expressed that 'naïve interpretations of these metrics could lead to exactly the wrong conclusions' (p. 241). They noted that if they had not included the multiple-choice assessment, they could have described the VR interface as inferior to the 2D activity, as students who used the VR took longer to complete the test activities. Instead, they concluded that the final assessment result need not correlate with the speed of completing the 2D test activities. Students using VR had the advantage of participating in a visual and sensorimotor context and taking a more reflective approach to the learning process. Therefore, even though the test scores were not significantly different, it was observed that VR students reflected more actively on CK when they completed the assessment. This demonstrated the value of VR, not necessarily for marks, but for reflection and a deeper analysis of the content. Similarly, Smith et al. (2018) noted that there were no differences in test results or time to complete the tasks between immersive VR and the other methods used. However, the students enjoyed working in the VR environment and both the students and the lecturers felt learning had occurred, although this was not reflected in the results. Although Parong and Mayer (2018) showed that the VR student group was better engaged, motivated, and interested in the content than the slideshow group, their post-test results were significantly lower.

The findings of Alhalabi (2016) and Ferreira-Cavalcanti et al. (2018) dramatically improved the performance of the students. Krokos et al. (2008) and Winn et al. (2005) support the idea that using VR experiences in education can improve student achievement and performance, helping to support the educational process, including clarifying abstract symbols. Although the results of the VR student group (Parong & Mayer, 2018) were significantly lower, the students were more motivated.

Makransky and Lilleholt (2018) identified two types of VR experiences that impact student satisfaction and perceived learning outcomes. First, VR environments were enjoyable and motivated to play, with a high level of VR usability features, giving students a sense of presence. Second, in VR scenarios, players have a high level of autonomy through a sense of control and active learning. Learners see the cognitive benefits of the VR lesson. Including immersive VR in teaching experiences has the potential to build knowledge, improve student performance, and motivate learners.

The effectiveness of incorporating technology as a learning tool depends on the questions teachers ask and the questions students ask to affect learning. Jurik et al. (2014) investigated the cognitive learning activity of students and intrinsic learning motivation and showed that teachers use deep-reason questions and provide regular feedback, showing that student learning, participation, and motivation were positively impacted by teachers using deep-reason feedback. When using technology, this needs to be considered; it is not just using the technology, but asking questions related to content or context that make the activity a meaningful learning experience. Research using 'Virtual Technical Trainer' (VTT) in vocational training for adults in metal machining identified a pedagogical problem that simulators were not designed to help learners think critically to solve complex problems or to support learners who had learning difficulties (Mellet-d'Huart et al., 2004). The VTT was not designed to solve pedagogical problems to support learners. The study showed the benefit of learning technical skills virtually and demonstrated the need to incorporate more complex thinking tasks to extend learners and tasks to assist learners with difficulty understanding a task. Incorporating VR into problem-based learning with VR allowed students to participate in creating questions and drawing their conclusions (Abdullah et al., 2019).

Using VR technology does not just have to be a tool for consuming content and information; by asking deep reasoning questions and providing regular feedback, students could be extended, and the learning could have a greater impact. The extension questions are most important for encouraging higher-order thinking.

Anderson et al. (2000) adapted Bloom's (Engelhart et al., 1956) taxonomy. Both taxonomies are described as increasing cognitive complexity on a continuum as a cognitive process, from Lower-Order Thinking Skills (LOTS) to Higher-Order Thinking Skills (HOTS), namely, from knowledge and recall to evaluation (Bloom, 1956; Mergel, 1998), or from remembering to create (Anderson et al., 2000). The 'Taxonomy for Learning, Teaching and Assessing' (Anderson et al., 2000) expresses verbs at each taxonomy level, connected to actions related to cognitive processes (Anderson et al., 2000; Wilson, 2006). These actions describe the knowledge and information students are required to construct or acquire (Anderson et al., 2000), encouraging them to engage and answer questions at different levels of thinking. These studies indicate that the use of technology on its own is not the key to learning; rather, the way the technology is used in questions and the time used must be considered when planning a lesson. Mishra and Koehler (2009) argue that technology integration within a lesson is complex. Therefore, the teacher's appreciation of the rich connections of pedagogical content and TK and the 'complex ways in which these are applied in multifaceted and dynamic classroom contexts' (Mishra & Koehler, 2009, p. 67) is relevant for meaningful application. Integrating VR (Alhalabi, 2016; Ferreira-Cavalcanti et al., 2018; Greenwald et al., 2018) and those prospective outcomes are evidence-based teaching practices (Molina et al., 2018) that teachers strive to achieve. The suggestion is to investigate the factors that influence user experience when using different VR technologies or analysing data based on the diversity of gender, age, and cultural background of participants. Assess any possible association of student learning performance and participation in VR-supported instructional contexts (Pellas et al., 2021).

2.7.4 Personalised learning

'Personalised learning is the concept of placing the needs of the individual learner at the heart of education' (Diack, 2004, p. 49). It moves away from the teacher having all knowledge to showing learners how to learn, inspiring curiosity and creativity. Raising educational standards by focusing teaching and learning on the aptitudes and interests of learners (OECD, 2006). Lee et al. (2019) highlighted the importance of empirical research in VR pedagogy, focusing on personalising adaptive, interactive, and immersive systems to support second language learners, thus providing educational equity. The assumption is that learners are individual and unique; therefore, learning should be a personalised and meaningful process (Philippe et al., 2020). Personalised learning content combines methodologies, non-digital tools, and digital tools, with VR being one of the tools available to teachers (Philippe et al., 2020).

Individualised immersive VR allows teachers to explore more personalised learning approaches to accommodate learners' learning styles, speeds, and abilities (Dick, 2021), which accommodate the individual learner's needs (Zimmerman, 2019; Al-Ansi et al., 2023). Learners found the help and advice offered by the personalised educational VR web service system useful (Katsionis & Virvou, 2008). Inclusion of VR in classroom lessons from grade R to grade 12 found that the interaction and participation of learners with educational content increased (Zantua, 2017; Craddock, 2018; Vishwanath et al., 2019).

The senses of sight, hearing, balance, and movement are affected when VR devices are used. Incorporating this type of sensual and multimodal learning (Philippe et al., 2020; Al-Ansi et al., 2023) into the classroom changes how teachers teach, impacts learners' involvement and interaction (Philippe et al., 2020). Virtual scenarios can change how individuals react and think (Slater & Sanchez-Vives, 2016). It has the potential to help teachers provide personalised and individual learning for each student. Not only one's senses, but emotions are also explored using VR. Examples are measuring the emotional characteristics of students (Katsionis & Virvou, 2008), or learning to be empathetic (Bertrand et al., 2018). In the school education environment, VR was considered beneficial in helping personalised and experiential learning (Chen, 2016; Lee & Lee, 2018).

2.7.5 Virtual reality and learning concerns

In a classroom that integrates VR, the advantages can address experiential learning (Asad et al. 2021); bridging virtual fieldwork into physical field trips; and inquiry-based learning (Minocha et al., 2017), as well as the dangers and risks associated with VR (Kaimara et al., 2022), and the negative perception of teachers toward the use of VR in lessons (Alalwan et al., 2020). Fowler (2015) creates an awareness that there may be situations in lessons where VR is integrated, therefore, the technology would remain the same, but the teaching and learning approach changes as the teacher rediscovers pedagogy due to the technology being used and applying it to more traditional face-to-face teaching. Here, the lesson content, learning outcomes, and the method of measuring the outcomes remain the same.

Beginning with teachers, exposing them to more complex scenarios by integrating VR technology into pre-service training (Freeman et al., 2017; Cooper et al., 2019) would broaden their general knowledge and world context, which could affect their pedagogy (Xiaorong, 2018; Mathende, 2021). Freeman et al. (2017) are proponents of integrating VR technology in schools as a part of pre-service teacher training (Cooper et al., 2019), educating teachers and learners about the technology (Alhalabi, 2016; Chen, 2016; Zantua, 2017; Xiaorong, 2018). The value of VR professional development for teachers that demonstrate educational value and relevance to using technology seems essential in building teachers' knowledge of the technological concept.

Teachers must not include VR technology for the novelty effect (Fowler, 2015), ensuring that the resource is aligned with the lesson outcomes. There is evidence of some negative affordances immersive VR technology may place on learners. The results of immersive VR simulation indicate higher negative symptoms of discomfort (Meyer et al., 2019). Learners in immersive VR experienced overload more easily, as their extraneous load is higher due to the increased amount of sensory information, compared to the same lesson in a less immersive format (Meyer et al., 2019). Learners using laboratory simulations led to cognitive overload, which degraded the individual's learning (Meyer et al., 2019). On the other hand, immersive VR results also showed a reduction in cognitive load and a higher memory recall performance than desktop users (Krokos et al., 2018)

Teachers may be reluctant to integrate VR, as learners may experience motion sickness or dizziness during virtual experiences (Fuch, 2017; Makransky & Lilleholt, 2018; Lavoie et al., 2021). The challenge of cybersickness was identified when using HMD VR, as the physical reaction of feeling nauseous or dizziness (Moro et al., 2017; Zantua, 2017; Oak, 2018; Kwon, 2019; Fransson, et al. 2020), due to sensory overload or mismatch (Rebenitsch & Owen 2016; Kawai & Häkkinen, 2018). Experiencing vertigo or nausea can interfere with the student's learning experience, preventing the individual from fully experiencing the simulation (Meyer et al., 2019). Most research on such challenges focuses on adults, although it is reasonable to assume that learners could experience similar effects in K-12 schools, as some studies indicate (Kwon 2019). The quest is to investigate and assess the effects of new technological devices on individuals and to develop a systematic assessment method (Shu et al., 2019). Investigating learning in immersive VR allows students to experience cyber or simulation sickness (Kennedy et al., 1993; Rupp et al., 2019).

Research on teachers' general understanding and perceptions about the suitability of VR technology for teaching and learning is limited and affects decision makers and teachers' decisions to judge whether it is viable, particularly in developing countries. Exposing learners to real-world situations (Nicas & Seetharaman, 2016; Niţu et al., 2018), museums (Kersten et al., 2017; Freeman et al., 2017) suggested that the inclusion and integration of VR technology was expected to be adopted into schools. However, time constraints for teachers have been another concern that prevented them from using VR regularly (Alalwan et al., 2020).

2.8 SUMMARY OF LITERATURE REVIEW

The essence of the study is to elaborate on the educational value of this immersive digital technology. The existing literature on VR in education is discussed in the preceding sections, presenting several limitations that set the foundation for the research questions addressed in this thesis. In this section, I begin by outlining existing limitations and highlighting potential research pathways.

Much of the focus of existing VR research is on pre-service training of teachers (Seufert et al., 2022) and in-service training on the use or evaluation of VR technology (Billingsley et al., 2019). There is a gap in the literature about how the incorporation of VR into lessons impacts the teaching practices of educators. Billingsley et al. (2019) suggested research on the transferability of VR training to the classroom by teachers. This aspect is mentioned in the investigation, as participants had received varying levels of professional development in VR. A lack of peer-reviewed literature on the benefits of VR has been identified in educational contexts (Bonasio, 2019; Alalwan et al., 2020). The significance of this study is to gain insight into the educational value of VR related to practising teachers in their classrooms.

The significance of the correlation between the pedagogical and technological affordances related to VR in teaching and learning is noted by Jowallah, Bennett, and Bastedo (2018) and Szabo (2021). This study would advance this body of knowledge by exploring whether VR scenarios create affordances for the changed pedagogical practices of teachers.

The challenge of achieving an effective integration of technology and classroom teaching practices (Billingsley et al., 2019) related to curriculum content (Padayachee, 2017). It questioned whether current learning outcomes developed from traditional pedagogy could be transferred to a virtual space (Billingsley et al., 2019). This was reiterated by Graeske and Sjöberg (2021), who noted that VR technology had opportunities for education, but must be aligned with the curriculum and specific lesson outcomes. The resulting implications of these recommendations for this study are the exploration of the use of VR in the classroom as an integration of teaching practices within curriculum subjects aligned with relevant outcomes.

Integrating VR technologies to improve teaching and learning within a range of subjects is also identified as a limitation, due to the lack of understanding (Alalwana et al., 2020). The proposed participants teach within primary schools, which implies that they teach a variety of subjects; this would contribute to a limited understanding of technology integration across subject areas.

In addition to the digital knowledge area, a larger sample size was suggested from different regions to gain a better understanding of the challenges and prospects of VR (Alalwana et al., 2020). This is partially addressed in this study, as the focus is also on primary school teachers, but only on a small sample of teachers. Teaching a range of subject areas, not just science teachers, located on a different continent, namely, Africa. Aligned to that is the request from South African researchers (Munje & Jita, 2020) for further research related to ICT, to address educational ICT challenges in the country. This study would add to these areas of knowledge about technology research in the South African context.

The purpose of this study is to add to the body of knowledge about the teaching practices of teachers in relation to the educational value of VR. The gaps addressed whether (1) VR scenarios create affordances for the changed pedagogical practices of teachers, (2) VR in the classroom could be incorporated within curriculum subjects aligned with relevant lesson outcomes, and (3) whether this technology might have a relevant integration across various subject areas. Furthermore, the study would contribute to the limited knowledge areas of technology research of primary school teachers in the South African context.

2.9 RESEARCH HYPOTHESIS

This research hypothesis developed from the literature review, which led to the establishment of the main question and the subquestions of the research.
Virtual reality research has been conducted for numerous years, spread across various industries and organisations, often involving facilities of universities such as training in engineering (di Lanzo et al., 2020), mining (Squelch, 2001), IT systems (Alfalah., 2018); military (Youngblut., 1998), nursing and medical (Dimitropoulos et al., 2007; Falah et al., 2014; Ekstrand et al., 2018; Anbro et al., 2020) and tourism (Guttentag, 2010). Reports on this research provided background context but was not directly relevant to the study.

The researcher's primary area of focus was education, with an initial search for VR information within schooling (Merchant et al., 2014; Mystakidis et al., 2021). Some research exists about VR in higher education (Squelch, 2001, Alfalah., 2018), and many studies report on teachers and VR that involve preservice teachers (Xiaorong, 2018; Cooper et al., 2019; Seufert et al., 2022, Jong, 2022;) as well as their reactions to VR technology products (Billingsley et al., 2019). These studies provided ideas of what could be researched within the schooling sectors. There are reports of studies on schooling (Grade R to Grade 12) for both high school (Huang & Chang, 2023) and primary school (Maher & Buchanan, 2021; Song et al., 2022). Studies in schools suggested that for the integration of VR to be practically implementable (Cooper et al., 2019), one should consider schooling intricacies such as safety, cost and monitoring. It was suggested that VR developments and advancements should be aligned with the key educational theorists, such as Dewey, Vygotsky and Piaget (Jowallah et al., 2018). The importance of linking pedagogy and technology to be really beneficial in the educational context is evident. 'For virtual reality to be successful designers must go back to the basics and develop encounters that make a connection to how young children and adults learn' (Jowallah et al., 2018, p.11). These considerations needed to penetrate the classroom.

Teachers are in the classroom and their perspective is important. K-12 teachers identified various pedagogical possibilities for integrating head-mounted VR resources, such as making teaching more interesting and experience focused, which might assist learners to visualise complex processes (Fransson et al., 2020). Twenty-nine primary school science teachers were interviewed about AR and VR technologies. The evidence indicated a lack of competency, time and limited resources, while suggesting exploratory tasks to be conducted in schools (Alalwan et al., 2020). The authors suggest that if teachers do not feel comfortable using technology, they may also reject using new technologies (Yildirim, et al., 2020). Teachers described VR as enriching the classroom experience (Dick, 2021). Researchers were also urging for VR resources to be aligned with the curriculum and educational outcomes (Graeske & Sjöberg, 2021).

A picture began to form for the researcher; she has taught across the schooling spectrum, but with a keen interest in primary school, that the research should focus on the primary school teacher. This thought was reaffirmed by Maher and Buchanan (2021) who highlighted the fact that there was limited research on the use of VR in a primary school context. Further study was suggested with a larger sample size and in different regions to acquire a better understanding of the prospects and challenges of VR (Alalwan et al., 2020). A knowledge gap emerged in teachers' perspectives regarding the incorporation of VR in their teaching (Albirini, 2006; Alalwan et al., 2020; Li et al., 2023; Garcia et al., 2023; Laine et al, 2023). Al-Ansi et al. (2023) note the lack of research studies exploring the complexity of implementing VR technologies in a learning environment. A study from a South African perspective resonated with the researcher; it highlights the need to address ICT challenges (Munje & Jita, 2020).

Therefore, these questions arose:

'How does the use of Virtual Reality simulation as a technology tool influence teachers' pedagogy?' to the study would attempt to find out how primary school teachers teach using VR from theories to practical ideas, which aligned with Alalwan et al. (2020), Maher and Buchanan (2021), and Jowallah et al. (2018).

The three sub-questions were formulated:

- 'What are the implications of VR simulations for changed pedagogical practices?'
    - VR experiences and pedagogical insights into the use of VR resources in classrooms (Lege & Bonner., 2020) in the South African context (Munje & Jita, 2020).
    - Its suitability for use in different school contexts (Craddock, 2018), and whether it could assist in closing the educational gap for disadvantaged learners (Freeman et al., 2017; Li et al., 2022).
    - Identifying theories and models associated with VR technology (Chen, 2006; Jowallah et al., 2018).
    - Meaningful integration into the curriculum and lesson outcomes (Padayachee, 2017; Billingsley et al., 2019; Graeske & Sjöberg, 2021).

    - Possibilities for VR technology to enhance existing teaching materials (Madrigal et al., 2016; Dick, 2021).

    - Improved VR technology pricing (Radianti et al., 2020).

    - Exploring the use of VR in a range of primary school subjects, not just the sciences (Alalwan et al., 2020; Graeske & Sjöberg, 2021; Villena-Taranilla et al., 2022).

    - A call for more practical teacher training opportunities is regularly raised (Huang, Richter, Kleickmann & Richter, 2021), and the need for professional development in VR (Khukalenko et al., 2022).

- ‘How does the integration of VR simulations influence primary school teachers' classroom practices?’

    - Impact on learners, improvements in learners' recall of information (Barrett et al., 2018; Xiaorong, 2018; Yildirim et al., 2019).

    - Taking learners to new or unusual places (Freeman et al., 2017; Quaid, 2015).

    - The inclusion of VR into lessons seems to have a positive effect in all subjects (Villena-Taranilla et al., 2022).

    - Cybersickness (Mukamal & Lipsky, 2017).

- ‘What are teachers’ beliefs and attitudes about the use of VR as a learning tool for teaching?’

    - Teachers’ levels of confidence and comfort in incorporating technology into teaching practices are affected by teachers’ attitudes (Yildirim et al., 2020).

    - Teachers might be hindered by a lack of knowledge or fear of the technology (Yildirim, et al., 2020).

- Teachers' positive attitudes increased; they felt their status was enhanced because they could promote the incorporation of high-end technology with their schools (Craddock, 2018; Fransson et al., 2020).
- Learner reaction - Immersive technology (Gracia et al., 2023).
- Learners learning easily and interacting within the digital VR environment (Sanchez-Cabrero et al., 2019; Asad et al., 2021).

2.10 CONCEPTUAL FRAMEWORK FOR THIS STUDY

'Virtual reality is a medium. Much like the media of music, painting, and dance, VR can be used for many purposes. A primary purpose for any medium is the communication of ideas' (Craig et al., 2009, p. 33). This conceptual framework addresses how virtual reality can be used as a learning resource to influence teachers' pedagogy? The conceptual framework begins with the assumption that teachers have been trained and exposed to teaching and learning theories, and that these theories influence their beliefs and attitudes. In turn, their beliefs impact their teaching practices. As teachers travel along their teaching journey, they attend further professional development sessions. In relation to how the use of VR resources influences teaching practices is a back-and-forth process. When teachers decide to integrate a technology into a lesson, it impacts their teaching practice and therefore lesson planning and implementation. They decide on how the technology would be integrated into the lesson, as suggested by the SAMR model. During and after the lesson the teachers react to their own observations and the learners' reactions. Depending on the input received, the teachers' beliefs and attitudes may be changed, and in turn their teaching practices may be altered. Figure 4 diagrammatically represents a conceptual framework of the potential process of change.

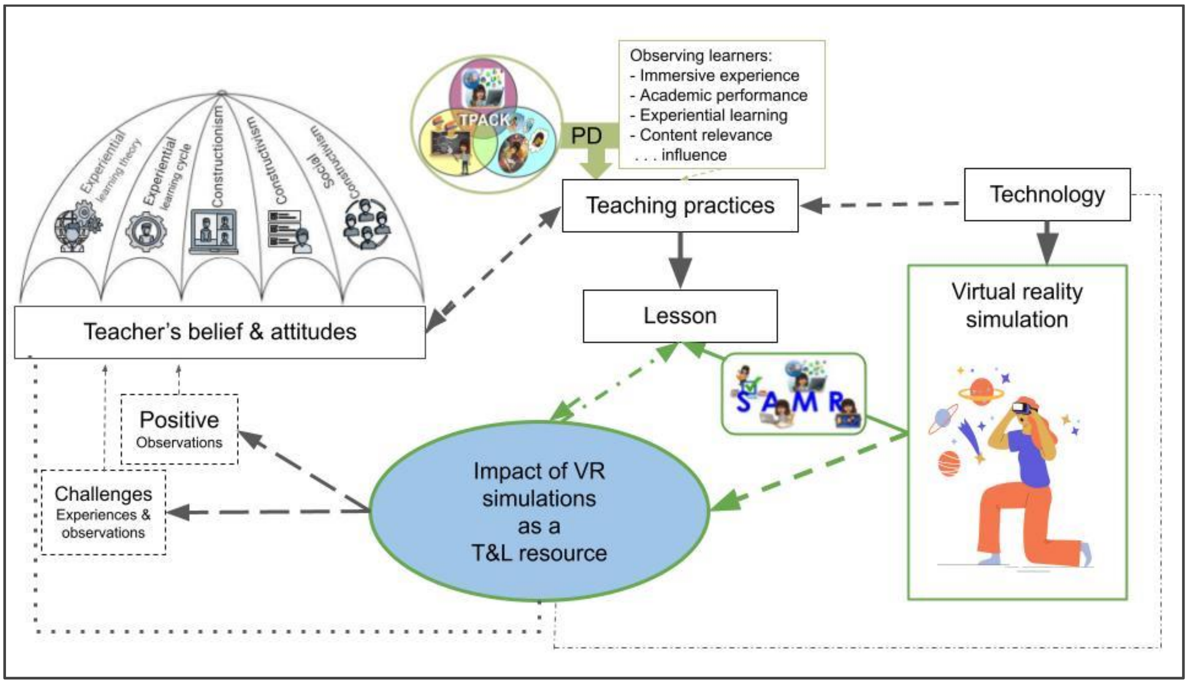

Figure 4: Conceptual framework - how teachers' teaching practices are influenced when using VR resources

The knowledge of learning theories impacts teachers' beliefs and attitudes when planning lessons. Learning theories provide a theoretical context for teachers when integrating technology into lessons. The experiential learning theory (Dewey, 1966), the experiential learning cycle (Kolb & Kolb, 2018), constructionism (Harel & Papert, 1991), and constructivist philosophy (Piaget, 1964; Vygotsky, 1978) are seen as an umbrella of overarching knowledge as teachers amalgamate VR into lessons. Teaching practices are often prescribed by different learning theories for similar situations, although with different terminology (Harasim, 2017). The teachers' attitudes and beliefs influence their teaching practices. Several factors contribute to teachers' beliefs which shape the way they teach and learn (Gilakjani & Sabouriit, 2017). The teaching practices are influenced by how they observe their learners reacting within the classroom. The reviewed literature illustrated the potential of VR as a technology to be integrated into the teaching practices of educators, identifying a gap in research of the implications on teaching practices of teachers when integrating VR scenarios into lessons. These teaching beliefs are formed by learning theory, training courses, learning experiences, professional development, teaching experiences, and teaching practices (Gilakjani & Sabouriit, 2017).

The learning theories encourage learning to be a sensory experience. VR is a digital multisensory resource, described as an immersive digital tool, likely to be beneficial in teaching and learning in schools (Craddock, 2018). It is suggested that the multimodality of VR affords authentic learning situations within interactive environments (Al Farsi et al., 2021; Philippe et al., 2020). The implications for changed teaching practices when using VR scenarios would explore learning theory teachers. These link into the study investigating how participant teachers incorporated VR into their teaching and learning experiences. The theory may sway changes in teachers' classroom practices. The research focuses on how the integration of VR simulations influences teachers' classroom practices, as a beneficial teaching resource (Nesenbergs et al., 2021), digitally replicating environments (Lee & Wong, 2014; Peltekova & Stefanova, 2016; Abdullah et al., 2018; Mohd-Isan & Samsudin, 2019), while potentially deepening the learners' understanding of concepts being taught (Parong & Mayer, 2018).

The lesson planning considers the teaching practices to be used, selecting the VR simulation, and relating it to subject content knowledge. The VR technologies available for the teachers conducting research lessons are low-cost VR applications on a mobile phone within a VR headset. Zantua (2017) described VR as an advancement in education technology that drives learning to become immersive. Focusing research on a South African educational situation would add to the knowledge gap and contribute to the national educational objectives of the South African Government to address digital learning through professional development. Attending professional development related to technology impacts the use of technology within teachers' lessons. In the TPACK framework, techniques are developed for describing how technology-related professional knowledge gets applied in practice and how it is implemented (Koehler & Mishra, 2009). The teachers' comments are assessed as to whether they align with the TPACK framework concepts.

Technology integration is complex because of the rich connections between pedagogy, technology, and content, and how these elements are applied in multifaceted classrooms (Koehler & Mishra, 2009). The study seeks to add information regarding a deeper understanding of the phenomena of integrating VR technology into a teacher's teaching practice. It addresses the knowledge gap of establishing the value of compelling technology integration into classroom teaching practices and lessons (Billingsley et al., 2019), and whether the lessons interlink with curriculum content (Padayachee, 2017; Graeske & Sjöberg, 2021). Identifying a gap in the research of the implications on teaching practices of teachers when integrating VR scenarios into lessons. Aligning the findings with the SAMR (Puentedura, 2006) model might provide an explanation as to how teachers integrated the technology.

These virtual environments enable scenario-based learning and experiential learning. Teachers would select relevant teaching practices as they integrate technology into the lesson to suit their interactive learner-participation teaching strategies. Phipps and Borg (2009), and Abdi and Asadi (2015) expressed that teachers' beliefs about teaching and learning are affected by their own experiences as learners and are established when they go to university, act as a filter through which teachers explain new information, exert a deep effect on teachers' instructional practices, are, not always indicated in what they do in the classroom, have a great impact on their teaching decisions, and greatly affect what and how they learn during language teaching education.

The concept of Mishra and Koehler's (2006) TPACK framework establishes whether teachers integrate technological knowledge, pedagogical knowledge, and content knowledge within their planning and implementation. The hands-on experience of using VR simulations during lessons facilitated the opportunity for learners to ask questions while physically experiencing the VR content. Building learners' knowledge within a ZPD scenario, exploring whether VR simulations create instances of changed pedagogical practices.

The conceptual framework provides a contextual guide in seeking these insights and understanding the teachers' experiences. Exploring whether VR in teaching and learning is related to the interrelationship between pedagogical and technological affordances (Jowallah et al., 2018; Szabo; 2021). The reviewed literature illustrated the potential of VR as a technology to be integrated into the teaching practices of educators, identifying a gap in research of the implications on teaching practices for teachers when integrating VR scenarios into lessons.

In education, VR is used to help learners understand contexts and knowledge areas by being exposed to areas that learners may not easily explore or get to know. Teachers are using VR technology in their classrooms to engage learners.

This small case study research would contribute to the dearth of literature within the field of immersive VR educational technologies. This review identifies the need for my study to contribute to the emerging discourse on possible applications of VR in educational environments in relation to the teaching practices of individual teachers. This study is unique in that it studies VR through the lens of primary school teachers, extrapolating the teachers' teaching practices and implications when integrating VR into lessons, while allowing groups of learners to experience places related to the lesson content.

2.11 CONCLUSIONS OF THE LITERATURE REVIEW

Despite theoretical inferences, no study has provided empirical support for whether VR simulation creates affordances for changing pedagogical practices, specifically in South Africa. Therefore, through interviews and classroom observations, explored how Intermediate Phase teachers integrate VR within the curriculum context and questioned whether VR technological resources influenced teaching practices.

3. CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, I describe the methodological research process in a logical flow to encompass the entire design of the study. This chapter explains my philosophical lens and I justify the choice of a constructivist-interpretivist meta-theoretical paradigm and a qualitative methodological paradigm, providing the paradigmatic perspectives that informed this study. The research design strategy of an instrumental case study is used to generate a multi-faceted understanding of teachers in their real-life context. The selected research design, paradigms, data collection methods, and analysis are justified. The chapter is concluded with discussions on issues of trustworthiness to ensure research rigour and ethical considerations for the research. This chapter attempts to functionalise the research design methodology and substantiates the choices made in the study. The table below (Table 1) summarises the research methodology used in this study.

Table 1: Outline of the Research Methodology

PARADIGMATIC ASSUMPTIONS	
Meta-theoretical paradigm	Constructivist-interpretivist paradigm
Methodological paradigm	Qualitative design
RESEARCH DESIGN STRATEGY	
Case study	Instrumental case studies
SELECTION OF RESEARCH SITES AND PARTICIPANTS	
Selection of research sites	Independent primary schools (N = 4)
Selection of participants	Intermediate-phase teachers at the research site (N = 8)
DATA COLLECTION	
Data Collection Methods	• Interviews (semi-structured, conversational) • Focus group interview • Classroom Observation • Document Analysis • Researcher Journal

DATA ANALYSIS	
Thematic Analysis	
ISSUES OF TRUSTWORTHINESS	
Quality Measures	● Credibility ● Transferability ● Dependability ● Confirmability ● Authenticity
ETHICAL CONSIDERATIONS	
Ethical Considerations	● Participant anonymity ● Participant confidentiality ● Participant's right to withdraw from the study ● Reflectivity of the researcher

The purpose of the study was to explore how do the affordances of VR technology incorporated into lessons influence the teaching practices of teachers. The focus was to engage in teachers' opinions and experiences when integrating the subject content with the selected VR technology and traverse the influence on their teaching practices. The research question guided the plan for this empirical research, which focused on the VR integrated teaching practice and experiences of the participants.

3.2 PARADIGMATIC ASSUMPTIONS

The researcher holds a worldview (Lather, 1986) associated with a constructivist-interpretivist paradigm (Guba & Lincoln, 1994). The word 'paradigm' is defined as a philosophical way of thinking (Kuhn, 2012); as human beliefs, which include the first principles of the empirical views of the researcher (Lincoln, 2000). Thus, it relates to how the researcher constructs and makes meaning of the embedded data. Creswell (2013) argues that there should be a link and coherence between the paradigmatic assumptions of the researcher and the research methodology. Before conducting the study, I had an underlying philosophical position regarding the phenomenon at hand. In the following sections, I provide an account of my philosophical worldview (meta-theoretical paradigm), which influenced the methodological approach of the research.

3.2.1 Meta-theoretical paradigm

This research study is located within the meta-theoretical paradigm of constructivist-interpretivism (Vygotsky, 1978; Cohen et al., 2000). Hjørland (2005) relates meta-theories as paradigms or theories that investigate, criticise, describe, and analyse within an area of knowledge. The research is concerned with meta-theories related to educational technology integration, focusing on how participants comprehend and explain their perceived experiences (Guba & Lincoln, 2001). The ontology related to the constructivist-interpretivist paradigm assumes that there is no single reality (Kivunja & Kuyini, 2017). In the following section, the overall viewpoint of the meta-theoretical paradigms and the rationale for selecting them as a research lens, are discussed.

Constructivism (Bada, 2015) explores the way people construct their knowledge from their interpretation and perspective of the world through their own experiences. The experiences of the participants are personally subjective from multiple points of view, and constructed through human interaction (Creswell et al., 2006; Lincoln et al., 2011). This study aimed to learn from the teaching experiences of the teacher participants when using VR technology in a South African school context. In doing so, the researcher affiliated with Guba and Lincoln's (2001) assumption that constructivism is a process where information from several stakeholders is first discovered, exposed, and mined for meaning, after which it is compared and contrasted in similar circumstances. As an approach to learning, a constructivist paradigm argues that people actively construct and make their own knowledge (Elliott et al., 2000), and their lived experiences determine that reality. The researcher valued the uniqueness of each participant teacher in this study.

The **interpretivist paradigm** focuses primarily on human experience to acquire the understanding and account for the individual's actions (Fossey et al., 2002, p.720). As an interpretivist researcher, she observed, listened, recorded, and examined the participants' world of meaning and attempted to interpret it (Schwandt, 1998). Interpretivist researchers are encouraged to use a variety of techniques, methods, and tools to investigate the phenomenon of interest (Denzin & Lincoln, 2011).

3.2.2 Methodological paradigm

The metatheoretical lens as a constructivist-interpretivist researcher is to comprehend and describe human experience (Chilisa & Kawulich, 2012) in its natural context. The above philosophical assumptions that informed the decision to be a constructivist-interpretivist researcher emanated from her personal experiences as a teacher. Using this lens, she aimed to gain insight into the phenomenon of the affordances that VR technology integration brings to teachers' classroom practices. The researcher is interested in the meaningful integration of technology into teaching, particularly the research problem of integrating virtual reality technology in the teaching of primary school students with the focus on teachers' strategies in practice. Merriam (1998) maintained that the main philosophical assumption of qualitative research is based on the individual's constructed reality by interacting with their social world. This study aimed to learn from the teachers' experiences in using VR technology in their practice, and thus a qualitative research approach was deemed appropriate (Creswell, 2014).

The methodological approach used in my research study was positioned within a qualitative paradigm, where the investigation sought to explore an intellectual puzzle in a well-planned manner, linked directly to the research question, research design, methods, and procedures (Keeves, 1997; Kivunja & Kuyini, 2017). This study allowed the researcher to contextualise the lived experiences of teachers in integrating VR technology into their teaching repertoire. She intended to generate meaningful data to interpret participants' beliefs, attitudes, experiences, interactions, and behaviour (Pathak et al., 2013).

A qualitative research paradigm is purported to fit an interpretive, naturalistic research approach and is useful for uncovering the participants' experiences (Guba & Lincoln, 1982; Flick, 2009). This argument is reinforced by Denzin and Lincoln's (2005) statement that qualitative researchers study participants in their natural settings, where they strive to make sense of or interpret phenomena in terms of the meanings that people bring to them.

3.3 CASE STUDY - RESEARCH STRATEGY

This qualitative instrumental case study intended to highlight insights into the phenomenon of how virtual reality can be used as a learning resource to influence teachers' pedagogy. The qualitative case study approach was selected to conduct an exploration of a case researched over time through in-depth data collection (Creswell, 2013), through analysis of informal semi-structured and conversational interviews, focus groups, and lesson observations. This case was of eight primary school teachers within four primary schools from different socioeconomic communities, being bounded, specific, and unique (Stake, 2012; Creswell, 2013).

The case focused on the experiences of teachers who incorporated VR technology into their teaching practice, exploring the implications of VR for changing pedagogical practices and how these simulations influenced these primary school teachers' classroom practices. These teachers' beliefs and attitudes about the use of VR as a learning tool for teaching were also explored. The researcher employed an instrumental case study method to understand a particular circumstance (Mertens, 2010). The data was collected, analysed, and interpreted to understand, describe, and predict this particular educational phenomenon (Mertens, 2005). This particular case aimed at providing insight into an educational issue (Stake, 1995) providing a rich description of teachers using VR technology in their teaching and learning environment.

3.4 SELECTION OF RESEARCH SITES, PARTICIPANTS AND RESEARCH DEVICES

This section describes the selection of research sites and teacher participants within the study. The initial focus is on the four research sites, primary schools. It sets the scene of the context, type, and particulars of each of the schools. The second focus is on the eight individual teacher participants. This information addresses their teaching experience and qualifications.

3.4.1 Selection of research sites

Purposeful sampling was used to identify four primary schools for the study (Patton, 2002). Qualitative inquiry calls for the selection of detailed and in-depth engagement within the research sites (Patton, 1999). The sites were selected within the South African independent school education context, making them information-rich cases in which I can learn about the issues which are of central importance to the purpose of the inquiry (Patton, 2002). Additionally, the intermediate phase teachers were interested in VR as a teaching tool. This gave me the opportunity to try to understand how the affordances of VR can influence these teachers' teaching practices.

In the process of purposeful selection of schools as research sites for the study, anomalies arose as to the demographics of students and teachers in the selected schools, their differences, and similarities. I considered independent schools across the Gauteng[8] province to provide rich information. The selected schools differed as they spanned a range of socio-economic contexts and followed different school calendars. The schools were similar in that they were all independent, co-educational primary schools that catered for Intermediate Phase grades, teachers, and learners for real-life contextual research. Due to Covid-19, two of the original schools that were selected and agreed to participate, often postponed, so alternative schools were sought. Finally, four research sites were selected; three schools from Gauteng Province and one from the North West Province[9]. Ridgeview Primary, Waterfall School, Damview School, and Birdsong Primary are the pseudonyms used for the four different research sites. Three of the independent schools are classified by the Department of Basic Education (DBE) as ordinary schools, and one is an LSEN school (a school for learners with special educational needs). By studying information-rich cases, greater insight and in-depth understanding may be achievable (Patton, 2002). A detailed overview of each of the research sites is described below.

[8] Gauteng is one of the nine provinces of South Africa

[9] North West is one of the nine provinces of South Africa, and borders Gauteng.

- **Ridgeview Primary School**

Ridgeview Primary is a co-educational[10], non-profit independent primary school from Grade 00 to Grade 7. There are two classes per grade from Grade 1 to Grade 7, with approximately 20 learners per class. The Grade R classes have approximately twelve learners per class. The school buildings are a mixture of brick-and-mortar buildings and prefabricated[11] classrooms, set on an established church property.

The school is located within the Randburg suburb in Gauteng province. The school is partly subsidised by the Gauteng Department of Education[12], as they compile the state subsidy requirements to receive the funding (Franklin, 2017). Most of its income is acquired through corporate and individual donations. The school is described as a low-fee-paying[13] independent school, as the learners attending Ridgeview Primary are predominantly from a low socio-economic context. Most of the learners come from an informal[14] settlement, which is approximately 11km from the school, while some learners travel further afield from other informal and low-income areas. The mission of the school is to provide opportunities for socio-economically disadvantaged children.

The technology resources at Ridgeview Primary are limited. Each teacher has a laptop provided by the school for administration and teaching purposes. There is an ICT laboratory that has sixteen desk computers connected to the Internet and Wi-Fi. There is one data projector in the school for teaching that teachers may use within their lessons. Although there is Wi-Fi access, it is not accessible throughout

[10] Co-educational, consisting of both girl and boy learners.
[11] Prefabricated classrooms are constructed in a factory, and a finished classroom is then delivered to site complete.
[12] Gauteng Department of Education is the education department of one of the nine provinces of South Africa.
[13] Low-fee paying
[14] Informal settlements are unplanned settlements, unauthorised housing, and areas where housing is not in compliance with current planning and building regulations. The homes in the informal settlements are often corrugated-iron-shack constructions, with no running water and only communal sanitation.

the school. This school has the least technology resources available to teachers and learners compared to the other research sites.

- **Waterfall School**

Waterfall School is an independent, co-educational school. It caters for children from one-year-olds to Grade 12, consisting of four areas of schooling: An Early Learning School, a Preparatory[15] (primary) School, a College (High School) and an International Foundation Year (IFY) through a partnership with universities from the United Kingdom and Australia. The research was conducted in the Preparatory School phase (Grades 1-6), which had three classes per grade, and an average of twenty-two learners per class. Waterfall School is situated in Midrand, in Gauteng province. The community is affluent, consisting of middle- to upper middle-class families.

Waterfall Preparatory School has substantial technological infrastructure, with access to Wi-Fi throughout the school. All teachers have laptops, and all classrooms are equipped with either interactive whiteboards or data projectors. Waterfall Preparatory School is equipped with a computer room with twenty-five laptops, and a STEM (Science, Technology, Engineering, and Maths) room. The school offers robotics as an extra-curricular[16] activity. Additional educational technology includes iPads and fifteen VR goggles that the teacher signs out for use during lessons, and the mobile phones of learners.

- **Damview School**

Damview School is a co-educational school in an affluent rural community associated within an exclusive residential estate at the foothills of a mountain range in the North West province. It caters for both day learners and boarding-house learners, with grades ranging from Grade 0000 (two- and three-year-olds) to Grade

[15] Preparatory, is another name for Primary School. This preparatory school has learners from Grade 1 to Grade 6.
[16] Extra-curricular activities are activities that take place at the school, after the academic day, generally in the afternoon.

12. The school is divided into three phases: the Pre-preparatory[17] phase, the Preparatory phase, and the High School phase (which provides an academic bridging programme). There are two classes per grade, with an average of twenty learners per class. The socio-economic status of the families in this school is characterised as middle to high. Damview School is technologically well equipped, with access to Wi-Fi throughout the school. In the Preparatory school, all teachers have laptops, and their classrooms are equipped with either interactive whiteboards or data projectors. There is an ICT room with 25 computers, in which the learners attend weekly lessons. Teachers have access to iPads for use in their lessons. Damview School has a separate technology room and a STEM room. They offer robotics as a co-curricular[18] subject, as well as robotics and drone clubs as an extracurricular [19]programme.

- **Birdsong Primary School**

Birdsong Primary is also a co-educational primary school consisting of grades from Grade R to Grade 7. The main function of this LSEN school is to offer interventions to remediate learning difficulties in an inclusive environment. Birdsong Primary School is located in the northern suburbs of Johannesburg and offers a variety of sporting and extracurricular activities. The socio-economic status of the families in the schools are a mix of low-middle to high-end.

Birdsong Primary has extensive technology access throughout the school. Teachers have laptops, and each classroom has either an interactive board[20] or a data projector. There are ICT and technology learning labs. The school also has a sensory room to cater for special needs learners. The school has six VR goggles and mobile phones, which are used for teaching and learning.

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[17] Pre-preparatory are the preschool years varying from a few months old to Grade R. Schools select the age groups of the children they would cater for.
[18] Co-curricular - An activity at a school offer in addition to the normal curriculum subjects
[19] Extra-curricular - or extra-academic curricular are activities that are outside of the academic day.
[20] Interactive board - an electronic teaching resource with resources, simulations and access to the internet, and often multiple user capabilities.

3.4.2 Selection of participants

In this case study, the units of analysis are the teachers that are exploring the use of VR in their teaching (Faltis, 1997; Merriam, 1998). The participants are Intermediate Phase teachers teaching at purposefully sampled sites (Patton, 2002), teaching in co-educational, independent schools. Selection criteria of the participants of this study were designed with the specific goal to collect rich and thick data. First, the participant teachers in the research sites were either using ICT or VR technology in their lessons as a teaching strategy. Second, the participants had to be Intermediate Phase teachers willing to integrate relevant VR technology within the curriculum content in their classroom practices. Teachers had to be willing to participate in the study and communicate their experiences in a reflective way (Palinkas et al., 2015). Initially, twelve teachers indicated their willingness to participate in the study. However, due to the Covid-19 pandemic interruptions in schools, the number of participants was reduced to eight teachers. The eight participants were all female, as all teachers at the four research sites (Intermediate Phase) were only female. Seven teachers worked in ordinary[21] schools (Damview, Waterfall, and Ridgeview), while one taught in an LSEN[22] school (Birdsong School). Figure 5 shows caricatures depicting the cultural diversity of the eight South African participants.

[21] Ordinary schools in South Africa are the public schools and private (independent) schools, and comprise roughly 97% of schools in South Africa, other than schools for specialised education (Mhlanga & Moloi, 2020)

[22] LSEN schools are schools with learners with special educational needs (LSEN); these learners need additional help and support in their learning.

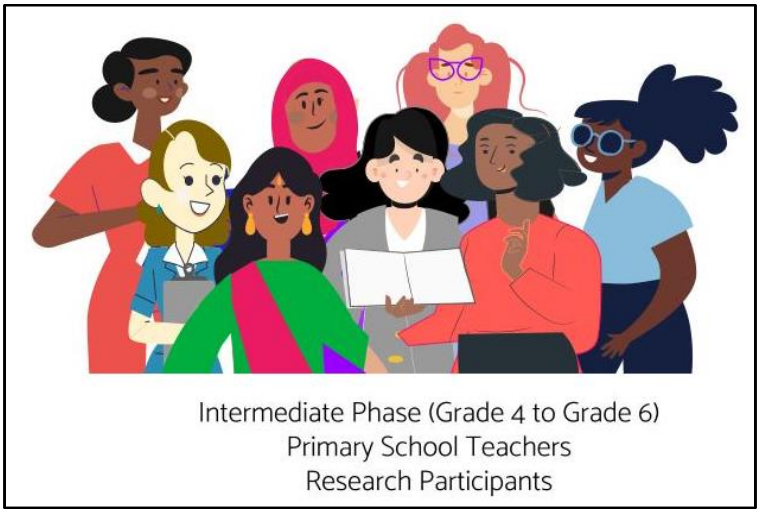


Figure 5: Sociocultural positions of the participants

The previous experiences of integrating VR as a teaching tool resource in lessons differed among the participants. Three teachers from Damview School and two teachers from Ridgeview Primary had not used VR in their lessons before the study. Two teachers from Waterfall School had used VR in their lessons. The teacher at Birdsong School was the most experienced in incorporating VR into her lessons, as she had been using it periodically for a few years prior to this study. The participants taught a range of different subjects in various grades within the Intermediate Phase (See Table 2). Pseudonyms have been used to protect teachers' identity, but to reveal their gender and ethnicity.

Table 2: Participant demographics

Participant	**School**	**Qualifications**	**Current teaching (Subjects and Grade)**	**Average age**	**Teaching experience (Number of Years)**	**Classroom technology access**
Bhavna	Waterfall School	• Psychology (Honours) • PGCE	• Natural Science • Life Skills (Grades 6, 7)	35-40	15	• Laptop • Interactive whiteboard • iPads • VR headsets
Sarah		• BEd	• Natural Science • Social Science	35-40	15	• Laptop

			(Grade 5)			• Interactive board • iPads • VR headsets
Dhriti	Damview School	• BTech • PGCE	• English • Social Science • RDI[23] (Grade 5)	50-55	10	• Laptop • Interactive board • iPads
Siara		• BEd	• NS • Technology (Grades 4-6)	25-30	5	• Laptop • Interactive board • iPads
Tammy		• BEd	• Maths & EMS (Grade 7) • NS (Grade 6) • HOD Maths	30-35	10	• Laptop • Interactive board • iPads
Kgomotso	Ridgeview Primary	• BEd	• NS & Maths • Science, Tech (Grades 6, 7) • HOD Maths	50-55	25	• Laptop • Data projector
Thandiwe		• BEd	• Life Skills & Language (Grades 5, 6)	35-40	15	• Laptop • Data projector
Mary	Birdsong Primary	• Higher Diploma in Education • Instrumental Enrichment Trainer	• Innovation, IT & Art (Grades 1-7) • HOD Innovation	55-60	30	• Laptop • Interactive board • iPads • VR headsets & mobile phones

The teaching affordances of teachers are influenced by the access they have to technology within their schools and within their classrooms. An affordance is the relation or action between a user and an object, the affordance enables (does not

[23] RDI - Respect Diversity Inclusion, taught as a subject at the school.

enable) an action (Hammond, 2010). An affordance enables the interaction between humans and technology, such as a chair affords being sat on, a handle of a door affords it being opened. With regards to digital technology, a button affords a link being opened. An app affords being used if you have downloaded it. For the user, the application does not afford being used if it is not downloaded.

Teachers were introduced to VR by being exposed to a variety of professional development (PD) sessions in VR, from attending SACE-endorsed workshops to short courses on using VR in lessons. Mary had the most extensive teacher training about VR integration into lessons, as she attended a six-hour, SACE[24] endorsed course in 2018. Bhavna and Sarah attended a 2-hour VR teacher training SACE endorsed course in August 2019. Kgomotso and Thandiwe participated in a 1-hour VR information session. Dhriti, Tammy, and Siara did not have formal training; rather, a 30-minute demonstration in May 2021, of how the VR applications and how the VR goggles are used. These eight participants made significant contributions to the study, as they provided a nuanced understanding of how they integrated VR technology into their teaching practices.

4.3.3 Device selection

VR goggles headsets were used for the research (McAdam, 209). These plastic headsets are designed on the Google cardboard concept, with two optical lenses (one for each eye) based on principles of stereoscopic imaging (Boehlert, 2015). The lenses trick the human brain to convert the double images into a single 3-dimensional image (see Figure 2). The image is generated on a smartphone application with the phone being placed into the front of the headset. These headsets are relatively inexpensive, making VR more accessible for schools and teachers to use (Zantua, 2017; Xiaorong, 2018). The VR goggles headsets are also lighter than headsets where the actual content is stored on the headset itself, making it easier for learners to wear, and to take on and off. The headsets have

[24] SACE - South African Council of Educators, is the professional council for educators, which manages Professional Development, instils the educator's Code of Ethics, overseeing appropriate registration, and with the aim of enhancing the teaching profession.

adjustable straps for learners to wear comfortably. There are free and cost-effective software applications available with which teachers can select lesson content. Applications are easily updated on the phones. In summary, the VR goggles headsets were selected as they are easy to use, comfortable to wear, easily accessed with a wide variety of content applications, updated content via selected smartphone applications, and are relatively affordable. Therefore, using this VR technology made it reliable and viable for the study's purpose.

3.5 DATA COLLECTION METHODS

It was important that the qualitative case study design of the research process followed a logical sequence linked to garnering appropriate empirical data to answer the main research question (Yin, 2002). Qualitative researchers typically use multiple data sources (Creswell, 2014) and in this study, numerous data collection methods were used, namely semi-structured individual interviews, classroom observations, focus group interview, document analysis, photos and videos and a researcher's journal to document field notes (Yin, 2003; Myers, 2009). Table 3 below provides information about the data collection methods used in this study.

Table 3: Data Collection Methods

N=4	**N=8**	**Interviews**		**Lesson Observation**	**Documents**
School	**Participant**	**Semi-structured Interviews**	**Informal Conversational Interviews**	**Number of Observations** **& Evidence**	**Documents obtained**
Ridgeview Primary	Thandiwe	3 Semi-Structured interviews (1 online Google Meet & 2 face to face, voice recordings) 3 Transcripts (p. 10, 10 & 6) 1 interview before lessons 2 after lessons	3 Informal Conversational Interviews (1 phone call & 2 discussions at school lessons Notes, p.1)	3 Lessons (Evidence: photos & observation notes)	3 Lesson preparation 3 VR experiences 1 Lesson activity sheets CAPS IP English First Language CAPS IP Life Skills
	Kgomotso	3 Semi-Structured interviews (2 online Google meet & 1 face to face voice recording) 3 Transcripts (p. 20, 10 & 7) 2 interviews before lesson 1 after lesson	2 Informal Conversational Interviews - 1 phone call and 1 discussion at school after the lesson (Notes p. 1)	1 Lesson (Evidence: photos & observation notes)	1 Lesson preparation 1 VR experience CAPS IP NS & Technology
Waterfall School	Bhavna	3 Semi-Structured interviews (2 online Google meet & 1 face-to-face voice recording) 3 Transcripts (p. 6, 7 & 5) 2 interviews before lessons 1 after lessons	2 Informal Conversational Interviews 1 phone call, 1 chat before lesson (Notes p.1)	1 Lesson (Evidence: photos, video & observation notes)	1 Lesson planning notes 1 VR experience CAPS IP NS & Technology

	Sarah	3 Semi-Structured interviews Transcripts (3 face-to-to-face voice recording) 3 Transcripts (p. 39, 7 & 7) 2 Interviews before lessons 1 after lesson	2 Informal Conversational Interviews 2 phone calls (Notes p.1)	1 Lesson (Evidence: photos and observation notes)	1 Lesson booklet 1 VR experience CAPS IP Social Sciences - History
Damview School	Tammy	1 Semi-Structured interview (1 face-to-face voice recording) 1 Transcripts (p. 5) 1 after lesson	2 Informal Conversational Interview - 1 phone call and 1 discussion at school (Notes p. half page)	1 Lesson (Evidence: video - 30 minutes, and observation notes)	1 Lesson preparation 1 Learner activities 1 VR scenario CAPS IP NS & Technology
	Siara	0 Semi-Structured interview (was not willing to conduct the recorded interview)	1 Informal Conversational Interview Approach notes (p.5) - Discussion at school	1 Lesson (Photos and observation notes)	1 Lesson preparation 1 Learner activities 1 VR scenario CAPS IP NS & Technology
	Dhriti	2 Semi-Structured interviews (1 face-to-face voice recording & 1 online Google meet) 2 Transcripts (p. 4 & 4) 2 after lessons	3 Informal Conversational Interviews - 1 phone call and 2 discussions at school after the lessons notes (p.1)	3 Lessons (Photos, short videos, and observation notes)	2 lesson preparation 2 Learner activities 2 VR scenarios CAPS IP Social Sciences - History CAPS IP English First Language
Birdsong Primary	Mary	2 Semi-Structured interviews (2 online Google meet) 2 Transcripts (p. 9 & 10) 1 before lesson 1 after lesson	2 Informal Conversational Interviews 1 phone before lesson, 1 phone call after the lesson	1 Lesson (Evidence: photos, short videos, and observation notes)	1 Lesson preparation 1 Learner activities 1 VR scenario CAPS IP NS & Technology

Data from a collection of multiple sources in this study (lesson observations, interviews, photographs, videos, and document collection) made it possible to align and verify the findings (Williams & Kimmons, 2022), triangulate it, and build a strong case for the validity of the study.

3.5.1 Semi-structured interviews

Interviews provide an opportunity to collect rich data from participants about their experiences and opinions and to gain a better understanding of their lived experiences (Creswell, 2007). This instrumental case study selected semi-structured interviews, which consisted of open-ended questions being asked, which allowed the participants to answer in their own words (Creswell, 2007). The interviews were conducted to elicit direct responses of the personal experiences of the participants with the integration of VR technology into their teaching. These interviews provided information for each of the sub-questions of the research.

A semi-structured interview protocol (Addendum 7.4) was developed for each of the two interviews conducted with eight participants. Semi-structured interviews allowed open questions and were augmented by ‘how and why' questions when necessary (Adams, 2015). Before the interview was conducted, informed consent documentation was obtained from the participants and permission for the session to be recorded. The questions from the interview instrument helped to develop a rapport with the participants because of the leading (background information) questions. Participants gave permission to voice record the interviews. The open-ended questions related to the research focus and considered time constraints during planning (Jacob & Furgerson, 2015).

The first interview (Addendum 7.4.1), focused on the nature of the research study, the roles of the participants, and issues of confidentiality, anonymity, and consent. This interview was conducted with the aim of building a rapport with the participants, understanding their current teaching strategies, their previous VR teaching experiences, and to grasp an understanding of the learners’ use of technology. Three participants had previously used VR before the study began. Therefore, Mary’s interview included information similar to the other initial interviews as well as detailed descriptions of her use of VR previously. Since the researcher was not able to observe lessons at Waterfall in 2021 due to Covid-19, she conducted an additional interview separately with Bhavna and Sarah about their experiences and use of VR in their lessons.

The second interview (Addendum 7.4.2) was conducted after observing the VR lessons. A conducive environment was determined for the face-to-face interviews, such as the use of comfortable venues with little distraction. During this interview, the teacher reflected on the use of the VR technology and the possible effect the technology had on the teacher's teaching method.

Due to the Covid-19 pandemic, the safety protocols in schools did not allow for some interviews to occur in a face-to-face context. The remotely conducted semi-structured interviews were recorded using video conferencing technology (Google Meet) (n=8). When face-to-face interviews (n=9) were possible 'Rev.com' application and software (iPhone app) was used to record the discussion.

This semi-structured interview approach allowed the researcher to probe and delve deeper into the responses of the participants. A benefit of open-ended interviews is that the results and data would differ from one participant to another, as participants have their own thoughts (McNamara, 2009; Turner, 2010). The benefit of interviews as a data collection method is the researcher's ability to collect the same focus information from each participant (McNamara, 2009).

3.5.2 Informal conversational interviews

This study also used informal conversational interviews (n=17) when spontaneous discussions and interactions that related to the ongoing fieldwork of the research study surfaced (Gall et al., 2003). The informal conversational interviews varied and built on the knowledge the participant had provided, enhancing the insights, where relevant, linked to each of the research sub-questions. The questions for the informal conversational interviews were spontaneous discussions with the participants. The informal conversational interview data was recorded in the researcher's journal as field notes and reflections. All eight participants engaged in the research about the lessons of informational conversational interviews. These discussions related to the lessons, whether it was about the VR content, or the number of groups, may be used within the lessons. These conversations added valuable information to understanding the phenomenon, as they provided insights into how the teacher participants planned their lessons and taught their classes. Teachers were focused on their lesson preparation and wanted the lessons with the technology to be relevant. I had informal conversational interviews with four of the participants (Thandiwe, Kgomotoso, Dhriti, and Mary) after their lessons where they discerningly and excitedly shared information in detail about their observations regarding learner reactions or experiences they encountered by integrating VR scenarios into their lessons.

3.5.3 Focus group interview

In the focus group interview, three of the teachers (Thandiwe, Sarah, and Mary), could reflect on the questions asked by the interviewer and the researcher (Dilshad & Latif, 2013). Informed consent was obtained from the participants before the discussion began. The use of the term focus group for this study is defined using Kitzinger and Barbour's (1999, p.20) description that 'any group discussion may be called a 'focus group' as long as the researcher is actively encouraging of, and attentive to, the group interaction.' The participants are encouraged to enter into a conversation in a safe setting to discuss aspects of the research project (Bergold & Thomas, 2012). The group is focused on a collective activity, with the categorical reason for the group interaction being to generate data (Kitzinger & Barbour, 1999).

A single focus group discussion was conducted to ascertain the collective views and opinions of the research participants, who are teachers who took part in the study. All eight participants were invited to participate, five of the participants responded positively to the invitation. However, on the day of the focus group, two participants withdrew due to unexpected personal reasons, so the focus group was conducted with three of the eight participants, namely, Thandiwe (from Ridgeway School), Sarah (from Waterfall School) and Mary (from Birdsong School), from three of the four schools.

During the group discussion, they were asked about their perceptions and opinions about the research topic. The collective understanding of the group may have been achieved through reflective dialogue (Finlay, 2002). The focus group interview (Dilshad & Latif, 2013) was conducted towards the end of the research period, after the participants' lessons were observed. The discussion was recorded with the participants' permission. This focus group was divided into two sections.

In the first section (45 minutes) of the focus group, the discussion was to acquire the teachers' inputs, feedback, and comments about VR and their teaching strategies. The focus group topic was 'Affordances of incorporating VR into teaching practices' was related to the research question about the implications that VR resources have on teachers' pedagogical teaching practices, while the questions related to teachers' experiences and perceptions of incorporating VR into their teaching practices. The instrument for the focus group was an interview protocol (Addendum 7.3). The questions related to the teachers' experiences and perceptions of the incorporation of VR into their teaching practices as a teaching resource.

Example questions:

- What is your favourite and least favourite aspects of using VR in lessons?
- What influences did you use when selecting the VR scenarios for your lessons?
- How has having used VR in lessons influenced the way you teach or affected your teaching strategies?

Focus groups can also be used in the latter stage of research projects, to assist in teasing out the findings (Barbour, 2017). Therefore, the second section (20 minutes) of the focus group was used to disseminate and give feedback information to the research participants (Morgan, Krueger & King, 1998). The Patient-Centred Outcomes Research Institute (PCORI) defined dissemination as 'the intentional, active process of identifying target audiences and tailoring communication strategies to increase awareness and understanding of evidence and motivate its use in policy, practice and individual choices' (PCORI, 2015). This aspect of the focus group involved a presentation of research findings and evidence context (Barbour, 2005; PCORI, 2015). Barbour (2005) expresses the value of feeding back preliminary findings in the form of a dissemination focus group and suggests that due to the potential of these sessions to generate further data, it would be a pity to limit these to validation of findings. Keeping that in mind, in this aspect of the focus group, I presented the qualitative data gathered and the themes that had been identified, without compromising any confidential information of individuals in any group. The presentation of the summary of preliminary themes was presented to the focus group to discuss and express their viewpoints about these themes. This discussion was used to ascertain the validity of the research themes and determine if new themes were identified.

The entire session allowed for interactive, open, and free discussion among participants (Denscombe, 2007; Dilshad & Latif, 2013; Anderson, 2019). The discussion acquired their input, feedback, and comments about using VR in their teaching strategies. The benefit of the focus group discussion (Gundumogula, 2020) was to explore what the group members thought and felt about the research topic, and perhaps gain new insights and information about the research. There was a potential that the focus group discussion may lead to the crystallisation of the findings (Russo, 2012), because the focus group participants were participants of the study, they could discuss the questions from an experiential point of view, and as members of the intermediate phase teacher community. The triangulation of the focus group data in relation to other data sources (interviews, observations, and document analysis) would enhance the credibility of the focus group findings (Shek, 2017).

3.5.4 Classroom observations

Classroom observation (n=12) of participants was an evidentiary source of data collection (Yin 2002), in which the researcher observed, examined, and inspected the setting where the research was being conducted as both an observer and a participant (Kawulich, 2012). The researcher established a rapport (Howell, 1972;

Kawulich, 2005; DeWalt & DeWalt, 2011) and managed to see the participants within their teaching environment. Participant observation occurred in the field (Yin, 1993) as lessons (n=12) within schools. The observations allowed the research to identify and establish data connections to the three sub-questions of the research. The nine lessons (Damview n=5, Ridgeview n=4) observed during the lower Covid-19 restrictions[25] were conducted outside the classrooms in the open-air; masks were worn by teachers, staff, and the researcher. Sanitiser was used for learners' hands. VR goggles were cleaned with surface sanitiser before and after each learner had used the headsets. In this study, the researcher documented the field notes on the observation schedule (Addendum 7.5) (Creswell, 2007) about the participants during the lesson observation as they taught with VR technology, still photographs, and video recordings were taken during these observations to provide further context for creating data-rich information.

Ridgeview Primary had two teacher participants, Kgomotso and Thandiwe, neither had experienced nor used VR in lessons before the study. The school did not have VR equipment. Kgomotso conducted one Grade 6 Natural Sciences (NS) lesson about nutrition. Thandiwe conducted three lessons, two Grade 4 Life skills lessons about Bullying, and one Grade 5 English comprehension lesson. Table 4 below provides information about the Ridgeview Primary VR lessons.

Table 4: Ridgeview Primary VR lessons

Name	**Subject and Grade**	**Lesson topic**	**Length of lesson**	**Interview after the lesson**
Kgomotso	Natural sciences (Grade 6)	Nutrition VR: YouTube - Click view: Food groups and Nutrition	50 minutes	Yes (Google meet interview)
Thandiwe	Life Skills (Grade 4)	Emotions and conflict VR: YouTube - Rocket	50 minutes	Yes, discussed both lessons, as a

[25] SA government Covid-19 regulations and guidelines https://www.gov.za/covid-19/resources/regulations-and-guidelines-coronavirus-covid-19

		kids - know Your emotion		combined, face to face interview
Thandiwe	Life Skills (Grade 4)	Bullying VR: Cyber bullying - create no hate	50 minutes	
Thandiwe	English (listening and doing) (Grade 5)	Listening comprehension VR: YouTube - The ant and the dove. Best Short Stories for Kids in English	50 minutes	Yes (face to face interview)

Damview School had three teacher participants, Dhriti, Tammy and Siara. Tammy and Siara conducted one Grade 6 revision lesson using VR. Dhriti conducted three VR integrated lessons. The school did not have VR equipment; however, all three teachers were aware of the technology and had seen VR headgear before. Dhriti's children had VR headsets at home*.* Table 5 below provides information about the Damview Primary VR lessons.

Table 5: Damview Primary VR lessons

Name	**Subject and Grade**	**Lesson topic**	**Length of lesson**	**Interview after the lesson**
Tammy	Natural Sciences (Grade 6)	Ecosystems revision VR: Google expeditions Ecosystems of Borneo	45 minutes	Yes (face to face interview)
Siara	Natural Sciences (Grade 6)	Ecosystems revision VR: Google expeditions Ecosystems of Borneo	45 minutes.	Yes (face to face interview)
Dhriti	Social Sciences - history	San and the hunt VR: YouTube - The Intense 8 Hour Hunt | Attenborough Life of	45 minutes	Yes (face to face interview)

	(Grade 5)	Mammals | BBC Earth		
Dhriti	English comprehension (Grade 5)	Shipwrecked / Deserted on an island Do These Things To Survive If You Get Stranded On an Island	45 minutes	Yes, discussed both lessons, as a combined, face to face interview
Dhriti	English comprehension (Grade 5)	Shipwrecked / Deserted on an island Do These Things To Survive If You Get Stranded On an Island	45 minutes	

Waterfall School had two teachers participating, Sarah and Bhavna. Both teachers had used VR previously in their lessons before the study. The school had 15 headsets which teachers signed out and used. Learners brought their own cell phones. Both teachers had experience using VR themselves as well. Table 6 below provides information about the Waterfall School VR lessons.

Table 6: Waterfall School VR lessons

Name	**Subject and Grade**	**Lesson topic**	**Length of lesson**	**Interview after the lesson**
Bhavna	Natural sciences (Grade 6)	Wetlands VR: YouTube - iSimangaliso Wetland Park, South Africa	60 minutes	Yes (face to face interview)
Sarah	Social Sciences - History (Grade 4)	Transportation YouTube VR mode: Roadtrip 2030: Future of Mobility Virtual Reality Experience | Covestro	60 minutes	Yes (face to face interview)

Birdsong primary School had one teacher participating, Mary. She had used VR in her lessons before the study. Table 7 below provides information about the Birdsong Primary School VR lesson.

Table 7: Birdsong Primary School VR lesson

Name	Subject and Grade	Lesson topic	Length of lesson	Interview after the lesson
Mary	Global collaborative design - an inquiry-based learning class Integrated with Natural sciences (Grade 6)	The Brain and circuits VR: InMind2 app	120 minutes	Yes (Google meet interview)

The VR resources of the eight participants related to their lesson content; therefore, they were very varied. The teachers incorporated the VR into the existing lessons they were teaching, no lessons were specifically made just for the VR research. Teachers shared how the VR activity might influence their teaching practices moving forward.

3.5.5 Researcher's Journal

A personal researcher journal is a qualitative methodological practice from the constructivist-interpretivist viewpoint (Denzin, 1994; MacNaughton, 2001). The researcher kept detailed records of observations, insights, and interactions in a digital journal about the lesson focus and possible examples of VR scenarios. She used the journal to note her reflections and subjective bias such as her experiences, thoughts, and perceptions about the participants and their teaching contexts. The personal journal recorded the date, names of participants, and specific facts about the teaching-learning setting. She actively observed and noted the interactions within each experience and drew interrelationships and engagements within the lessons. There were twelve lesson observations across the four schools' sites (four lessons at Ridgeview school: Thandiwe (n=3 lessons), Kgomotso (n=1 lesson); five lessons at Damview: Tammy (n=1 lesson), Siara (n=1 lesson), Dhriti (n=3 lessons); two lessons at Waterfall school: Bhavna (n=1 lesson), Sarah (n=1 lesson) and one lesson from Birdsong School: Mary (n=1 lesson). The lessons occurred between May 2021 and June 2022. She was a participant when she assisted teachers with technical technology assistance when using the VR headsets during lessons, if required. In the personal journal, a record was kept of how the participants reacted the researcher. There were interviews after each lesson for the six teachers who taught one observed lesson, while the two participants, Dhriti and Thandiwe, who conducted three observed lessons, had two interviews after their lessons.

Bracketing is a method used to alleviate the potential detrimental effects of unidentified preconceptions connected to the research, which would increase the rigour of the study (Tufford & Newman, 2010). Bracketing (Fischer, 2009) was used as a reflective technique across the different phases of the research and detailed descriptions. Bracketing was used to aid the researcher, to maintain a focus on the research questions, at the same time using signals from her own experiences and emerging interpretations during the data collection to augment questions for additional data collection (Tufford & Newman, 2010). She guarded against bias (Surry & Land, 2000), while bracketing may have an adverse effect on the research endeavours by facilitating herself, as the researcher, to explore and reach deeper levels of reflection across the research (Tufford & Newman, 2010). She examined and reflected on the contextual and social issues that shaped her research. The opportunity for in-depth reflection may enhance the acuteness of the research and facilitate more profound analysis and results. Her role as a researcher was that of an interpreter (Stake, 1995).

3.5.6 Photographic Analysis

Photography was described as a silent voice, an alternative way to communicate with participants and to understand their world view perception (Walker, 1993). Photographic analysis was used to verify or augment teachers' comments and views about learners' engagement and participation, which assisted in addressing the research sub-question, 'what are teachers' beliefs and attitudes about the use of VR as a learning tool for teaching?' In this study, learners were not interviewed, however, permission was granted by the students and their parents for videos and photos to be taken. Anonymity of the learners was ensured, and photographs and videos were taken when learners were wearing the VR headsets. The analysis of the students' body language in the photographs (n=89) and in the videos (n=9) was observed to ascertain student engagement and participation in the lesson's selected VR scenario. An analysis tool (Addendum 7.6) was created to record the observation of body language regarding body position when viewing VR and how the researcher was aware that photographs provided an alternative observation method (Cleland and MacLeod, 2021). Walker (2020) suggested that photographs may offer further insight which was not captured by written text or spoken language. The value of analysing the photographs and videos, therefore, was to provide further context to the research data in creating rich resources.

3.6 DOCUMENT ANALYSIS

Analysis of documents (words or text, and images) followed the path of aggregating words or images into categories of information and presenting the diversity of ideas collected during data collection (O'Leary, 2014). The qualitative analysis of documents assisted in addressing two sub-research questions namely 'what implications have VR resources had on teachers' pedagogical teaching practices?' and 'how does the integration of VR simulations influence primary school teachers' classroom practices?' Participants shared their personal documents, such as lesson plans and lesson activities. Sourced curriculum subject documents of South Africa (CAPS - curriculum, policy statements) of the subjects taught in the research lessons. These digital documents were accumulated during the research (O'Leary, 2014). The documents were read, interpreted, analysed, reviewed, and evaluated through a systematic procedure (Bowen, 2009). The documents provide additional and supplementary knowledge to the research base (Bowen, 2009). The management of transcripts, quotations, extracts, and codes was conducted and recorded in Google spreadsheets.

VR applications and websites used within the lessons were also included. The analysis of the documents can be used to verify and corroborate the findings from other sources (Bowen, 2009). The researcher analysed and interpreted the study documents and sourced data into coherent and logical codes and themes (Creswell, 2007), using Braun and Clarke's (2012) six-stage Data Analysis Process. The titles of the six stages in the diagram are the terms which Braun and Clarke identified in their description of their six-step thematic analysis process. The data was analysed by identifying patterns through acquaintance with the data, further analysis generated the initial codes to be created, these codes were narrowed further by identifying themes, a continued analysis review of the potential themes, and finally the themes are defined and named (Braun & Clarke, 2012). Once the analysis is complete, the conclusions are validated, and findings are recorded. The diagram (Figure 6) is my interpretation of how the data were refined and analysed through the six stages of thematic analysis, so a finding report can be written. Figure 6 below is an illustration by Walstra (2022) about the data analysis process of Braun and Clarke (2012).

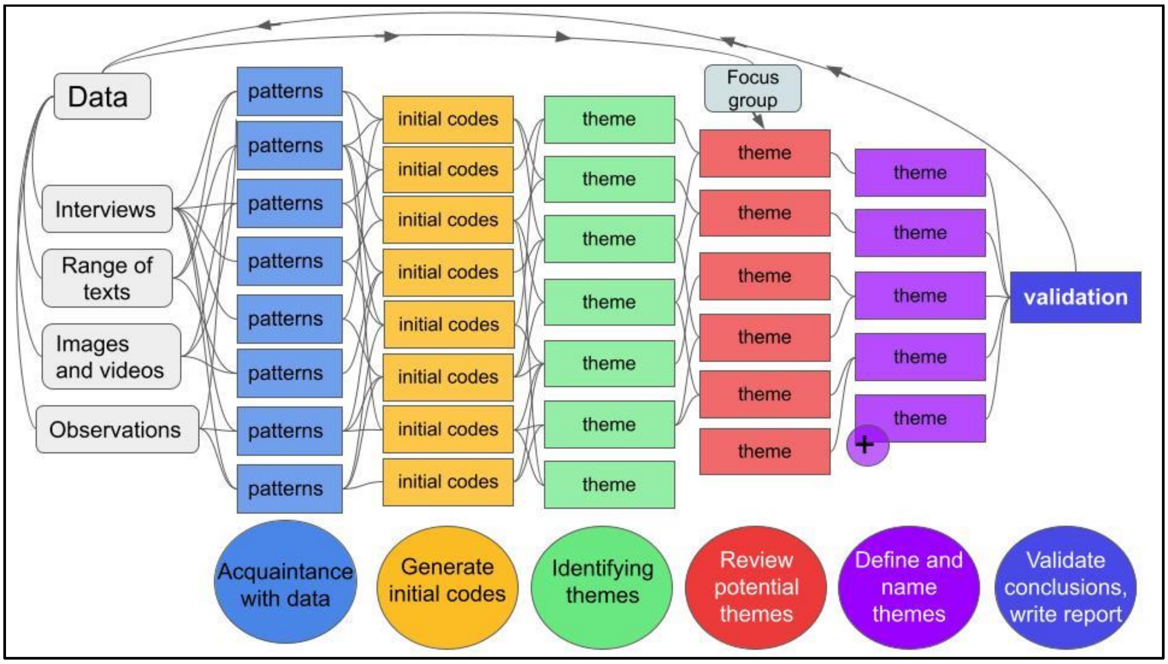


Figure 6: Walstra (2022) after Data analysis process of Braun and Clarke (2012)

The thematic process created and deciphered the meaning, so empirical knowledge was produced, and understanding was developed (Bowen, 2009). The research data from the study was saturated, when no new theme or code 'thematic' saturation, often equated with 'no new themes', and 'no new codes', saturation has emerged as the 'gold standard' in qualitative inquiry [2, 26]. Table 8 below provides information on the type of documents analysed.

Table 8: Documents analysed

No	Item	Description
1	Lesson preparation	Participant documents to conduct the lesson.
2	Lesson activities	Participant documents for learners to complete related to the lesson
2.	Various subject Curriculum Assessment Policy Statements documents	Official DBE curriculum subject documents

When evaluating documents, it is of utmost importance not to consider the information as automatically precise or accurate, or to assume that the recordings of the events are complete (Bowen, 2009). Researchers need to gather relevant texts that are suitable for the study and develop a detailed organisation and management scheme. Table 9 below indicates a summary of the data collection methods, instruments, and recordings accumulated during the study.

Table 9: Summary of data collection methods, instruments, and recordings

	Data collection methods				
Data Collection	**Interviews**	**Classroom Observations**	**Focus Group Interviews**	**Document Analysis**	**Researcher journal**
Participants	N=8	N=8	N=3	N=8	N=1
Instruments	• Interview protocol • Digital • Voice recorder - Rev application • Video call Google Meet	Observation schedule Digital video camera	Interview protocol Presentation	Lesson plans Lesson activities CAPS Curriculum	Researcher Journal
Recording	Transcripts (n=17)	Observation schedule Field Notes Photos Videos	Transcript (n=1)	Typed notes in digital format	Field Notes
Analysis	Thematic Analysis	Thematic Analysis	Thematic Analysis	Thematic Analysis	Thematic Analysis

3.7 Data analysis

Due to its flexibility and accessibility, thematic analysis was used for the data analysis of the qualitative documents (Braun & Clarke, 2012). It provides the novice researcher in qualitative research, an entry into a way of conducting research that may seem vague, overly complex, and conceptually challenging. It offers an avenue for qualitative research that teaches the mechanics of coding and analysing qualitative data systematically, which can be linked to broader theoretical or conceptual issues. The researcher interpreted and represented the findings of the data (Yin, 1994), using an inductive approach (Thomas, 2006) to code and analyse the information. When using an inductive approach, the themes which have been identified, are intertwined, and firmly linked to the data itself (Patton, 1999). The codes and themes are derived from what is in the data itself that were collected through observations, interviews, and the researcher's journal. The digital audio interviews were transcribed and converted to text, which constituted the main form of data analysis. The information was processed through thematic analysis (Bowen, 2009; Braun & Clarke, 2012), by identifying and recognising patterns within the data. The flexibility of thematic analysis is essential (Braun & Clarke, 2012); it is not trying to limit this flexibility, but rather to provide a vocabulary and pattern for the researcher to start conducting thematic analysis in a thematic and methodological manner that represents a level of patterned response or meaning within the data set. The theme encapsulates an important aspect of the data related to the research question and represents a level of patterned meaning within the data set.

> *A theme might be given considerable space in some data items, and little or none in others, or it might appear in relatively little of the data set. So, researcher judgement is necessary to determine what a theme is. Our initial guidance around this is that you need to retain some flexibility, and rigid rules really do not work* (Braun & Clarke, 2012, p. 10).

Thematic mapping, visual (Braun & Clarke, 2006) and text-based findings (Frith & Gleeson, 2004) depicted and exposed the main themes and subthemes. The interconnections within the codes and themes were identified and redrawn. The thematic approach used in this study progressed through the six steps of Braun and

Clarke (2012). Figure 7 below is an image created by Walstra (2022) illustrating the data analysis process after the funnel by Braun and Clarke (2012).

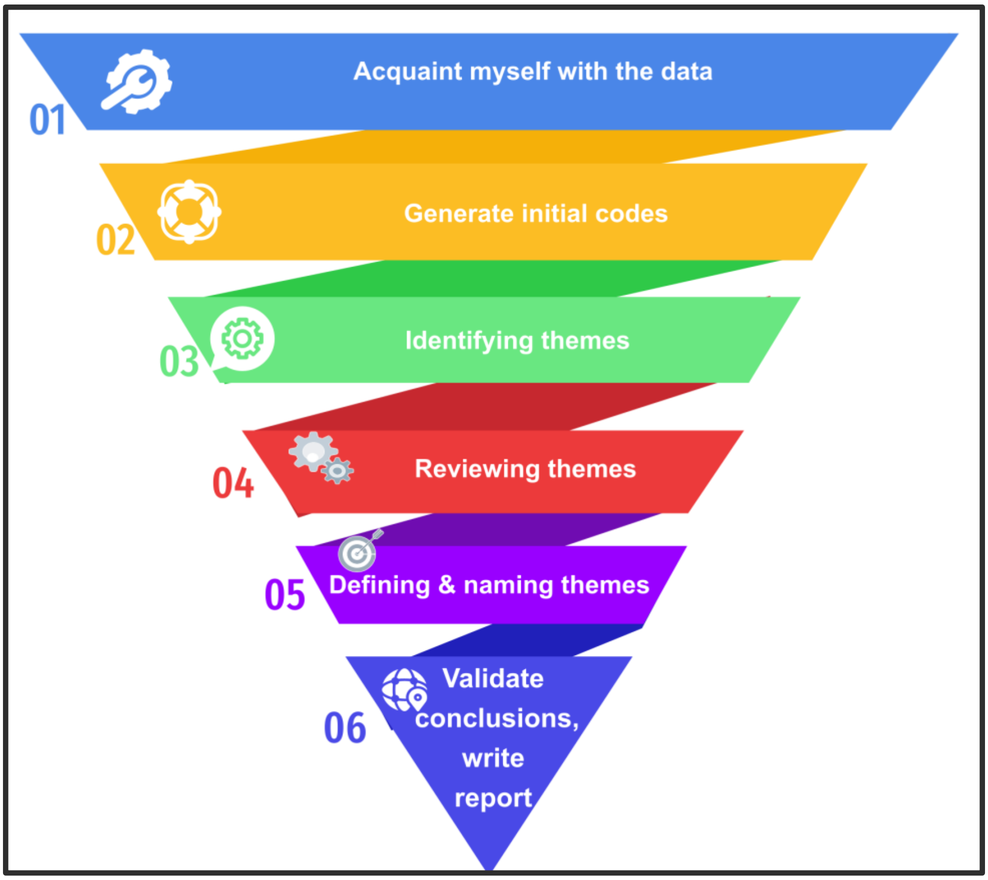


Figure 7: Walstra (2022) after Data analysis process funnel by Braun and Clarke (2012)

3.6.1 Step 1: Getting acquainted with the data

During the exploration phase (Adams et al., 2007), the researcher immersed herself in the data. The interview recordings were carefully listened to and personally transcribed. The transcribed text was read and re-read. She investigated and explored the detailed information of the documents (O'Leary, 2014). Walker (2020) suggested that photographs may offer further insight that is not captured by written text or spoken language. Therefore, the value of analysing photographs and videos was to provide further context to the research data in creating rich resources.

The purpose of acquainting herself with the data was to detect patterns and identify deviants and oddities, making notes on the entire data set and the individual transcripts.

3.6.2 Step 2: Generating initial codes

The content of the interview transcripts was coded or labelled as short descriptors of sentences through a systematic procedure (Bowen, 2009). These codes provide labels for the characteristics of the data that could be relevant to the research question (Braun & Clarke, 2012). The researcher was critical of the content of the lesson plans and interrogated their comprehensiveness and selectiveness when assessing and analysing their data (Bowen, 2009) in relation to the curriculum document content for the associated lessons (for example, the lesson content knowledge and outcomes should align with the curriculum content description). Both latent and semantic levels of meaning were sought and looked for when analysing the information. The semantic or descriptive code is an explicit presentation of the meaning of the participants' data content and is the surface meaning of the data (Byrne, 2021). Latent or interpretive code identifies and informs deeper meanings underlying the semantic surface of the data, such as underlying assumptions or ideas (Braun & Clarke, 2012; Byrne, 2021). As part of this step, she coded all data and ensured that the relevant data for each code was collated. The novice coder needed to remember and ensure that all codes were relevant to answering my research questions.

3.6.3 Step 3: Identifying themes

This process, rather than focusing on codes, was to realign broader themes. This is accomplished by sorting the various codes into possible themes and collating the relevant extracts of coded data into identified themes (Braun & Clarke, 2012). I systematically identified and organised all information by actively searching for similarities in data. During this process, overlapping patterns emerged between code patterns. Thematic analysis of identifying and analysing qualitative data (words, text, or images) followed the path of aggregating words or images into themes (Miles et al., 2014). These themes should make sense of the content to enable a researcher to derive meaning. She constructed and generated themes by collapsing or clustering existing codes. The themes emerged from the data's congruous and common phrases or statements (Kvale, 2007). Themes were identified in the data set (common statements and extracts) as the information was analysed (Bowen, 2009; Braun & Clarke, 2012). The relationship between themes was explored by collating the data extracts connected to each theme. These themes related to the affordances and teaching practices of the teacher participants and themes identified within the literature. To answer the research question, she investigated how themes might work together to tell an overall story about the data. Before beginning to review the themes, she created and collated a thematic table and a map that summarised the potential themes (Braun & Clarke, 2012).

3.6.4 Step 4: Reviewing Potential Themes

This step had two levels of review administered as a recursive process of drawing conclusions. It was done by comparing and analysing the themes, and by quality checking themes throughout the entire data set and analysing identified recurring patterns, language, and opinions. An iterative review process (Hay, 2005; Turner, 2010) was then used as a more in-depth process to interpret the collected data and to combine elements of thematic analysis. During the iterative data analysis process, the data was scrutinised through cycles of analysis, in which more specific trends and patterns were interpreted. The process was repeated until decisions and results were achieved (Braun & Clarke, 2012).

As in level one, coded data extracts were reviewed; reading and collating each theme’s extracts to create coherent patterns (Braun & Clarke, 2012). For example, if a theme has a coherent pattern, it must move to the second level. If the themes were inadequate, I had to consider whether the theme was problematic, or whether parts of the data extracted did not fit. In both cases, the themes had to be reworded, recreated, or I had to source new homes for ill-suited extracts. With all these themes, an initial thematic representation became evident.

A similar process was conducted during stage two, but in relation to the entire data set. Research dissemination is evidence translation by communicating findings back to the participants in a focus group (Knerr et al., 2016). The validity of individual themes was assessed in relation to the data set and the accuracy of the level one thematic map reconsidered. The last twenty minutes of the interview was used to disseminate and verify these identified themes. The interview was transcribed and used to validate the existing themes.

These themes were analysed by identifying potential themes. Data triangulation using individual interviews, a focus group interview, documents, photos and videos, and researcher journal, resulted in a broader understanding of the phenomenon of my particular research (Carter et al., 2014). Some codes and themes had to be identified, discarded, or reallocated to other themes. Additional themes were created. The themes were discarded if the correlation with the data that answered the research question was not evident. Braun and Clarke emphasise that the analysis should not be forced into coherence (2012). By the end of this stage, the potential themes are identified, indicating how they interlinked, and the story data revealed (Braun & Clarke, 2012).

3.6.5 Step 5: Defining and naming themes

Each theme had to have a specific name with a clear singular focus, scope, and purpose (Braun & Clarke, 2012). A detailed analysis was written for each theme, indicating its direct support in addressing my research questions. Sub-themes built on previous themes. The description of each theme was clearly described; what is unique, and how it is building on the previous themes. Each theme’s story was identified, how it interlinked with the other themes, and how it provided a coherent overall story about the data. The data collection and analysis of the small and diverse group provided 'high-quality, detailed descriptions of each case, which were useful for documenting uniqueness and shared patterns that cut across cases and derived their significance from having emerged out of heterogeneity' (Patton, 1990, p.174). I took due care to triangulate the data by considering multiple sources and gaining various perspectives to support the analysis of the phenomenon of the study (Patton, 1999; Carter et al., 2014).

3.6.6 Step 6: Validating the conclusions, writing the report

Finally, this step validates the conclusions and findings of the data. The combined data was synthesised, and conclusions were drawn and verified. The data were then translated into a report. It provides an informed and compelling story about the data based on the analysis. The story is complex, convincing, and clear (Bowen, 2009; Turner, 2010; Braun & Clarke, 2012) while embedded in the field of education, it addresses the research question. She considered the plans of Braun and Clarke (2012) to ensure that the research data is critically analysed to provide a rich answer to the research question.

3.7 ISSUES OF TRUSTWORTHINESS

The trustworthiness or rigour of the study refers to the degree of confidence in the truth of the research and the research findings. As researcher, it was her responsibility to put measures in place to maintain the rigour, trustworthiness, and quality of the research study (Pilot & Beck, 2014) and to establish valid and reliable knowledge, to produce ethical findings. According to Morse et al. (2002), research without such rigour becomes fiction and loses its usefulness. In seeking trustworthiness in qualitative studies, she addressed the credibility, transferability, dependability, and confirmability of the research results. This qualitative study is trustworthy; I maintained a high measure of objectivity and credibility by attending to matters of trustworthiness (Creswell & Miller, 2000) for establishing trustworthiness and rigour (Guba & Lincoln, 1982; Graneheim & Lundman, 2004; Cho & Trent, 2006). In the following section subheadings, I present some measures that were put in place during the entire research process to maintain the trustworthiness of the research study.

3.7.1 Credibility

The credibility of a study indicates confidence and truth about the research data by incorporating the views of the participants and the interpretation and representation of information by the researcher as the most important criterion (Polit & Beck, 2012; Amankwaa, 2016). Using multiple data sources and various approaches to analysing the data enhanced the study's credibility (Salkind, 2010). The data collected (observation notes, my researcher's journal, participant interviews, videos, and audio recordings) was analysed. The diligently accumulated records formed the foundation for creating a credible study and an accurate audit trail (Cope, 2014). According to Sadenloski (1986), a qualitative study is credible when other individuals recognise and associate with the human experience described by one participant. In this study, all eight participants (n-8) were invited to participate in a focus group to validate and discuss the themes that emerged. Three of the eight original participants attended this session. The viewpoints of the participants were also shared as a corroboration to build credibility and confidence in the truth of the findings (Amankwaa, 2016).

3.7.2 Transferability

In this study, transferability is achieved by providing vibrant pictorial descriptions, as Amankwaa (2016) referenced that when researchers relate vivid pictures that readers can relate to and describe. Transferability of research data described by Polit and Beck (2012) and Houghton et al. (2013) can be applied from this study to other primary school groups or settings. This study also demonstrates transferability by the extent to which the results are beneficial to people in other settings and is determined by how applicable the reader found the situation (Polit & Beck, 2014), such as other primary school teachers. The researcher assisted and supported the transferability of the study by producing detailed descriptions of the research methodology, participants, research sites, socio-economic context, and being explicit about the analysis and trustworthiness of data.

3.7.3 Dependability

Dependability refers to the data being constant and consistent under various similar conditions (Tobin & Begley, 2004; Polit & Beck, 2012). Guba (1981) explained that dependability is about discerning the same findings or outcomes under interchangeable circumstances. Koch (2006) explained that a study could be deemed reliable when the findings are replicated with similar participants under similar conditions. In this study, schools and individual participants were unique and varied; however, within the uniqueness, there was a commonality: the schools were all primary schools and the teachers taught Intermediate Phase learners. From this point of view, the study may be replicative and dependable. Study data was processed, and an audit trail of the analysed data findings was conducted because, as Koch (2006) indicated, an audit is a way to show that a study is reliable.

3.7.4 Confirmability

What Tobin & Begly (2004), Politie & Beck (2012), and Amankwaa (2016) describe as confirmability, is evident in this study when one considers the participants' actions. The findings are clearly obtained from the data. Data were triangulated, incorporating participant feedback, and this provided another safeguard against researcher bias. These were not influenced by her bias, interests, or viewpoints. Confirmability is also demonstrated and exhibited by the participants' quotes that reinforce and substantiate each of the emerging themes identified (Cope, 2014) during the analysis of the study.

3.7.5 Authenticity

The authenticity criteria are based directly on constructivism assumptions (Guba & Lincoln, 2001). Authenticity refers to how the researcher expresses the feelings, ideas, and emotions of the participant's experiences faithfully, realistically, and authentically (Polit & Beck, 2012).

3.8 Ethical Considerations

The ethical clearance and approval process assisted me in reflecting deeply on the way she conducted her research (Head, 2018; Velardo & Elliot, 2018) throughout the study. The selected participating schools were independent schools, and the teachers were not employed by the Gauteng Department of Education or the North West Department of Education[26]. Therefore, permission directly from the province was not required. The school principals provided approval for the research to be conducted in their schools.

[26] North West Department of Education, is the education department of one of the nine provinces of South Africa.

Research ethics ensure that participants are treated with dignity and respect while participating in and contributing to the study (Wassenaar & Slack, 2016). The confidentiality and anonymity of the participants (Bos, 2020; DoH, 2022) were ethically considered, pseudonyms replaced the names of individual participants, and the names of the school sites, documents and transcripts were securely stored. **Participant anonymity:** Anonymity in the research is to ensure the protection of the identities of the research participants (Clark, 2006; Allen, 2017) and not disclose their views and opinions. Informed consent is the standard and compulsory way of respecting the autonomy of participants (Edwards, 2005). The research participants, through informed consent, received the details of how the anonymity process would be achieved (Oliver, 2005). All reasonable protection was taken to ensure anonymity. Pseudonyms replaced the names of individuals and the names of schools. Descriptions of the schools' locations were also carefully considered. The participants were informed that they had the right to withdraw from the research at any time (Edwards, 2005).

Ethical considerations about the use of VR in the classroom and the principle of non-maleficence (do no harm) were a cornerstone of my consideration for the well-being of participant learners during their experiences in the VR study (Madary & Metzinger, 2016). Participants' learners used VR goggles. Safety considerations and discussions with each class of learners, ensuring no harm came to the learners. **Participant confidentiality** is the core tenet to ensure the protection of private information from participants by separating or modifying any personal identifying information provided by participants from the data (Allen, 2017), that were linked directly to participants (Wiles et al., 2007). The researcher took measures to protect participants' identities from being recognised or discovered by others (Mortari, 2015). Confidentiality within research is rooted in trust, understanding of access, analysis, and reporting of sensitive and private information between me as researcher and the participant with absolute care (Oliver, 2003; Bos, 2020). The participants also needed to trust her and that she would fulfil her responsibilities, protect the participant's information, and ensure confidentiality (Bos, 2020).

She found that going through an ethical clearance and approval process helped her to deeply reflect on the way she conducted her research (Head, 2018; Velardo & Elliot, 2018). The principals allowed research to be conducted in their schools within the Covid-19 pandemic regulations and limitations. The pandemic affected ethical considerations about the health and safety of participants, their learners, and the researcher. The new ethical considerations of wearing masks, using a hand sanitiser, and cleaning VR goggles and cell phones with product sanitise were factored in. These considerations were added to the permission documentation. Researcher bias was also addressed, with issues of trustworthiness and reflectivity.

3.8.1 Ethics and use of VR for research

The learners of the participating teachers were not research participants, but they used VR technology as part of their teacher's lessons. Ethical considerations regarding the inclusion of VR were considered in every lesson.

Awareness of age restrictions when using technology is most important. The producers of immersive VR systems noted an average age restriction of 13 years (Samsung, 2010; Oculus, 2016). The lower-cost, less immersive VR technologies used in the study, such as Google cardboard (Google VR, 2014) which used a mobile phone for the image, had no age restriction, but suggested that children use it under adult supervision. Therefore, the teacher always had to be present when the devices were being used.

Limited time frame when using VR in lessons: the VR technology interacts directly with the human being's phenomenological identity (Metzinger, 2014). Prolonged immersion and embodiment in VR could cause depersonalisation (Sierra & Berrios, 2000) or Derealisation Disorder (Madary & Metzinger, 2016). Although the studies are related to fully immersive VR systems, the VR experiences selected during the study were between three and ten minutes long. The teachers and the researcher consciously limited the time frame for using the VR goggles in lessons.

Vision and Use of VR: Howarth (2011) explained that seeing detail depends on producing a sharp image on the retina; therefore, intermittently using VR should not adversely affect the eye. The Canadian Association of Optometrists (2016) cautioned that prolonged use or extended exposure to the awkward and uncomfortable visual posture created by VR headsets could negatively impact the development of depth perception, tracking, and focusing. Howarth (2011) indicated that VR devices could mimic orthoptic treatment machinery, such as lazy eyes. Some VR headsets enable vision development and improved vision if used under an optometrist's instruction (Canadian Association of Optometrics, 2016). Rather than causing eye harm, noted Howarth (2011), VR headsets could assist in diagnosing and treating eye problems. There does not seem to be sufficient evidence of negative effects on the eyes when using VR headsets for a limited period. This was corroborated by Mukamal and Lipsky (2017); that VR headsets would not damage eye development, health, or function. However, making learners aware of possible dangers and limiting the time used, was important.

Motion sickness or cybersickness could be associated with VR technology (Canadian Association of Optometrics, 2016). Learners could feel dizzy, uneasy, or nauseous during the visual experience, as the experience matched what was happening physically. Viewing a VR experience involved motion, which provided the same signals to the brain as received during actual physical motion (Mukamal & Lipsky, 2017). Learners were informed that if when using the VR headset and they felt uncomfortable, dizzy, or nauseous, they should remove the headset. To ensure user safety, learners were carefully observed for dizziness and nausea while using the devices. There is a discourse about the physical impact of VR technology on the human body, especially if it is used for long periods. The devices were only used for short periods during lessons and under the supervision of both the teacher and the participant researcher in the classroom. Awareness and incorporation of the methodological considerations mentioned above were exercised throughout the study.

3.8.2 The role of the researcher

The role of the researcher learner (Glesne, 2006) incorporates reflexivity as a tool (Finlay & Gough, 2008) to analyse the personal experiences and presuppositions, which shaped and influenced the research journey (Mantzoukas, 2005). The need to guard against researcher bias was a priority. Reflexivity is a continuous introspective process of subjectivity to the researcher's values throughout the research process (Parahoo, 2008). In bracketing (Fischer, 2009), the research to guard against bias (Surry & Land, 2000), while bracketing may have an adverse effect on the research endeavours by facilitating herself, as the researcher, to explore and reach deeper levels of reflection across the research (Tufford & Newman, 2010). She examined and reflected on the contextual and social issues that shaped her research. The opportunity for in-depth reflection may enhance the acuteness of the research and facilitate more profound analysis and results. The role of the researcher was that of an interpreter (Stake, 1995). She acknowledges the changes within herself because of the research process and how these personal changes impact and affect the research process. Authenticity (Palaganas et al., 2017) is achieved through her personal reflexivity reporting (Mantzoukas, 2005). The path of self-learning and the influence on the research process result in an empowering, iterative process, informing the reader by acknowledging her role, describing her involvement, experiences, and interests (Fossey, et al., 2002), and the position and situatedness (Vannini, 2008) of her research.

3.8.3 Researcher reflexivity and reflectivity

Reflectivity reflects turning back to self and reflecting on the information, therefore, being both observed and being an active observer (Steier, 1995). Reflexivity is dynamic, immediate, and involves reflexive introspection (Finlay, 2002). As a researcher she reflected on the practical aspects of the research and the metacognitive (mental thinking) processes about the meaning of the study (Mortari, 2015), and the data analysed. Bracketing (Ahern, 1999) was employed to reflect on the participants' experiences while engaging as the researcher with life-in-my-world in a thoughtful manner, providing the opportunity for acute, multifaceted analysis (Tufford & Newman, 2010). To reduce bias, attempts were made to address these issues: a comprehensive literature review was presented; she took care to use a representative sample of Intermediate Phase teacher participants, and a systematic and thorough data analysis process was followed. A question guide was used during the interviews, which also helped control researcher bias. Interviewing participant teachers interested in integrating technology into lessons was another measure against researcher bias. Using multiple data sources and various approaches to analysing the data enhanced the study's credibility (Salkind, 2010). Bracketing is implemented as a multi-layered process using reflection as a critical cognitive practice to assess levels of consciousness in the research field (Finlay & Gough, 2008), the process of self-dialogue and self-discovery of one's experiences (Maslow, 1996). It is used to validate research procedures. These personal reflexive introspection practices within oneself as the researcher across the study could allow for insights to emerge, supporting a generalised understanding and interpretation (Finlay, 2002) of the findings. The study uses the researcher's reflection and intuition as primary evidence (Moustakas, 1994). Biases are described as a researcher's systematic distortion of responses by participants or the instrument (Melville & Goddard, 2001). Readers may question the findings if they suspect any leaning on a researcher's personal agenda (Chapman, 2014). Therefore, the researcher sought reflexivity throughout the study, trying to limit her involvement, and striving only to observe. She always tried to be aware of her role as a participant-observer.

3.9 SUMMARY OF RESEARCH METHODOLOGY

This chapter outlined the meta-theoretical and methodological paradigm, research design, and the research strategy that informed the study. She presented the rationale for selecting a qualitative methodological approach and an instrumental case study inquiry to conduct the study. The chapter also describes in detail the research sites and participants that are consistent with the case study research design. The research instruments and relevant ethical issues and examined how the data were collected and collated. The data was analysed and interpreted to address the research question: How does the integration of VR simulations influence teacher classroom practice? This paved the way for Chapter 4, where the research findings are presented.

4. CHAPTER 4: FINDINGS

4.1 INTRODUCTION

This study examined the experiences and perceptions of eight primary school teachers who have used virtual reality as a teaching resource to understand how VR affects their pedagogy. I also observed and commented on how VR impacts learners' learning and engagement, and discussed with teachers the challenges and limitations they encounter with VR. To gather data, observations of lessons, in-depth interviews and a focus group discussion with primary school teachers using VR as a teaching resource were conducted. Lesson plans, the researcher’s journal notes, and curriculum documents were also gathered for analysis. In general, the findings suggested that teachers who have used VR in their classrooms had positive experiences and believed that it could improve their teaching and the engagement of learners.

Chapter 4 presents the in-depth findings on the phenomenon of how the use of VR simulations influences the teacher’s pedagogy. Eight participants’ vignettes are introduced. Understanding the implications of VR simulations for pedagogical change is the theory and techniques of teaching of teachers. Incorporation of VR into lessons identifies the value of self-growth, lesson preparation, safe integration of VR technology, and highlights challenges. Learners acquire knowledge and react to experiential learning with focused and immersive interaction with the use of VR technology. This new experience also influences teachers' classroom practices. Learners become excited and motivated. The increased memory retention, achievement of the results, and the impact on the assessment answers all affect beliefs and attitudes about the use of VR resources of the teachers. These findings identify nuances that impact teachers’ practice.

4.1.1 Vignettes of the research participants

The eight participants in this study were all South African intermediate phase teachers teaching in independent, co-educational schools. Intermediate phase learners were between 9 and 12 years old in grades 4 to 6. The participant teachers have all used the technology in lessons before the study. Only three of the teachers (Bhavna, Sarah, and Mary) have used VR in their lessons prior to the study. The five teachers who have never used VR before, were assigned the nicknames of Thandiwe, Kgomotso, Tammy, Ditria, and Siara; typical names of their sociocultural positions.

Thandiwe is an enthusiastic teacher, interested in learning about the 21st century skills and tools that are available to use with her students. She completed an educational degree in the senior phase, majoring in history and life orientation. However, she has only taught in the Intermediate Phase. Figure 8 is a character drawing of Thandiwe.

Figure 8: Character drawing of Thandiwe

Ten years ago, she started teaching at a government school in Mpumalanga. She has been teaching at an independent Christian school in Gauteng for the last seven years. She elaborated:

> *… since I taught at a primary level, I taught most subjects. I taught the languages isiZulu and English. I'm really passionate about English. So, it's not something I did at university, but I just see the need for learners to learn English. So, I would say, I enjoyed teaching English. I also loved life orientation and life skills. [Thandiwe]*

When Thandiwe spoke about the technology she used in the lessons, she recollected that

The only thing we used was the projector, but I normally used it in grade seven when I did creative arts. I'm a Grade 4 class teacher, most of the time I taught the grade fours, but I also taught creative arts to the Grade sevens… so sometimes I showed them whatever we were doing, whatever topic and things like that, that normally I used with the Grade Sevens. [Thandiwe]

Thandiwe had not used VR before the research.

Dhriti was a teacher who spoke excitedly and fondly of her lessons. Figure 9 is a character drawing of Dhriti.

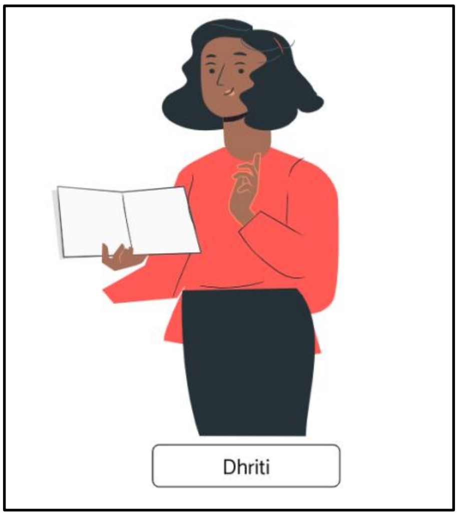


Figure 9: Character drawing of Dhriti

She planned thoroughly and gave the impression that she loved teaching.

Sure, I'll tell you about my teaching experience. I had only been a teacher for five years now. I originally studied environmental health. I worked at a platinum mine for nine years, from 2000 to 2009. And that's when my second child was born, which is when I decided I couldn't do it with two little kiddies. I couldn't keep working in the mines. So, I took a voluntary package and I stayed at home with my children for the next seven years. In the last two and a half of those years, I studied for my PGCE to become a teacher.

I happened to be chatting to a friend, outside my children's Maths class, and I said, don't you have a job for me? Because she wanted people. And she said, give me your CV. And here I am five years later. When I first joined, I stepped in for a teacher in the last term who went on maternity leave. So, then I taught computers and coding with the learners in all the Grades, including Grades R, 1, 2 and 3. I also taught Afrikaans to Grade R, 1, 2 and 3 at that same term. The following year I began to teach Grades 5 and 6 Social Sciences. I took over English from the teacher who left in 2018. I have been teaching English and Social Sciences ever since. I was also the Head of Social Sciences for the intermediate phase. [Dhriti]

Dhriti spoke about having bought a VR headset for her own children years ago. They had not used it for a long while,

> *because kids get bored very quickly. It was a reawakening of the VR headset the weekend before the lesson. [Dhriti]*

She explained that they found and used her VR headset, the one Dhriti had been given, as she looked for lesson resource ideas. She had not used VR in her lessons before the research. Despite their inexperience, both Dhriti and Thandiwe conducted three VR lessons for the study.

Kgomotso was keen to participate in VR research and explore whether there were potential benefits for her learners. Figure 10 is a character drawing of Kgomotso.

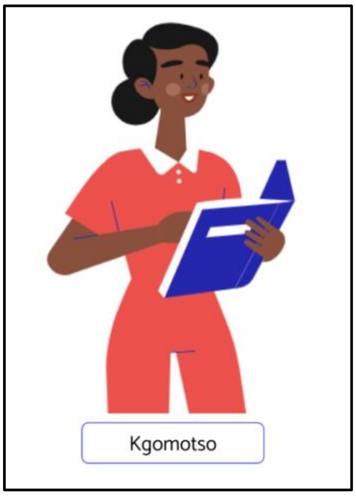


Figure 10: Character drawing of Kgomotso

Kgomotso obtained an educational diploma at a Zimbabwean church college. She taught in Zimbabwe for three years before she moved to South Africa. She began teaching at her current school in 2009 as a Grade 2 teacher. In 2014, she moved to the Intermediate Phase and completed her Bachelor of Education degree for the intermediate and senior phase in 2017. She now teaches from Grade five to Grade 7. She teaches Grades 5 and 6 mathematics, Grade 6 English, Grade 5 to Grade 6 NST, and Grade 7 natural sciences. She is the acting Head of Department (HOD) for Intermediate and Senior Phases. She explained:

We do not have subject HODs because it's a very small school. So, it's just a general, HOD. I act as a HOD for all the teachers. [Kgomotso]

She spoke about her teaching,

My favourite was teaching Grade seven Natural Science. There was challenging content, that I actually felt challenged myself. You know, when you were teaching, you were also learning so many things and I thrived in finding out, tried to see how my children really solved certain problems that they encountered for the first time in senior phase. The topic that fascinated me was space. I loved that topic. [Kgomotso]

Kgomotso used the data projector and previously showed her learners videos during her lessons. She planned to do more than one VR lesson, but finally, like Tammy, only one lesson was presented.

Tammy was keen to do a VR lesson as soon as possible after the initial meeting. Figure 11 is a character drawing of Tammy.

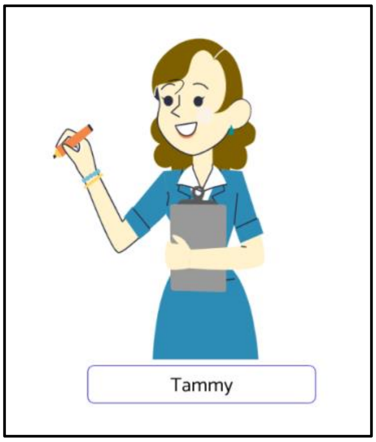


Figure 11: Character drawing of Tammy

She requested help when researching VR examples to relate to her selected lesson. She was an FET high school teacher with more than 14 years' experience. She was approached to teach in the primary school when they were looking for someone to teach Economic Management Sciences (EMS).

This was why I came in first. I have now been teaching at this school for five years. It was not a new thing, of being an intermediate phase teacher anymore. I also taught Gr 6 and 7 Natural Sciences and Technology (NST) and Maths, as well as Grade 7 EMS. So, I was always between those subjects. I preferred the younger age groups, than FET. I hadn't taught younger than Grade 6, and I think that was low enough. [Tammy]

Tammy was the Head of Department for Mathematics. She prepared lessons for the other teachers in her department. Although she was very interested in learning about virtual reality and to participate in the study, she had never been exposed to VR before the initial meeting. At the initial meeting, she wanted more information about VR and ideas of where she could source the resources. Thereafter, the principal, Tammy, and I had an informal conversational interview. After the lesson, she suggested lessons later in the term, but these did not materialise.

Siara's teaching position at the school was relatively new, although she has five years' teaching experience. Figure 12 is a character drawing of Siara.

Figure 12: Character drawing of Siara

She arrived midway through the previous term, and a colleague prepares the lessons that she teaches. She currently teaches Natural Science and Technology (NST) from Grade 4 to Grade 6. During her lessons, she uses a data projector and iPads. She has never used a VR headset before. With a limited number of headsets, discussions about the possibilities of group work were had. She found the idea of group work teaching interesting since she had never used it before. Her preference was for whole class instruction because she had more control; she wanted to ensure that all her students were on the same page. According to the rows in the classroom, she divided the learners into four groups. In addition to an introduction to wetlands, she reminded them of what they had learned in the previous term. She used

PowerPoint slides that illustrated various points. Siara taught only one lesson with VR. Although she agreed to participate in the study and even to be recorded, she found it was extremely difficult to participate in a recorded interview after the lesson. After the lesson, Siara and the researcher discussed it, and the information was documented. We left at the same time. Thereafter, she did not find the time to participate in a recorded interview, despite many requests.

Although the abovementioned five teachers had not used VR in their lessons prior to the study intervention, they were willing to participate. Bhavna, Sarah, and Mary had used VR in their lessons before the study. They were also interested in sharing their opinions about VR as a teaching resource.

Bhavna is an energetic teacher who speaks with passion and enthusiasm about her lessons and her learners. Figure 13 is a character drawing of Bhavna.

Figure 13: Character drawing of Bhavna

She seems to enjoy teaching and was keen to have her learners engaged interactively. She said that she loved VR as a teaching resource. Bhavna has a Bachelor of Social Sciences, specialising in psychology, and completed a post-graduate psychology diploma. Initially, she worked in a corporate environment and then made a complete career shift. The shift resulted in her completing a PGCE and thereafter, an honours qualification in education. She has been teaching for 11 years, starting at a government high school in KZN for four years and thereafter, predominantly teaching life orientation from Grade 8 to 12. She also taught EMS, business studies and accounting for a short while. When she moved to Johannesburg, she taught at a Montessori school for about three years. There, it was arts and culture, then English, and finally, natural sciences. She has been teaching Natural Sciences and Life Skills at her current school for three years.

Bhavna spoke about looking for ways to keep her learners participating in the lessons. She discussed the use of VR and other technologies such as iPads for students, the data projector, and cell phones, as well as the incorporation of textbooks, posters, and charts. She enjoyed the solar system and space-related VR scenarios for her lessons and shared her thoughts enthusiastically:

> *The VR videos took the learners well beyond the topics that we were exploring. I put a list on the board of the videos they could explore in VR. I used quite a lot of YouTube, as I felt it was accessible, and we used expeditions as well, when I first started using VR. [Bhavna]*

Sarah always wanted to teach.

> *I actually wanted to teach from the time I was in Grade two. It was a thing that didn't ever go away. I had an aunt that was a teacher and when I used to go and visit her, I was drawn to her. She loved books, she loved music, and she was a big character to me. She would always talk about her school children. Teaching was a wonder for me, it wasn't a career. It was more, 'wow!' [Sarah]*

Figure 14 is a character drawing of Sarah.

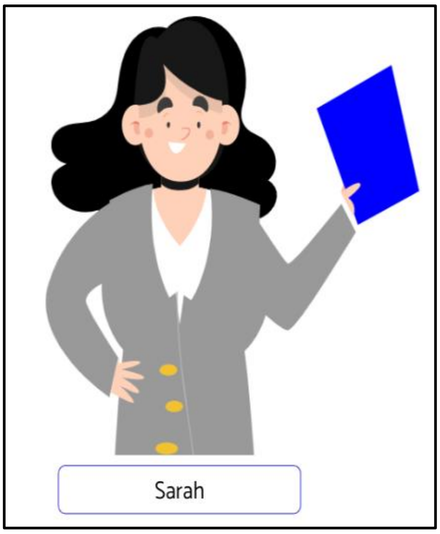


Figure 14: Character drawing of Sarah

While in Grade 12 during 1985, she applied for JCE and was accepted. Staying in residence, she qualified in 1989 with a Bachelor of Education degree. During a teaching practice, she taught at St. Vincent School for the Deaf, which she found interesting and challenging. She designed games that they could play and to learn on their own instead of relying on spoken language. Twice a week in the afternoons, she also taught nurses' children at Baragwanath Hospital in Soweto, for an American company. The focus was on maths and English. Thereafter, she taught maths and English at Saturday school. These various experiences highlighted the language barrier in different teaching circumstances. When she qualified, she began teaching in Bryanston and loved it. She described her teaching colleagues as guiding her wisely. Sarah was allowed to explore. She taught art. Learners made 3D food and birds with wings that flapped. She also taught at a small community school with limited resources and created her own posters and teaching resources. Joining an international exchange student programme which brought students to South Africa from South America and Europe, she taught them twice a year for six months at a time. Her role was that of hosting coordinator; she found host families for the students. After two and a half years, she went back to teaching, running the media centre at the Bryanston School. The media centre was an exciting space with a movie room, magazine subscriptions, visual displays, music, and books. There was a big budget to work with, and she had to generate ideas to promote reading. There were learners who were little librarians. This was a lovely teaching experience for her. After this interlude, she returned to the community school and ran the maths department. In 2013, she was approached to apply at the school where she currently teaches. The school was new and had many digital resources; iPads, Apple TV, and smartboards. It also introduced robotics, and Sarah taught STEM and coding. She spoke about the change of the school when it became curriculum-focused; encouragement of innovative learning ceased. She saw the impact of Covid on her learners, how they became bored and screen-fatigued. Sarah spoke about changing her teaching to actively engage with the learners and encouraged learners to focus on detail.

> *If they watched a YouTube video, what I started doing was asking them questions like why, asking probing questions. We are now all back at school, so it's more focus driven*

watching as opposed to just consuming. So, teachers by and large, I'm generalising, I don't think put on a video and say, right, let's discuss or let's stop. Let's just stop. It's almost like frenetic busy-ness. We are assuming that kids are learning at a rate of knots, but actually like to stop. What are we doing?

So, I think that information technology, or basically critical thinking and skills of discerning information, I see that as lacking. And, I think, there are walls between home and learning. What happens at home on Netflix, DSTV, PlayStation and anything, anything. The walls are very thin. And I think, whereas I even look at my own teaching, kind of a kid used to come in, and this was your isolation tank. So, your four walls were just so, your knowledge was bound by the covers of a book. Those were your boundaries for learning. And now there is no cover and there are no walls. So, if I found the more I've linked learning that the kids can have maybe got from home, the more brought home into, or experience into the classroom, the more there's connection and the more open the learning environment becomes. [Sarah]

Sarah questioned the system and wanted more freedom. She enjoyed creating innovative lessons to inspire her learners.

Mary was the final participant. A character drawing, Figure 15 depicts Mary, the final participant.

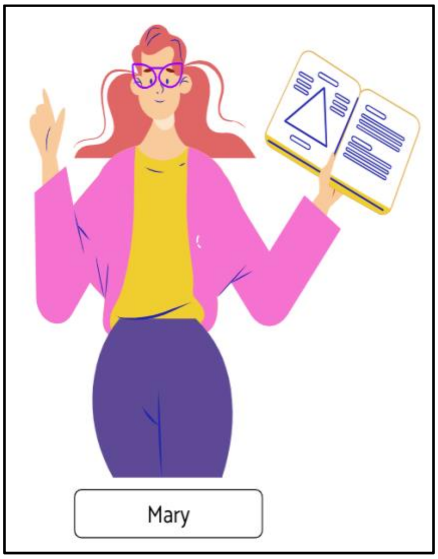


Figure 15: Character drawing of Mary

She gave the impression of thinking deeply about what she was going to teach and planned very thoroughly. She explored teaching methods to inspire and benefit her learners and used a range of resources and technologies. Mary had been teaching since 1986. She began teaching the intermediate phase in Johannesburg and then moved to the foundation phase, which she had trained in.

After that, I homeschooled my children for a year when we were in Europe, which gave me insight into how parent teachers work. When we returned to South Africa I taught here and there on and off, and then I started a special needs school because in the small town there were so many children who were just discarded and turned away from school. It started off as a little cottage school. And then, for five years around that, it grew to about 20 children a year. About a third of the learners went back to mainstream schooling within a year. Then the other third went to technical high school. And the last group stayed and continued at the school. [Mary]

After Mary and her family moved to Gauteng, the school became a school for adults as well. They provided adults with sheltered employment opportunities. She expressed it as follows:

so, it moved on, at least those children are cared for, and at least their parents have some sort of security for the kids. Despite the fact that it was quite exhausting, I enjoyed working with learners who had learning disabilities. It's a pleasure to watch them grow. [Mary]

When she got the opportunity to work at the LSEN (Learners with special education needs) school, she jumped at it. She began teaching art and technology. After eight years, she had worked on a whole school from Grade 1 to Grade 7. An opportunity came up to work in the computer room, but she did not want to be a conventional computer teacher. Her belief was that all learners should be digitally apt, adept, and they should all be working on computers with their teachers. At this stage in 2018, the integration of VR grabbed her attention. The school bought five VR headsets and mobile phones and started using VR in lessons.

Mary and two colleagues developed an enquiry-based learning approach subject called global collaborative design. As part of this subject, these teachers explored more natural and social science issues and applied them to the real world. Mary explained:

So, I felt quite happy because we had used the UN sustainable development goals. Those goals had come into play, especially with the big COP (UN Climate Change Conference) meeting and whether or not it was viable. Probably the children realised this was a reality. And we had to put ourselves out there. So, at any opportunity, I liked to take the children on an adventure. Took them outside of their own space, made them excited about learning. I was given the freedom to try new things. So, in my qualifications, I had done Feuerstein Instrumental Enrichment (IE) which was a thinking, cognitive thinking and enrichment tool set of tools. [Mary]

Mary had used VR in a variety of lessons and teaching opportunities. She spoke about being much more hands-on and practical than academic. She said, *I just felt that the children learnt through the experience, whatever the experience might be. So actually, that was how, that was why I liked the VR, unfortunately with Covid, we didn't do VR nor even robotics. But recently, we began to use VR again. The way we used them was a station when we had completed a theme's work. Recently, we had groups and they moved from station to station. VR was one of the stations. We did the weather, and then I had this great VR of a weather balloon that went up. And then the children were taken up into the atmosphere of the earth, and they absolutely loved it. It was from Grade one to Grade seven, they just thoroughly enjoyed that experience. [Mary]*

In conclusion, I observed 12 lessons presented by eight teachers in these wide variety of circumstances, as part of the study. During the interviews, teachers shared their opinions and information about using VR as a teaching tool and how these views impacted their teaching pedagogy. These comments are recorded in this findings chapter.

In the next segment, I discuss the VR connections that were explored, and the value of VR in lessons regarding self-growth, lesson planning, technology use, and the observed teachers' challenges. As a result, the eight teachers shared their observations on the potential effects of virtual reality on their pedagogical practices.

4.2 WHAT ARE THE IMPLICATIONS OF VR SIMULATIONS FOR CHANGED PEDAGOGICAL PRACTICES?

This study aimed to create an understanding of the implications of using VR simulations in lessons from primary school teachers' point of view. These could result in changed pedagogical practices within the eight teacher participants' lessons. The participants recounted their inferences of VR resources in relation to teaching theory and described their teaching methods and the learners' reactions and responses. Teachers explained the value of VR integration into their lessons. Some teachers spoke about the benefits of personal development. They explained their planning methods and how the technology was used within their classrooms. The section concludes by recounting the challenges that the teachers experienced when planning the learning process. Below, Figure 16 indicates the implications of VR simulations to change pedagogical practices and describes the layout of the section.

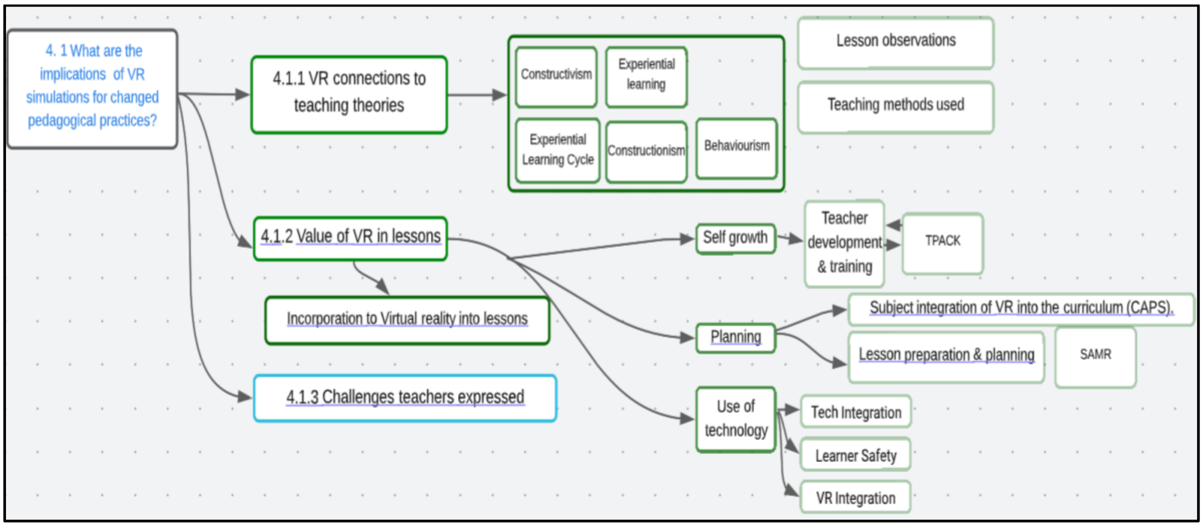


Figure 16: Indicates the implications of VR simulations to change pedagogical practices and describes the layout of the section

Tammy's experience succinctly addressed the value of VR as a teaching and learning resource. She used VR for the first time while participating in this study. In her reflection of the Grade 6 (NS) lesson, she stated that the inclusion of VR was enjoyable; it was different. She explained that this lesson was much more than learners simply completing an activity in a book. Her learners asked questions, and VR made the learners think out of the box. Moreover, she recounted how VR provided another learning opportunity about the subject content. It encouraged learners to think differently about content information and how it influenced teaching practices.

4.2.1 VR connections to teaching theories

Five learning theories served as an overview of teaching theories for this study, namely, Constructionism, Dewey's Experiential Learning, Kolb's Experiential Learning Cycle, Constructivism, and Behaviourism.

From a constructionist point of view, VR resources help create mental models for learners. It helped the learners understand the world around them. The eight participants spoke about how VR helped their learners build context and understanding when viewing VR scenarios.

Dewey's (2016a) 'theory of experience' suggests that everything occurs within a social environment and, in this case, the classroom. The learners' knowledge was socially constructed through questions and discussion and is based on experiences when using VR resources. All eight participants spoke about observing their learners' learning through these experiences.

Kolb and Kolb's (2018) Experiential Mode of the Experiential Learning Cycle noted that learning occurred here and now. Sarah spoke about how her learners discovered information when they viewed VR. Thandiwe mentioned that her learners asked questions about what they had seen. Tammy related how VR encouraged the learners to think. Seven of the participants (Tammy, Dhitri, Mary, Bhavna, Thandiwe, Kgomotso, Sarah) described examples of learners' reactions to the feeling that they were experiencing. They elaborated how their learners reflected on the content they had viewed and the information they were learning about in the lesson.

Constructivism described cognition as developing through mental construction, suggesting that people learn by constructing new knowledge when connecting their past experiences. Five of the participants (Tammy, Dhitri, Mary, Bhavna, Sarah) used constructivist strategies in their lessons by encouraging their learners to explore, determine, question, and interact with the VR scenarios. The learners then used the information to help them complete a lesson or task or to participate in a discussion.

Three participants (Thandiwe, Kgotmotso, Siara) used a combination of constructivist and behaviourist teaching methods. They began the lessons with a teacher-centred approach of explaining or revising content information, while not encouraging learner interaction. In all three cases, when the learners had to participate and complete the activities, they were encouraged to share ideas and ask questions.

When participants used VR technology as a teaching resource, teaching theories were identified. Figure 17 illustrates the teaching and learning theories the participants referred to and used. All eight participants referred to constructionism and the theory of experiential learning tendencies. Seven participants described situations related to the concrete experience mode of the experiential learning cycle here and now in their teaching practices. Five participants referred to constructivism as a learning theory they related to. While three participants described the use of both constructivist and behaviourist teaching methods. Figure 17 below provides the data about the teaching and learning theories the participants used during the study.

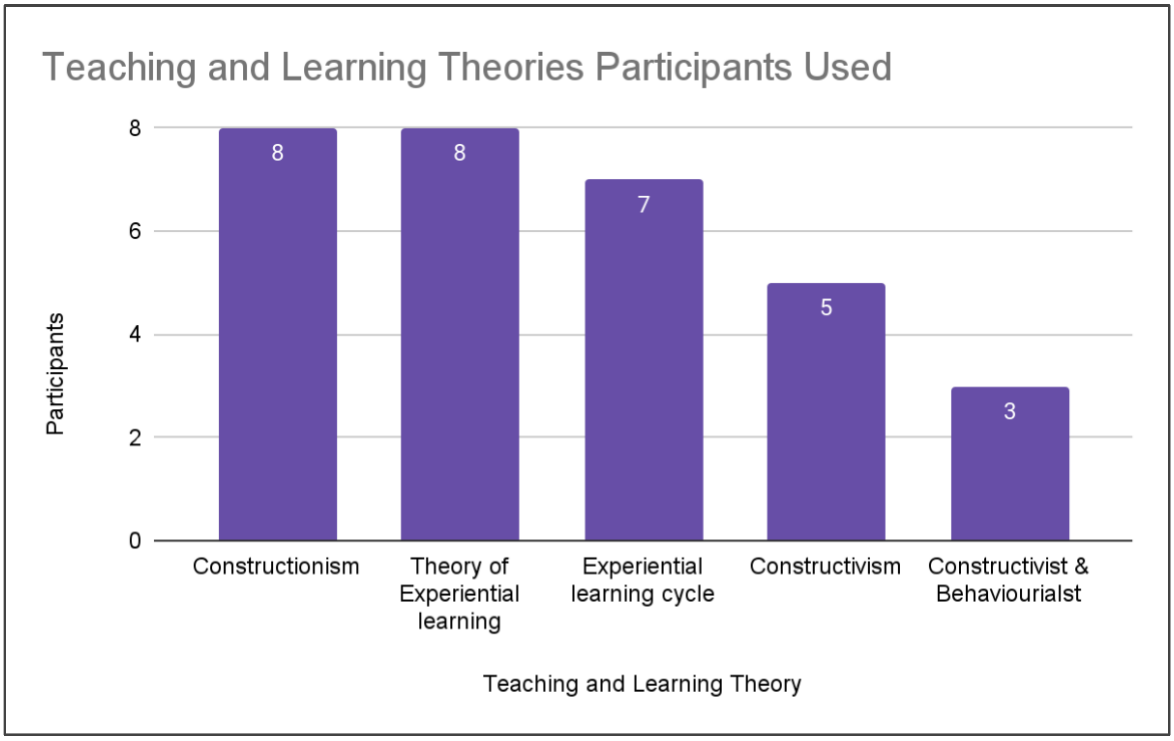


Figure 17: Teaching Theories Participants Used

Constructionism and experiential learning through interaction and participation were evidenced in all observed lessons. When the lessons were analysed, participants' connections were drawn to the teaching theories. The participants also used a variety of teaching techniques.

4.2.1.1 Teaching techniques

The subtheme 'teaching techniques', as part of the theme 'VR connections to teaching theories.' In addition to the teaching theories, the teachers presented various teaching techniques that they used in their lessons. Tammy, Dhitri, and

Siara had attended courses on Ryan's (2014) Thinking Keys and De Bono's (1985) Thinking Hats. These were built into their lesson plans. Dhriti's San lesson preparation, for example, included a Thinker's Key (Ryan, 2014) question task and used the Red and Green Hats of De Bono's Thinking Hats within the lesson activity.

- The Thinker's Key question prompted the different uses of an ostrich egg. Learners were asked to 'Look carefully at the ostrich egg. Can you come up with other uses for an ostrich egg, that is different to what the San used them for? Come up with as many as you can.'
- The Red and Green Hats activity posed the question, 'Pretend that you are a San person from 3000 years ago. Describe a day in your life'. The Red Hat represents emotion and intuition. Learners explored the question and shared feelings, fears, likes, and dislikes (The DeBono Group, 2019) that a San person might have experienced. While using the Green Hat, learners had to think of creative possibilities, alternatives, or new ideas that a San person might have considered.

Teachers used a range of strategies and techniques to facilitate learning. Some participants were encouraged by the school, while for others it was their own choice. Mary described how she and two other colleagues at her school had developed a subject that was an inquiry-based learning approach called Global Collaborative Design (GCD). They looked for ideas, explored them, linked them to natural science and social science topics, and applied them to the real world by using the UN Sustainable Development Goals (SDG) (United Nations, 2022). They linked it to the COP26 (UN COP26, 2021) and COP27 (UN COP 27, 2022) meetings to create awareness of reality among learners. Bhavna encouraged the engagement and interaction of the learners during lessons and talked about how her lessons had a question, discussion, and visualisation strategy. Sarah said that her learners were encouraged to explore and discover relevant information during lessons. Thandiwe used a question-and-answer strategy in learner presentations. Teachers integrated different teaching strategies into their lessons that they had been exposed to. They also used different teaching approaches.

4.2.1.2 Approaches to teaching

The subtheme 'approaches to teaching', as part of the theme 'VR connections to teaching theories.' Teachers used a variety of techniques in the way they approached their lessons. All used group work due to the limited number of headsets available for the lesson. When describing their manner of teaching, four teachers (Dhitri, Mary, Bhavna, and Sarah) spoke about a learner-centred approach. Three of the teachers (Thandiwe, Kgomotso and Tammy) spoke about using a combination of teacher-centred and learner-focused approaches, while one participant (Siara) preferred a more teacher-centred approach. Figure 18 graphically represented these views, showing that one of the participants (Siara) preferred teacher-centred teaching methods, four of them (Dhitri, Mary, Bhavna, and Sarah) used a combination of teaching approaches, and three (Thandiwe, Kgomotso, and Tammy) conducted learner-centred lessons. Figure 18 displays the data of the approaches to teaching that the participants spoke about and demonstrated during the observed lessons.

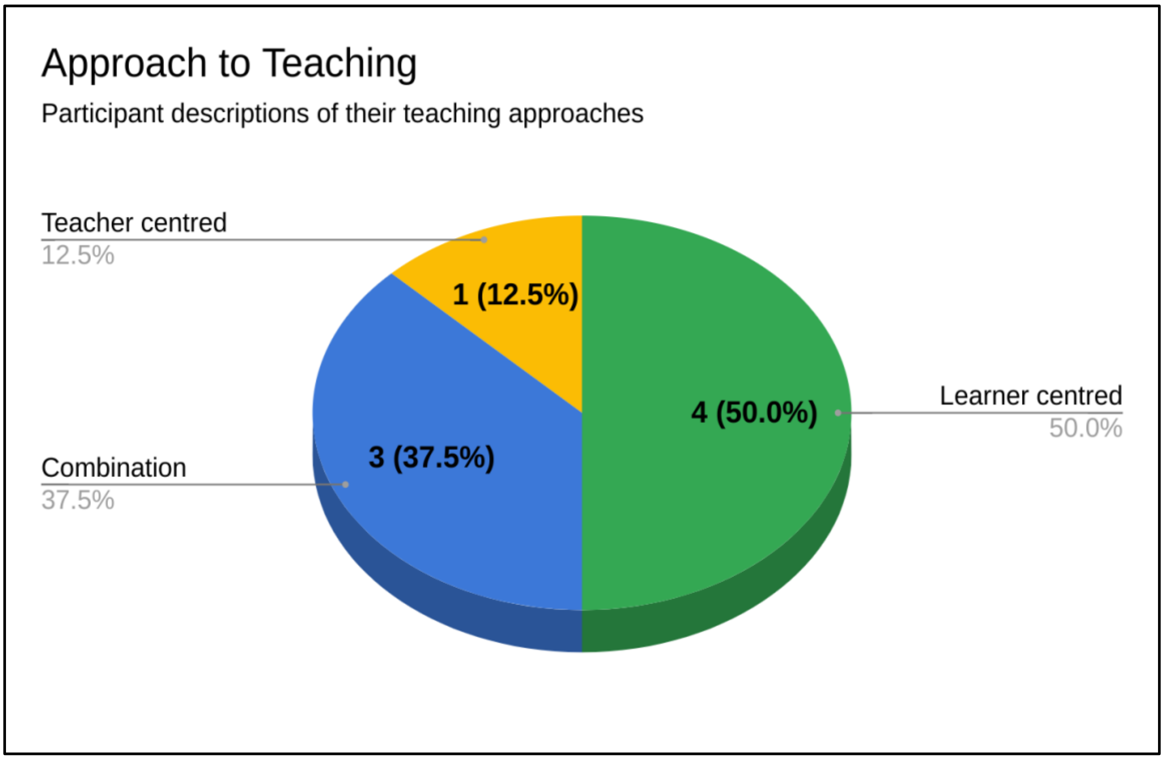


Figure 18: Approaches to Teaching

Teacher centred teaching

- Siara explained that she had never used group work before in her VR lesson. She said she preferred the whole class teaching approach; she could control and ensure that all her learners were on the same page. However, she thought that teaching with group work for the VR lesson was an interesting idea.

Combination of teacher-centred and learner-focused

- Thandiwe recalled that she taught one lesson and then gave the learners an exercise or activity to complete, usually as a whole class. As the learners worked, she assisted and provided additional information and support to those learners who required remedial assistance.
- Kgomotso spoke about her mixed teaching method as an explanatory teaching method, where she narrated and explained the information while the learners interacted and engaged. With the learners participating in groups, she would encourage them to ask and answer questions. While using her phone as a technology resource to source answers, she created and printed her own learner booklets beforehand and showed pictures or videos to clarify content information.
- Tammy stressed that she used different teaching strategies. The lesson began with a discussion. Information was drawn from previous lessons and questions were asked about the content. She encouraged learners to think about the content and ask questions. She found group work beneficial, as it allowed all learners to comment. She saw group work as using the strengths of each child to reach the learning goal.

Learner-centred teaching

- Bhavna had used VR before participating in the study. She spoke about using a learner-centred teaching approach. In these instances, she taught a topic, observed her learners, and observed their reactions. If she noticed that they were losing interest or drifting off, she would change the lesson strategy and encourage them to engage. She said that this was where the VR lessons came into play. She noticed that the learners thoroughly enjoyed the VR and reiterated her statement; she repeated that they absolutely enjoyed it.

- Sarah described her teaching style as allowing learners to explore and research a topic while she encouraged them to ask questions. She sourced resources for learners as they explored and built their content knowledge. Sarah facilitated learning in her lessons.
- Mary saw herself as a facilitator as she guided her learners' direction of learning. She would point them in a direction and allow them to explore and learn about the information from a safe space. Learners were encouraged to extend themselves by being asked relevant and specific questions, rather than general broad questions.

When addressing the potential implications of VR simulations for changing pedagogical practices, the participants' comments drew connections to differing teaching theories, techniques, and approaches. They perceived the value of VR in the lessons was explored while drawing inferences from observations and interview discussions.

4.2.2 The Value of VR in lessons

The word *value* was described as to consider with respect 'worth, excellence, usefulness, or importance' (dictionary.com, 2022). This section highlights the value of using virtual reality resources when teaching primary school. When using the VR headsets, the participants observed the learners' involvement, enjoyment, and participation in the lessons. The overarching theme is the value of VR in lessons. The participant teachers expressed the value they saw in incorporating VR as a resource into their lessons and reflected on the effective connection between the VR simulation resources to the content of the lessons across various subjects. This section focuses on three areas: The influence of professional development on the value of VR in lessons and its correlation with TPACK, the importance of lesson planning, and finally, the use of technology and learner safety. The eight participants had varying views and thoughts about their lessons and the influence that the VR resources had on the learners and their learning. Table 10 illustrates the number of participants who commented on each of the sub-themes. The theme 'Self-growth' has the subtheme 'Teacher PD'. The theme ‘Planning’ has four subthemes, namely: ‘Subject integration of VR into the CAPS curriculum', 'Lesson preparation and planning’, 'VR related to the content of the lesson', and ‘Covid-19 impact’. The theme ‘Use of technology’ has three subthemes, which are ‘learner safety’, ‘technology integration’ and 'VR integration' in lessons. Table 10, below, provides information about how the participants saw the value of VR resources in their lessons, by themes and sub-themes.

Table 10: Value of VR in lessons: Themes and Sub-themes

Overall theme: Value of VR in lessons			
Themes	Subthemes	Participants	Comments
Self-growth	Teacher PD	6	19
Planning	Subject integration of VR into the curriculum (CAPS).	8	10
	Lesson preparation & planning	8	38
	VR linked to lesson content	8	11
	Covid-19 Impact	4	7
Use of Technology	Tech Integration	8	15
	VR Integration	8	14
	Learner Safety	4	7

The participants related aspects of the VR lesson where they observed or where the learners expressed their excitement and engagement in the VR resource. When Bhavna was asked, 'Do you think VR was the kind of resource you would recommend to other teachers to explore and use?' She expressed how she found great value in using VR.

> *Absolutely. Absolutely. I don't know. I don't think every subject can probably use VR. I'm not too sure I could be wrong, but I know that like with science maybe like social sciences, I absolutely recommend it, so far in our school, I know I have probably used that VR headset more than anybody else has used it. [Bhavna]*

Kgomotso conducted one VR lesson and spoke about her learners as being

> *… more engaged. It is something that they were using for the first time, so because of the excitement, they were more engaged. [Kgomotso]*

Mary also indicated that during the lesson, her learners 'were excited, engaged, and participated' in the activities. Dhriti conducted three lessons (SS - History and English) with two classes using VR. More than once, Dhriti spoke about the value of VR in her lessons. She expressed that

> *The children really loved it. I see great value in using it, and want to incorporate it into my lessons. . . The learners were so involved and interested. They used it individually, but it reinforced what they were doing in the other activities. . . reinforcing their knowledge and building their knowledge. [Mary]*

Tammy noted that the value of VR is that 'I think this technology could be used in lessons for kids to interact.' Siara said that she would have been keen to use the VR technology in her lessons. She recalled her learners were interested and involved during the lesson. Each of the participants talked about the participation of the learners and the value of this involvement.

The teachers noted the participation of their learners and discussed the value of lesson integration. In this study, the VR scenarios ran across four Intermediate Phase subjects, namely English (Thandiwe and Dhriti), SS - History (Dhriti and Sarah), and Natural Science and Technology (Kgomotso, Tammy, and Siara). Thandiwe felt that the VR resource was beneficial to her learners and to herself, in that she saw the benefit in more than one subject; she conducted two Life Skills lessons and one English lesson. Dhriti felt the same, with her lessons also in the two subject areas. Sarah saw the value of using VR as she was able to take learners to places that would be inaccessible due to cost or access, such as visiting an international museum. Mary agreed with Sarah and explained that when using VR in lessons, learners could be taken 'on a journey without leaving the classroom.' Tammy supported the view, recalling that one of her learners mentioned that he 'got to see all the different places'. All these teachers spoke about the various ways they valued VR in their lessons. As one progresses through the chapter, the value of VR as an educational tool was further illustrated.

4.2.2.1 Self-growth - Teacher Professional Development

The exploration of the value of VR in lessons is the subtheme ‘teacher professional development’, as part of the theme ‘self-growth.’ Participants spoke about the value of learning and self-growth within their teaching context. Thandiwe mused about learning continuously.

> *As the teacher, I always said there was always room to improve. We were all learning. We were all learners, lifelong learners and we learned, we also told them (the learners), I learnt from you guys. I was the teacher, but I do not know everything. [Thandiwe]*

According to Sarah,

> *teachers needed to learn to play. That sounded really weird, but teachers needed to learn to play. They needed to experience it (the VR) themselves so that they saw the value in it. [Sarah]*

Kgomotso spoke about wanting to try the VR herself, to see what it was like. She saw the value in using VR; her learners had access to cell phones, and therefore this technology could be an added value in a lesson.

- Professional Development Training

Participants were exposed to varying intensities of VR professional development (PD). During 2018, Mary had attended a course of three VR sessions on the integration of VR into the classroom. Bhavna and Sarah attended a two-hour introductory workshop to VR when the school acquired VR headsets. Thandiwe and Kgomotso attended a one-hour awareness workshop about VR and examples of VR resources, to decide if they wanted to participate in this study. Tammy, Dhriti and Siara had a 30-minute demonstration and discussion about VR when they agreed to participate in the study. Table 11 provides further details about professional development, the first column are the participants’ pseudonyms, second column contains information about the VR related professional development (PD), and the last column addresses the overall reason for the VR PD.

Table 11: Participant VR PD Exposure

Participant Pseudonym	**VR related PD**	**Reason for VR PD**
Bhavna	2-hour SACE endorsed course, full staff (Aug 2019)	Whole staff PD workshop
Dhriti	No formal workshop, short 30 min demonstration and discussion (May 2021)	Requested by Principal for participant teacher for awareness related for lesson integration
Kgomotso	Staff information session - 1 hour show and tell (March 2021)	Requested by the Principal for teachers to decide if they wanted to be involved in the study.
Mary	3 x 2-hour SACE endorsed course (Nov 2018)	Self-selected PD course
Siara	No formal workshop, short 30 min demonstration and discussion (May 2021)	Requested by the principal for the participant teacher to have awareness related to lesson integration
Sarah	2-hour SACE endorsed course, full staff (Aug 2019)	Before research
Tammy	No formal workshop, short 30 min demonstrations and discussion. (May 2021)	Requested by the principal for the participant teacher to have awareness related to lesson integration.
Thandiwe	Staff information session - 1-hour show and tell (March 2021)	Requested by the principal for teachers to decide if they wanted to be involved in the study.

- Teachers' Practices correlated with TPACK

The study also explored the participants' teaching practices and associated them with the TPACK (Mishra & Koehler, 2006) knowledge areas. In all lessons observed, the teachers (n=8) demonstrated that they had sufficient content knowledge of the subject they were teaching. These eight teachers also demonstrated pedagogical knowledge (n=8) in their lesson planning and in the way they taught the lesson or lessons. All participants had also previously used technology in their lessons. Each had a laptop that they used for lesson preparation and school administrative tasks. These teachers had various forms of technological knowledge. In VR lessons, the eight participants identified and incorporated relevant VR scenarios to suit their lesson content. The resources were also age-appropriate for the learners they were teaching. Therefore, all participants (n=8) displayed Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006) within their lessons' creation and execution, as illustrated in Table 12 which listed the topics of the observed lessons and the titles of the VR scenarios.

Table 12: Participants' lesson topics and VR scenarios

Teachers' nicknames	Lesson topic	VR scenario
Tammy and Siara	Revision lesson Ecosystems	Google Expeditions: Ecosystems of Borneo (Google, 2015)
Dhriti (2 classes)	San and the hunt.	YouTube VR: The Intense 8 Hour Hunt | Attenborough Life of Mammals (BBC Earth, 2009)
Thandiwe	Emotions	Youtube VR: Know your emotions (Rocketkids, 2018)
Dhriti	Shipwrecked / Deserted on an island	YouTube VR: Do These Things To Survive If You Get Stranded On an Island (The Infographics Show, 2018)
Kgomotso	Nutrition	Youtube VR Food Groups And Nutrition (ClickView, 2020)
Thandiwe	Bullying	Youtube VR Cyber Bullying creates no hate (CreateNoHate, 2016)
Thandiwe	Listening comprehension	Youtube VR The ant and the dove (BooBoo, 2018)
Sarah	History of transport, looking into the future	Youtube VR transport 2030 (Covestro, 2018)
Bhavna	Wetlands (ecosystems)	Youtube VR iSimangaliso Wetland Park, South Africa (Drink Tea & Travel, 2020)
Mary	The Brain and Circuits	InMind 2 VR application (Luden,io. 2017)

The teachers' lessons were all related to curriculum topics for the subject area and for that term. The information of the lesson was relevant content knowledge (CK) (n=8) as prescribed within the curriculum context. (See Table 14 Subject Topic correlation to CAPS). The teachers' pedagogical knowledge (PK) (n=8) is evident in their lesson planning (see 4.2.2.2 Planning) and their association with learning theory (see 4.2.1 VR connections to teaching theory). All the teachers have used technology and VR technology (see 4.2.2.3 The use and safety of VR technology integration, Subtheme 2: Technology integration and Subtheme 3: Integration of VR technology) in varying forms within their teaching practice, exhibiting their technological knowledge (TK) (n=8) in varying degrees of competence. Therefore, it was established that the teachers have Technological Content Knowledge (TCK) (n=8) in the way they integrated the technology related to the content of their lessons. They demonstrated evidence of Technological Pedagogical Knowledge (TPK) (n=8) as they used the technology within their pedagogically considered lessons. Finally, they also illustrated Pedagogical Content Knowledge (PCK) (n=8) in the way the lessons were formulated. Therefore, it may be inferred that all eight participant teachers exemplified the comprehension of Technological Pedagogical Content Knowledge (TPACK) (n=8). Figure 19 illustrates TPACK and the observations of participants' practices.

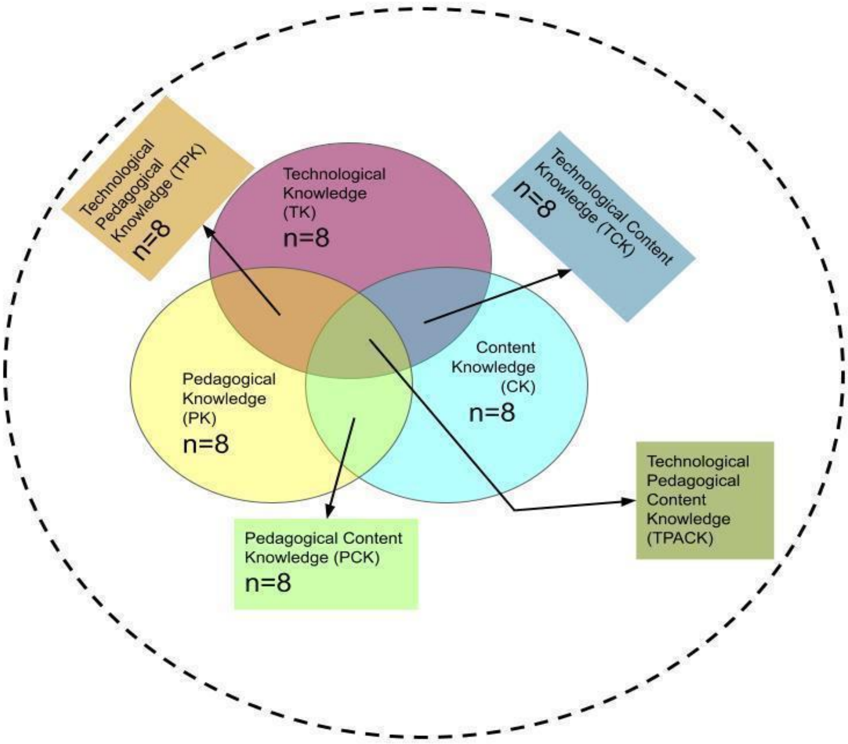


Figure 19: TPACK and Observations of Participants' Practices

The integration of technology into a planned lesson with pedagogical considerations illustrated the value of the TPACK framework (Mishra & Koehler, 2006). Because the study was specifically about VR technology, it indirectly demonstrated the value of VR in primary school lessons. The evidence of the planning of these lessons follows in the next section.

4.2.2.2 Planning

Planning lessons accurately is the most important. In this section, the exploration is how the teachers planned the lessons. Beginning with how the VR simulations were aligned with the curriculum subject content, and looking into the way the teachers undertook their preparation and planning of the lessons. Some teachers planned lessons for or with colleagues, others for themselves as individuals, and then some had to teach a lesson prepared by another teacher. Teachers considered the value of the lesson plans.

- Integration of VR into the curriculum (CAPS) subject.

The exploration of the value of VR in lessons is the subtheme ‘subject integration of VR into the curriculum (CAPS)’, as part of the theme ‘planning.’ Teachers did not prepare special lessons for the study; the focus was on integrating VR resources into existing lessons. Furthermore, the researcher wanted to determine whether these lessons aligned with the Curriculum Assessment Policy Statements (CAPS) (2012). The Intermediate Phase (IP) subjects are Language, Mathematics, Natural Science and Technology (NST), Social Sciences (SS), which include Geography and History, Life Skills, and Arts and Culture. The teachers (n=8) taught four different subjects in the three Grades (Grades 4 - 6) of the IP. Twelve lessons were observed. The number of lessons observed, the subjects, and grades taught by each participant (teachers’ nicknames) are displayed in Table 13.

Table 13: Observed research lessons

Teachers' nicknames	Observed lessons	Subjects	Grades
Dhriti	3 lessons	English & SS	Grade 5
Thandiwe	3 lessons	English & LS	Grade 4
Tammy, Siara, Kgomotso, Bhavna	1 lesson each	NST	Grade 6
Tracy	1 lesson	SS	Grade 4
Mary	1 lesson	GCD linked to NST	Grade 6

Four of the subjects were standard curriculum subjects, namely, Natural Science and Technology (NST) (n=4 lessons, Grade 6), Life Skills (LS) (n=2 lessons, Grade 4 and 5), Language - English Home language (HL) (n=2 lessons, Grade 4 and 5), and Social Sciences (SS) (n=3 lessons, Grade 4 and 5). SS lessons consisted of Dhriti's Grade 5 history lessons, taught to two classes, and Sarah's Grade 4 SS history lesson. Mary taught the fifth subject entitled Global Collaborative Design (GCD) (n=1 lesson), which was linked to NST. Figure 20 illustrates the number of observed lessons across the five subjects of the intermediate phase.

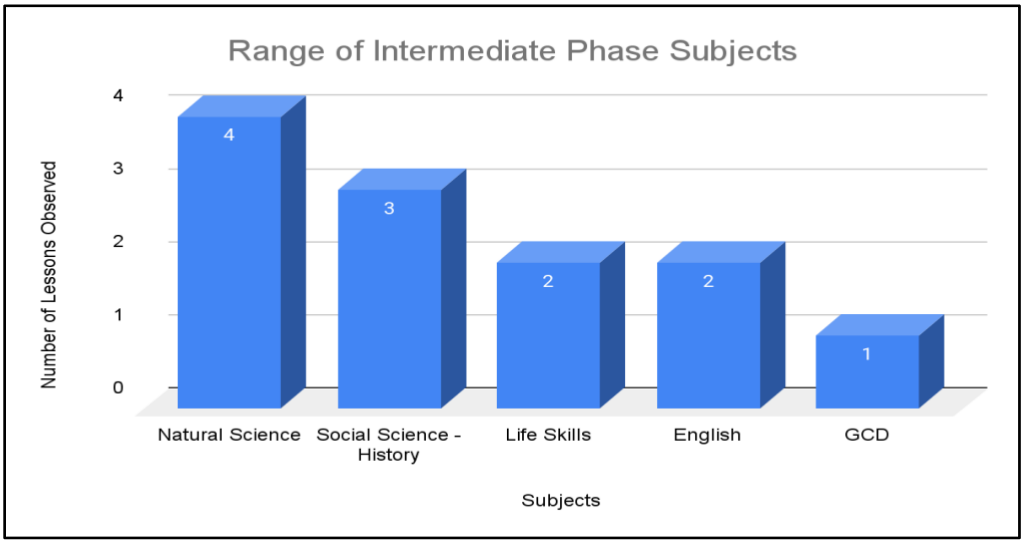


Figure 20: Range of lessons and subjects observed

All participants taught the South African national curriculum, called CAPS, even though they taught in private schools. Kgomotso spoke about how her lessons are directly aligned with CAPS and the Gauteng Department of Education requirements. She explained

> *When I planned my lessons, I used the resource books that we had, I had books that are CAPS orientated. … So normally when I looked at the topic (the lesson content) that I was about to teach, I also checked the documents that we got from the department, so that I knew I was in line with what the department wanted. (Kgomotso, Grade 6NS). [Kgomotso]*

Table 14 records the correlation between the lesson topics, the VR resource, and the content information of the CAPS subject curriculum. The first column lists the nicknames of the teachers. The second column indicates the subjects and grades taught by the various participants. The third column gives the titles of the VR resources. The fourth column names the lesson topics, and the fifth column describes the documents that describe the CAPS curriculum content related to each lesson.

Table 14: Subject Topic correlation to CAPS

Teachers' nicknames	**Subject & Grade**	**VR resources**	**Lesson topic**	**CAPS correlation**
Dhriti	English (HL) (Gr 5)	YouTube VR mode: Do These Things To Survive If You Get Stranded On an Island (The Infographics Show, 2018)	Visual literacy - Shipwrecked / Deserted on an island	CAPS IP HL - English Grade 5 Reading & Viewing - Visual Literacy Visual literacy (range of graphics and visual texts, e.g., advertisements, notices, posters, comics, cartoons, photographs, pictures): Creative writing -
Thandiwe	English (HL) (Gr 5)	YouTube VR mode: The ant and the dove (BooBoo,2018)	Listening comprehension	CAPS IP HL - English Grade 5 Listening and Speaking - Listening Comprehension • Retell the story • Recall specific detail in a text • Reflect on values and messages in a text • Reflect on stereotyping and other biases • Discuss character, plot and setting • Express opinions • Clarifying questions

Thandiwe	Life skills (Gr 4)	YouTube VR mode: Know your emotions (RocketKids, 2018)	Emotions	CAPS IP LIFE SKILLS GR 4-6 Development of Self - Emotions: Understanding a range of emotions (p 11) • Dealing with conflict Emotions - Understanding a range of emotions: love, happiness, grief, fear and jealousy
Thandiwe	Life skills (Gr 4)	YouTube: Cyberbullying create no hate (CreateNoHate, 2016)	Bullying	CAPS IP LIFE SKILLS GR 4-6 Development of Self - Bullying: appropriate responses to bullying
Tammy and Siara	NS & Tech (Gr 6)	Google Expeditions App: Ecosystems of Borneo (Google, 2015)	Revision lesson Ecosystems	CAPS IP NS & Tech Grade 6 - Life & Living: Ecosystems and Food webs (p.14) Different ecosystems (p. 49)
Kgomotso	NS & Tech (Gr 6)	YouTube VR mode: Food Groups and Nutrition (ClickView, 2020)	Nutrition	CAPS IP NS & Tech Term 1 Grade 6 Nutrients in food Nutrition (p. 17) Nutrition - balanced diets (p.49)
Bhavna	NS & Tech (Gr 6)	YouTube VR mode: iSimangaliso Wetland Park, South Africa (Drink Tea & Travel, 2020)	Wetlands (ecosystems)	CAPS IP NS & Tech Grade 6 - Life & Living: Ecosystems and Food webs (p.14) Different ecosystems (p. 49)
Sarah	Social Sciences - History (Gr 4)	YouTube VR mode: Roadtrip 2030: Future of Mobility Virtual Reality Experience (Covestro, 2018)	history of transport, looking into the future	CAPS IP SS, History Term 3 Grade 4 - Transport through time (p.17) Transport on land - 6 hours (p.36) - Modern forms of transport
Dhriti (2 classes)	Social Sciences - History (Gr 5 - 1st class & 2nd class)	YouTube VR mode: The Intense 8 Hour Hunt | Attenborough Life of Mammal (BBC Earth, 2009)	San and the hunt.	CAPS IP SS, Term 1 Grade 5 - Hunter-gatherers and herders in Southern Africa (p.17)
Mary	GCD class (global collaborati ve design) (Gr 6)	InMind 2 app (VR app) (Luden.io, 2017)	The Marvellous Brain (Correlation electric circuits in NST, and 'circuits' in our brains)	CAPS IP NS & Tech, Grade 6 Energy & Change - Electric circuits Electrical conductors and insulators Mains electricity (p.14) Electric circuits - Simple circuit (p.56)

As indicated previously, all (n=8) of the teacher lessons were related to the content of the CAPS subject that they taught, even though they were private non-government schools.

Mary taught Global Collaborative Design (GCD) (n=1 lesson); an inquiry-based learning subject that is linked to NST. She worked in collaboration with science teachers, taught children about the brain, and linked the information to electrical circuits. One of the lesson activities was to build electrical circuit badges. The images of the wire models of the brain created after viewing the VR scenario, illustrated the learners' interpretation of the neurons in the brain. As the neurons used electrical pulses, the information was useful to understand electrical circuits. The two pictures on the right show a learner building an electrical circuit badge. Below in Figure 21 are examples of the Grade 6 products produced as additional activities in the VR GCD lesson by Mary's learners.

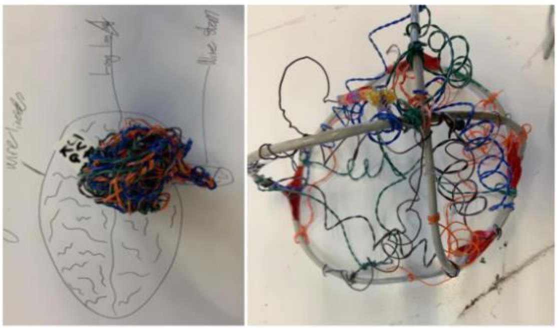
	
Wire models of the brain after VR	Electric circuit badge activity

Figure 21: Products produced as additional activities in the lesson (Mary, Grade 6, GCD)

When planning lessons, teachers considered the content of the curriculum and ensured that they addressed the relevant information.

- Preparation and planning of the lesson

The exploration of the value of VR in lessons is the subtheme 'preparation and planning of the lesson', as part of the theme 'planning.' The preparation of the lessons played an important role in teaching and learning. The teachers were asked to explain how they went about their planning. The eight participants had various approaches to how the lessons were planned. One participant (Mary - 11% of responses) spoke about collaborative planning, working with colleagues, and creating lesson plans together. Four individuals (Bhavna, Kgomotso, Thandiwe, Dhirti - 44% of responses) created individual lesson plans for their classes. Two participants (Saiba, Sarah - 22% of responses) used lesson plans that were created by a fellow colleague, and the lessons were provided to them to use in their classes. Two more participants (Tammy, Sarah) spoke about preparing lesson plans for others to use. One of the research participants (Tracy) spoke about planning lessons for others, as well as having to use lessons provided by colleagues, and therefore, the total number of responses was nine. The chart (Figure 22) illustrates the number of research participants who were assigned or created lesson plans for themselves or for colleagues to present.

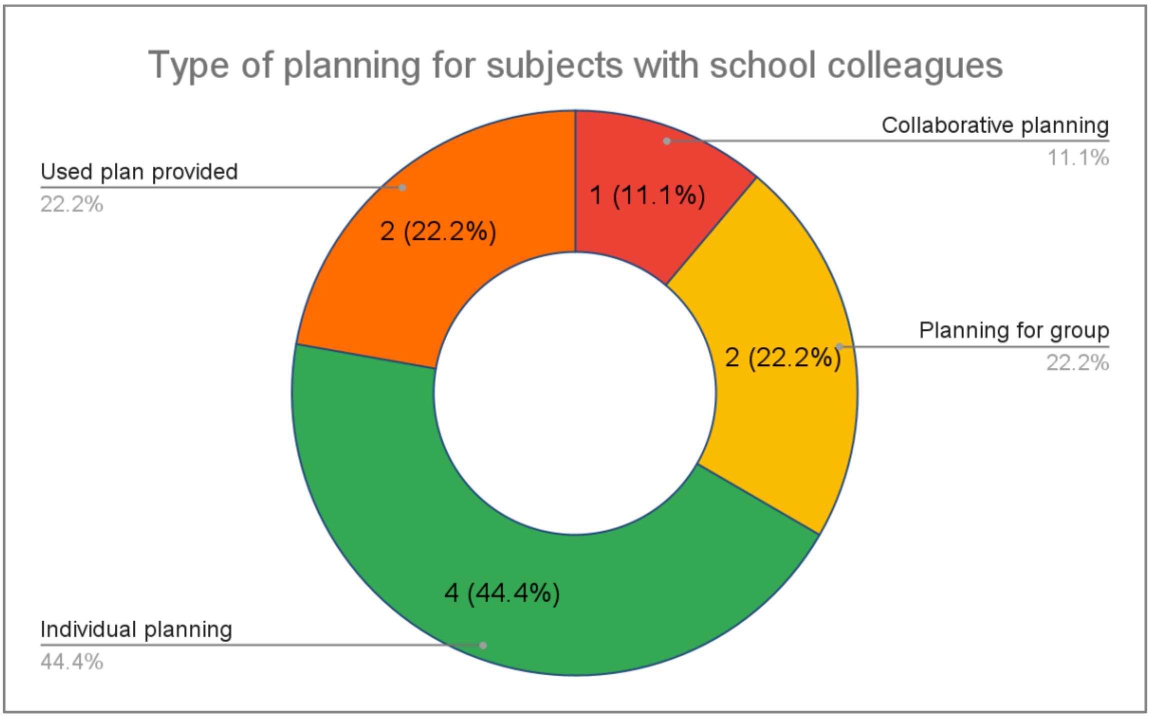


Figure 22: Type of planning for subjects

- Planning lessons for or with colleagues

The exploration of the value of VR in lessons is the subtheme ‘planning lessons for or with colleagues’, as part of the theme ‘planning. ‘Three participants (Mary, Tammy, and Sarah) referred to lesson planning with, or for colleagues. Mary explained how she collaborated with her colleagues and created the GCD lessons. The VR lesson was linked to circuits in Natural Sciences and the correlation of the electrical circuits with the neurological circuits of the brain. She explained that because they are an LSEN school, many learners take medication, and while playing this VR app (inMind2) learners could relate to the neurons in the brain, the impact of their medication, and their emotions. The adventure VR game InMind 2 application was inspired by the Pixar/Disney movie 'Inside Out " and Lövheim's theory of emotions and placed emphasis on the chemistry behind human emotion (Luden.io, 2020).

In both Tammy and Sarah's cases, lessons were prepared for other teachers to use. As the subject head, Tammy prepared the lesson for both her class and for Siara to use in hers. The VR was integrated into the lesson as one of the activities that the learners performed as part of the lesson. Figure 23, below, is an extract from Siara's Natural Science (NS) Grade 6 lesson plan.

What this may look like	Possible Resources / Games / Activities
A PowerPoint Presentation is used to revisit different ecosystems. Small group work activities carried out to explore this topic. VR equipment used to visit Borneo to observe an ecosystem.	A PowerPoint presentation Crossword Wordsearch Virtual reality

Figure 23: Extract of the Natural Science lesson plan (Siara, Grade 6, NS)

Sarah's lesson planning in her grade was similar. She usually planned a lesson for a group of teachers teaching the same subject and grade, which was vetted by the subject head before sharing it with her colleagues. In her comment, Sarah explained that there was resistance when she wanted to integrate VR as a resource in the actual lesson for all teachers to use. She was told to move the resource to the back of the book as an extension. She said,

> *It was natural science. I used one of those guided VR tours. The way we prep is you create a booklet and I kind of tried to insert the technology into the booklet. Our booklets needed to be checked, obviously. And they told me to put all the experiential learning at the back as an extension where, for me, it was part of the process and part of the changing of thinking. [Sarah]*

Sarah was a participant in the VR research, she created a lesson on a transport topic, linked to the SS History that she was teaching that term. She focused on the future of transport and innovation. The lesson was also linked to a line in the school song, ‘Innovation nurtured all the way.’ The students discussed and brainstormed the word *transport* before applying VR to the 2030 topic. Figure 24 below is an image of Sarah’s whiteboard illustrating the link of the topic to the school song, during the Grade 4 Social Sciences lessons.

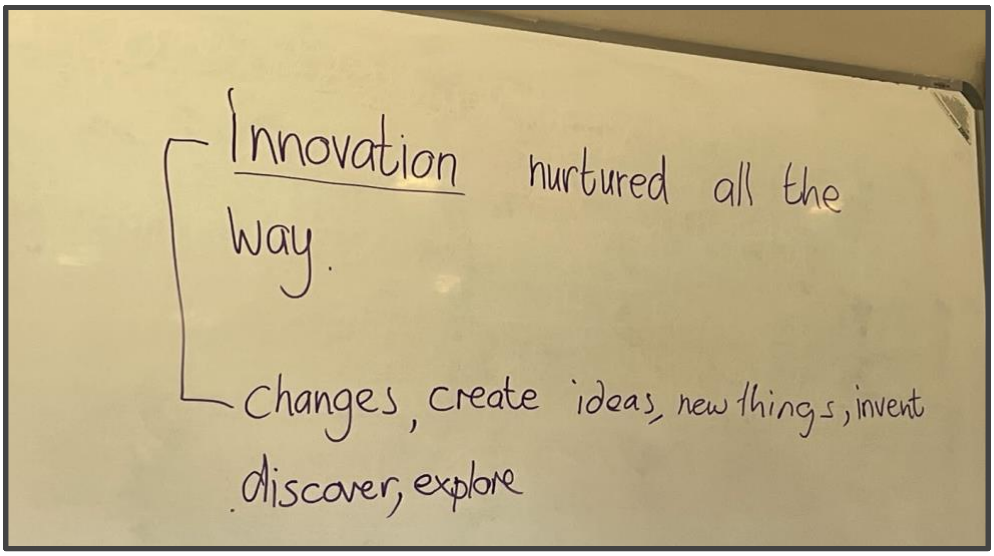


Figure 24: Whiteboard image showing a link of the topic to the school song (Sarah, Grade 4 SS)

- Planning own lessons

The exploration of the value of VR in lessons is the subtheme ‘planning own lessons’, as part of the theme ‘planning. ‘Four of the teachers planned their own individual lessons and integrated VR into the lesson as a resource. Table 15 below provides information about the participants who planned lessons individually.

Table 15: Participants who planned lessons individually

Teachers' nicknames	Subjects
Thandiwe	Grade 4 English and Grade 5 Life skills
Kgomotso	Grade 6 Natural Science
Bhavna	Grade 6 Natural Science
Dhriti	Grade 5 Social Sciences (History) and English

Thandiwe said that when she was planning, she wanted to create a link between the VR scenario and the Life Skills content. Teachers also had to keep the rest of the learners engaged while some were using the VR; simultaneously, the lesson content linked to the same topic.

> *So, I just thought, how would I keep those ones engaged while they were doing this VR and made sure that it all links together, the visual that they were getting also linked with what we were doing in class. So maybe, there should be that link. Okay. I needed to create that link that they shouldn't be doing something in life skills and then something different in their visual. There needed to be a link. [Thandiwe]*

Two teachers spoke *about* the use of textbooks and other resources when planning their lessons. Bhavna included information from textbooks and VR related to the topic being taught when planning. She then used both resources in her lessons.

> *I have them (the learners) have the textbooks open. We have a general discussion. I linked it to the VR and the textbook information. [Bhavna]*

When she planned her lessons, Kgomtso recorded all information; she recorded the textbook pages as well as any experiments, activities, and if I used a VR example. All I would be going to do during the week, my lessons were guided by that.' Dhriti incorporated the actual link to the VR into her lesson preparation. She did not just provide the title or make a general statement that VR was used. Below, Figure 25 illustrates how Dhriti incorporated the actual link to the VR into her lesson preparation.

What this may look like	Possible Resources/Games/Activities
A discussion as to who the original people of Southern Africa were. A power point highlighting key aspects. A Thinker's Key (Different uses) activity A Red and Green Hat activity Word Scramble game (group work) with the key words. (see attached)	Social Science Textbook page 93—95; 97-8 Printed activity sheets YouTube video in VR mode of an actual San Hunt from the BBC, narrated by Sir Richard Attenborough. https://www.youtube.com/watch?v=826HMLoiE_o VR Goggles provided with cell phones with Wifi connection.

Figure 25: Dhriti incorporated the actual link to the VR into her lesson preparation

Teachers integrated the VR technology into all their teaching practices and lesson plans. Technology integration was correlated with the SAMR model (Puentedura, 2006), augmentation (n=5) and modification (n=3) stages. Figure 26 shows a graphic representation of the VR resource integration into lessons related to those two SAMR stages. Figure 26 below depicts the VR resources in the study's lessons linked to SAMR stages.

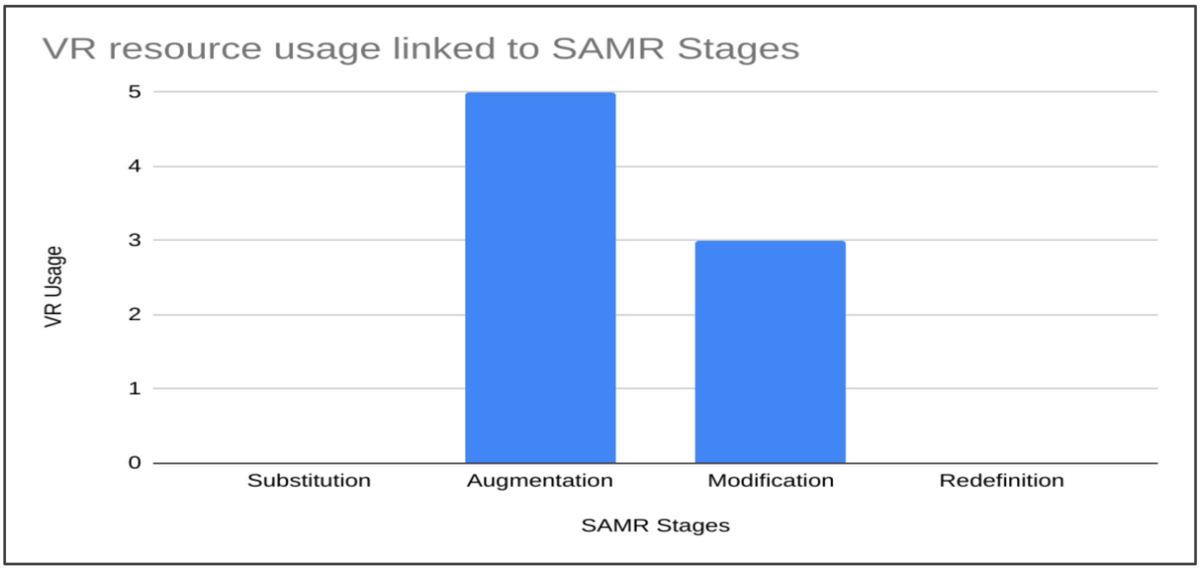


Figure 26: VR resources in lessons linked to SAMR stages

Siara, Tammy, Bhavna, Thandiwe, and Kgomotso (five participants) used VR resources as an augmentation, which were a direct substitute for a video or going on an outing. However, they also included functional improvements within the lessons, such as questions about the VR resources and activities, which further enhanced the lesson content. Tammy expressed that the learners

> *do not have enough hands-on experience and things, and I think that's a nice substitute for actually being able to see things.' [Tammy]*

Therefore, the resources were used to augment the content of the lessons and the learning experience.

The VR resource was used by Mary, Dhriti, and Sarah (three participants) to modify their lessons. SAMR's modification consisted of designing the task significantly (Puentedura, 2006) for the lesson. Mary struggled to convince her learners that neurons in the brain are like electrical circuits rather than solid structures. By using VR, students were able to visualise and interpret the neurons in the brain more accurately. When considering the models of the brain that the learners created, it was obvious that they understood the principles. Sarah modified her lessons not only by teaching the history of transport, but also by challenging the learners to prompt them to think about and explore future transport. Dhriti's lesson about the San hunt allowed the learners to experience the hunt in VR. She modified her lessons to incorporate various group tasks. When asked, 'So how did you find them working in groups?' She expressed that

> *This was lovely. We do more group work in English lessons, not so much in SS, … teachers feel they have got to get through the curriculum. And so, we kind of, you know, pushed. So that's the sad part. You know, I think teachers always felt a bit uncomfortable and uneasy, that they thought they were not gonna get through the curriculum. You were not going to make it, and you were not going to work through it and keep them doing everything that they needed to know. And so, yeah, I definitely think we need to do more group work. I saw again how beneficial it was and how the learners were interacting. [Sarah]*

After the lesson, she recollected that

> *I think it (the VR) was very immersive and they (the learners) were able to come up with questions and make comments about it. So, it was brilliant, it got them thinking, so yes, it was good. [Sarah]*

The VR scenarios that the teachers selected were directly related to the lesson as well as to the curriculum content. Tammy explained

> *Those VR things provided another opportunity, and they were nice for NS. Getting them the learners) to think, linking it (the VR) to the thinking hats, I think that's nice getting them (the learners) to think. [Tammy]*

When Dhriti was asked how the VR simulation related to what was being taught, she responded positively.

> *Perfectly, absolutely related perfectly because it was aligned with the San and the whole reason that we actually teach them about the San. [Dhriti]*

Teachers felt confident that the technology integrated the resources they had selected, positively impacting their learners in the lessons from an augmentation and modification point of view. Integrating VR requires the teacher to consider the safety aspects of learners wearing VR headsets.

4.2.3 The use and safety of VR technology integration

The actual, practical use of integrating VR technology into the lessons also influenced the participants' teaching practices, both positively and negatively. This theme addressed three sub-themes; 'learner safety' regarding the use of virtual experiences, 'technology integration' by exploring the technology teachers used within their lessons, and how teachers found integrating VR technology into their teaching context. Figure 27 indicates the number of participants (blue) and the comments (green) that were made for each 'use of technology's' sub-theme

- Four participants made seven comments on 'learner safety'
- Eight participants made 15 comments on 'technology integration'
- Eight participants made 14 comments on 'VR integration'

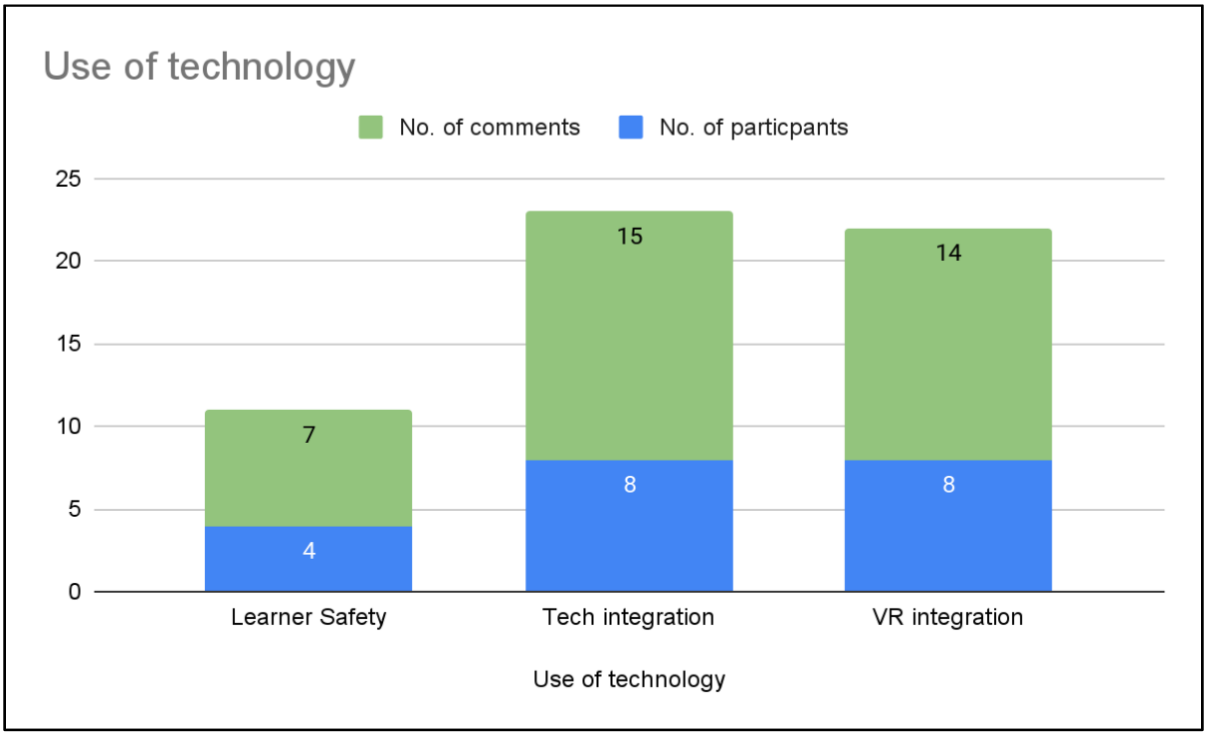


Figure 27: Subthemes for the use of technology

These sub-themes were explored further in the section below.

- Sub-Theme 1: Learner Safety

The exploration of the value of VR in lessons is the subtheme 'learner safety', as part of the theme 'use of technology.' When one discusses the use of technology, it also implies that some focus would be trained on the safety of the users. Therefore, when immersive technology is used, teachers must be aware of user safety. In this instance, the users were the learners in the VR lessons. Learners were informed of the safety considerations in each lesson. If they had used VR headsets before, they were reminded to preferably sit down while using the VR. If they did not want to sit, they should stand in one spot and not walk around. The VR headsets used for this study do not indicate an area of movement as more advanced VR technologies do. Therefore, teachers needed to be extra careful. The learners were also told that if they felt dizzy or nauseous, they should immediately remove the headsets.

The learners used a variety of positions when they viewed the VR scenarios. A total of 72 still photographs were taken of learners viewing the VR scenarios in the 12 lessons. Most of the learners were seated (74%), either on the grass (50%), on a chair (10%), or on a classroom carpet (14%). When viewing the VR scenario, 15% of the learners were standing, and only 1% were kneeling. Figure 28 indicates the number of physical positions of the learners when viewing the VR scenarios.

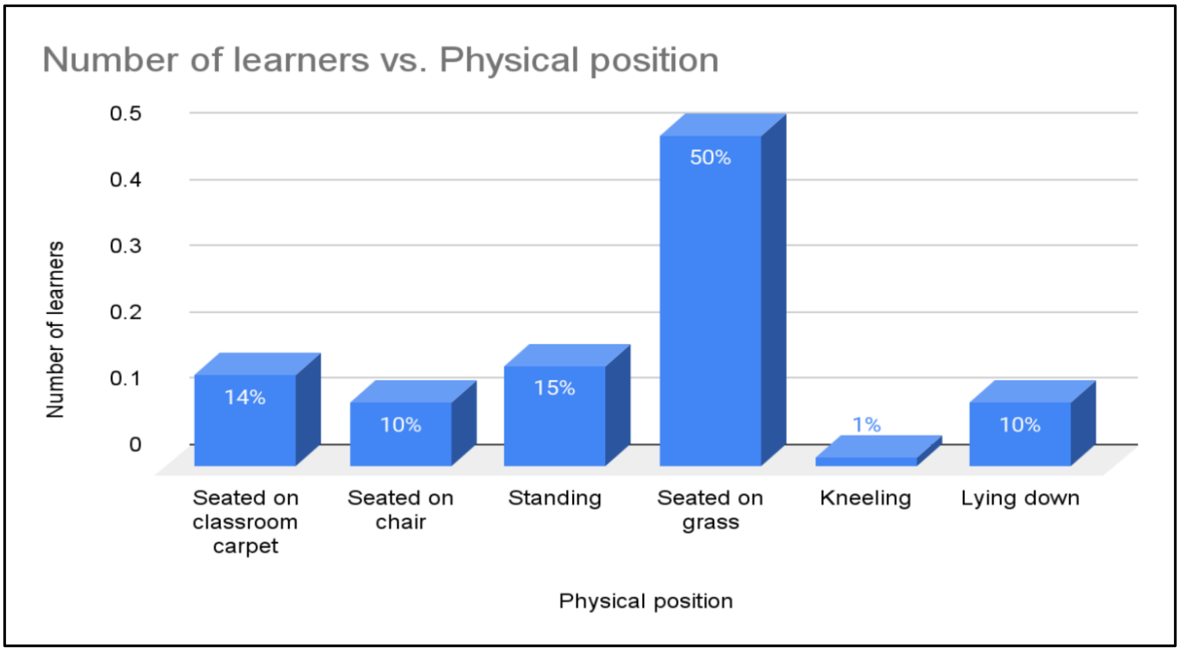


Figure 28: The number of learners versus the physical position VR was viewed

The learners spent a variety of hours in VR activities. When participants planned the lessons, the length of the VR resources was limited to a maximum of 10 minutes, and so limited the amount of time spent within the digital VR display. Figure 29 below indicates the amount of time each VR resource was played. The 'ecosystems of Borneo' (5 mins) and 'the San Intense eight-hour hunt' (7.09mins) were each used for two lessons; therefore, there are only ten resources listed in the table. The InMind2 application game was the longest interactive resource (8 minutes). 'The Ant and the Dove' (2.13 min), an English listening comprehension lesson, was the shortest experience. The other scenarios which were less than five minutes were 'Cyberbullying create no hate' (2.39mins), the 'iSimangaliso Wetland Park' (3.01mins), 'Know your emotions by Rocket Kids' (4.04mins), and 'Roadtrip 2030: Future of Mobility Virtual Reality Experience by Covestro' (4.06mins). The scenarios that were longer than five minutes included 'Do These Things To Survive If You Get

Stranded On An Island' (6.46mins) and 'The San Intense 8 Hour Hunt' (7.09mins). Figure 29, below, provides information about the length of time each VR resource was used for during the VR lessons.

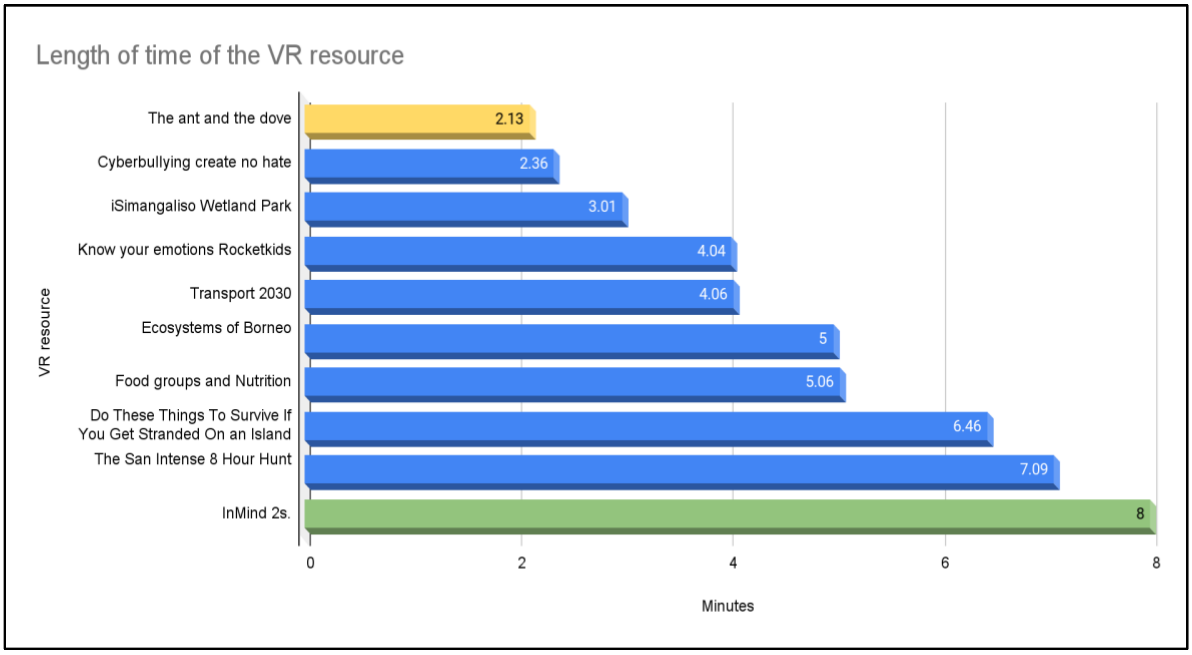


Figure 29: The Length of time each VR resource is used in a lesson

The average viewing time was 4.9 minutes across all VR videos. Two VR videos were less than three minutes long, and four experiences were longer than 5 minutes; no experiences were longer than 10 minutes. There is not sufficient evidence of the negative effect of VR resources on eyes, however, limiting the time of use is important (Howard, 2016; Mukamal & Lipsky, 2017), therefore the timeframe is indicated for each VR resource used in the observed lesson. Mary refers to the safety of using VR by exposing learners to information while being safe at school. Which also meant that travelling costs were not incurred. She also ensured the length of time was less than 10 minutes per learner using the VR headsets. Mary said.

> *I think that you need something to motivate children to excite them, and it [VR] would be the virtual experience today which actually could assist or supplement when you could not go out. If I just took a Covid for example, does that mean we could take them on a journey without leaving the classroom? And that experience meant that they were safe, that it wasn't expensive, but at the same time, they got that feeling that they were travelling and moved and explored new places. [Mary]*

Here, safety referred to being within a classroom, and not on an outing, and not being exposed to Covid-19.

Bhavna happily allowed her learners to move around as much as they wanted within the classroom. She explained.

> *Fortunately, I had a very big classroom. So, we utilised almost the entire classroom when we did the VR. [Bhavna]*

She also discussed how the desks and chairs were pushed out of the way so that learners had the freedom to move throughout the class.

> *… generally, they (the learners) had a very big open space because I moved all the desks right away. [Bhavna]*

To ensure the safety of the learners, she continuously moved around the classroom to monitor their safety. She explained what she was doing.

> *I walked around a lot because I had to, you know, redirect kids (learners) away from a wall, away from the door. [Bhavna]*

Figure 30 below illustrates how Bhavna's classroom furniture was moved out of the way for learners to explore the space.

Figure 30: Bhavna's classroom furniture moved out of the way

Sarah had her Grade 4 learners sitting at their desks viewing the VR task. She spoke about safety concerns and walking around. She explained that they could turn in their chairs and look up and down to see the VR completely. During the activity, one child spoke about feeling dizzy. She asked the learner to remove the headset and then found the 3D view of the video for the child to watch. Therefore, all her learners saw the VR experience. In Mary's class, one learner told another learner that she felt dizzy but wanted to continue playing. When she removed the headset, the learner said that she was fine and not dizzy any more. She walked off to the next activity. Learner safety was the most important consideration. Each teacher addressed safety in relation to their learners and where the VR was viewed.

- Subtheme 2: Technology integration

The exploration of the value of VR in lessons is the subtheme 'technology integration', as part of the theme 'use of technology.' When discussing the use of technology, some attention should also be paid to the integration of it. All participant teachers (Deli, Sophia, Monica, Shabaana, Trusha, Siara, Tracy, Arshnie, n=8; 100%) used technology in their lessons before the study started. They all had teaching resource laptops for lesson planning, submission of marks, and school emails. Five participants used data projectors (Thandiwe, Kgomotso, Tammy, Siara, Dhriti, n=5, 63%), while three participants (Bhavna, Sarah, Mary, n=3; 38%) used interactive boards in their lessons. The iPads were shared resources that could be signed out; those were used by six participants (Tammy, Dhriti, Siara, Mary, Bhavna, Sarah, n=6; 63%) with their learners. One participant (Mary, n=1; 13%) also had access to learner laptops for her lessons. Three participants (Mary, Sarah, Bhavna, n=3; 38%) had VR headsets at their schools before the study. Two of the teachers (Sarah, Bhavna, n=2; 25%) had access to 15 VR headsets. They asked their learners to bring their cell phones to school when they used the VR for their lessons. A third participant (Mary, n=1; 12.5%) used six headsets and six cell phones with her learners. The variety of technology used by the participants varied from school to school, and individual to individual.

The graphic representation of Figure 31 shows the total number of participants (n=8) who used various types of technology before the study began (in blue) and the technology they included during their VR lessons (in red). Figure 31 indicates the use of technology by each individual participant before and during the lessons.

Seven participants (not Mary, n=1, 13%) used laptops during their research lessons. Five participants (Thandiwe, Kgomotso, Tammy, Siara, Dhriti, n=5, 63%) used data projectors, three participants (Bhavna, Sarah, Mary, n=3,) used interactive boards, and one participant (Mary, n=1, 13%) used laptops with learners during research lessons. Only one participant (Dhriti, n=1, 13%) used iPads for an activity during her research lessons. Below, Figure 31 provides a numeric representation of the technology used by the participants in the lessons before the research and during the research lessons.

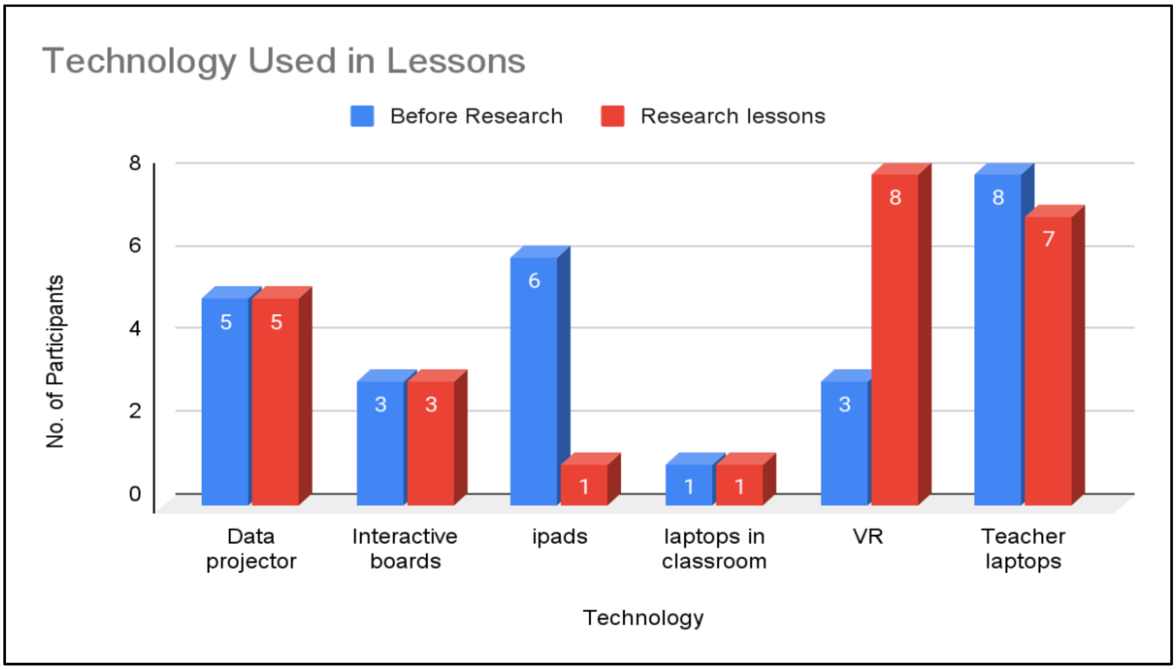


Figure 31: Numeric representation of technology used in the lessons before and during the research lessons

When the type of technology used before the study and the actual technologies during the lessons are compared, differences emerge. While Table 16 below indicates the technology used by each participant before and during the study's lessons.

Table 16: Technology used by each participant before and during study lessons

Technology used in lessons by individual participants												
Thandiwe	x	x		x			x	x				
Kgomotso	x	x		x			x	x				
Bhavna	x	x	x	x					x	x	x	
Sarah	x	x	x	x			x	x			x	
Tammy	x	x		x			x	x			x	
Siara	x	x		x					x	x	x	
Dhriti	x	x		x			x	x			x	x
Mary	x		x	x	x	x			x	x	x	
Technology used before study (before) or within study lessons (Lessons)	Before	Lesson	Before	Lesson	Before	Lesson	Before	Lesson	Before	Lesson	Before	Lesson
Technology	Teacher laptops		VR headsets		Laptops in classroom		Data projector		Interactive boards		iPads	

The incorporation of technology as a teaching resource was evident before the VR lessons began in all eight participants' classrooms. For five participants, the addition of VR technology was new and different to the technology they had been used up until then.

- Subtheme 3: Integration of VR technology

The exploration of the value of VR in lessons is the subtheme ‘VR integration’, as part of the theme ‘use of technology.’ After considering learner safety and general technology integration, the attention turns to VR technology integration specifically. All participants included the VR simulation resource within their own lesson plans. They contemplated where the group of learners using the VR would be placed in the learning space, whether inside a classroom or outside. Each participant told me where the learners were going to work for each lesson. It can therefore be assumed that they had each thought about appropriate ways of practically including this multimodal technology.

The VR integration resources use three different applications, namely YouTube's VR mode, Google Expeditions, and InMind2.

Eight YouTube videos were viewed in VR mode across all four subjects.

- In Life skills, the VR resources used in Grade 4 (all Thandiwe's lessons), were 'Know your emotions' (RocketKids, 2018), and 'Cyber bullying creates no hate' (CreateNoHate & Culhane, 2016). In the Grade 4 English lesson, 'The Ant and the Dove' (BooBoo, 2018), was used.
- The Grade 5 English lesson used 'Do These Things To Survive If You Get Stranded On An Island' (The Infographics Show, 2018) (Dhriti's lesson);
- The two SS History lessons used YouTube VR mode videos. One was the Grade 4 lesson 'Roadtrip 2030: Future of Mobility Virtual Reality Experience' by Covestro (Covestro, 2018) (Sarah's lesson), and the other was the Grade 5 lesson 'The Intense 8 Hour Hunt, the Attenborough Life of Mammals' by BBC Earth (BBC Earth, 2009) (Dhriti's lessons).
- In the NST Grade 6 lessons, four VR resources were used, two were YouTube videos viewed in VR mode, namely 'iSimangaliso Wetland Park', South Africa (Drink Tea & Travel, 2020), (Bhavna's lesson) and 'Food Groups And Nutrition' (ClickView, 2020) (Kgomotso's lesson).

The third NST lesson (Tammy and Saiba's lessons) was a scenario from the Google Expeditions Application entitled 'Ecosystems of Borneo' (Google, 2015). The fourth lesson (Mary's lesson) was a combined NST and GCD lesson which used a separate application called inMind2 (NIVAL, 2016). Figure 32 graphically depicts the types of VR applications used in each subject as described above.

VR Resources used in the various research lessons			
Life Skills	English	SS - History	NST
 Know your emotions by Rocket Kids	 Do These Things To Survive If You Get Stranded On An Island	 Roadtrip 2030: Future of Mobility Virtual Reality Experience' by Covestro	 iSimangaliso Wetland Park
 Create No Hate	 The Ant and the Dove	 The Intense 8 Hour Hunt	 Food Groups And Nutrition
			 InMind 2
			 Google Expeditions| Ecosystems of Borneo

Figure 32: VR resources used in the various research lessons

Because the study focused on the integration of VR in the classroom, it was important to note that all teachers shared comments related to technology. All of them (n=8) spoke about the value of using VR technology in their lessons. When referring to VR, only participants Tammy, Kgomotso, Siara, and Thandiwe (n=4 participants) had one comment each. Dhriti and Bhavna (n=2 participants) each made two comments, and Mary and Sarah (n=2) made three comments each related to VR only. The comments related to VR and technology were made by Tammy, Sarah, Siara, Kgomotso, Bhavna, and Thandiwe (n = 5), because each made a comment. Sarah and Kgomotso (n=2) made a single comment on technology in general, and Mary and Tammy (n=2) made two comments about other technologies. Figure 33 Indicates the total of individual participants related to their comments on VR (blue), VR and other technologies (red), and other technologies (yellow). Number of VR and technology comments per participant. All participants expressed their comments and views on technology within an educational context.

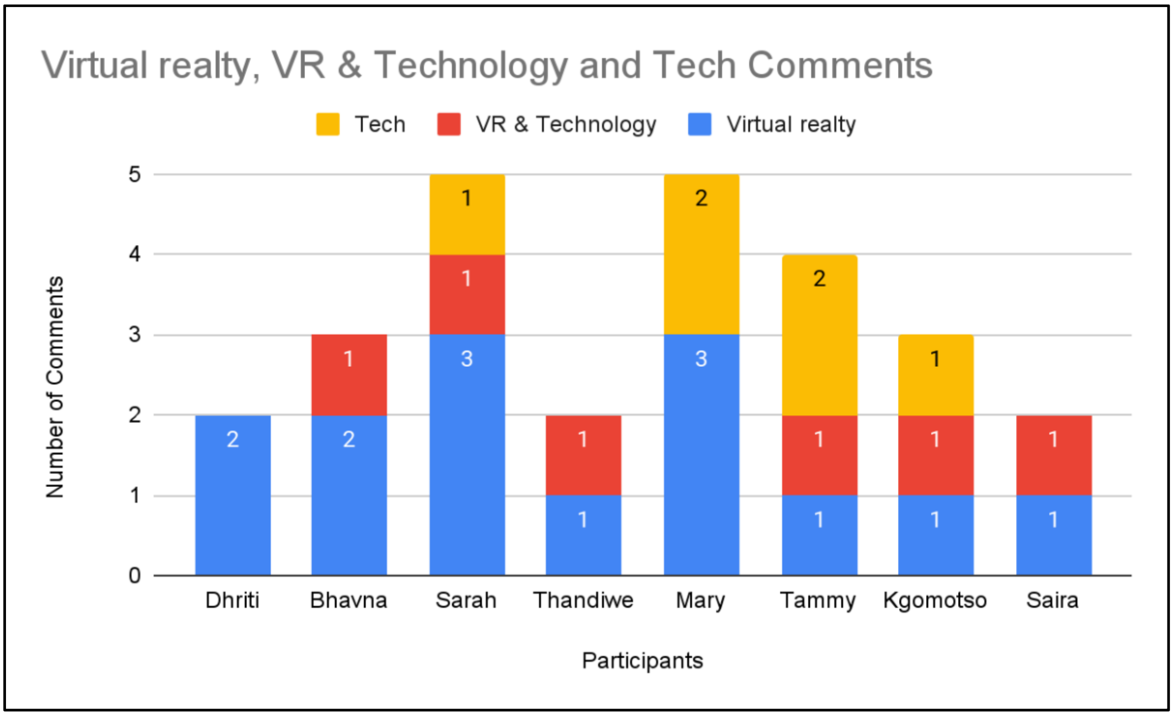


Figure 33: Number of VR and Technology comments per participant

Tammy (Grade 6 NS) mentioned that with the incorporation of thinking skills in lessons, using VR assisted learners to engage with De Bono’s Thinking Skills (1985), VR becomes useful as an additional resource in the overall lesson content.

Dhriti (Grade 5 SS) spoke about integrating technology after the San hunt lesson and how it might help teaching strategies. She commented:

> *I suppose we could get through more contents as well then. Because I mean, if the VR and the other things (activities) are used in the lesson the learners are involved, I suppose if they were doing the similar content in many different ways, you were almost reinforcing their knowledge in different ways, building their knowledge. [Dhriti]*

Bhavna’s (Grade 6 NS) school had fifteen sets of VR headsets. While speaking after her VR lesson, she revealed that she was not sure if VR would be suitable for every subject, *but I know with science, maybe social sciences and stuff, I absolutely recommend it. So far in our school, I know I had probably used the VR headsets more than anybody else had used them. [Bhavna]*

Thandiwe, after her English lesson in 2022 expressed the following about VR:

I think it really helped a lot. [Thandiwe]

She elaborated about the value of having had VR lessons in two different subjects (English and Life Skills):

And I'm glad that we did it (the VR lessons) in different learning areas or subjects. Because we did one in life skills. So, it also works for life skills. Then again, I saw you could also use it for English as well. Thandiwe]

Dhriti was asked if the incorporation of VR was valuable.

Absolutely. The learners were so involved and interested. They used it individually, but it reinforced what they were doing in the other activities. [Dhriti]

Sarah spoke about the VR technology as a resource learners could relate to and explained.

… because that was the world they were a part of. If they were not even thinking, you know, even at this level, definitely VR was very helpful. It was also helpful for them, you know, they were asking me about various models of VR. Some of them have had experience in a gaming world. I think it was vital. I really do. I really do in terms of sparking interest and, and looking at bringing real reality, you know, the reality of the tech in here. [Sarah]

Sarah also mentioned how VR was seen as beneficial to her teaching pedagogy and the use of the technology

My pedagogy changed from not using much technology, to exploring how to use VR more, I even asked the principal to purchase VR goggles and phones. [Sarah]

Thandiwe found it beneficial to use the VR resources in more than one lesson. She noted that by integrating VR in two different lessons, it showed her that it worked in both subjects, English and Life Skills.

Kgomotso explained that the VR headset and resources were

great tools for teachers to try and use. [Kgomotso]

She noted the benefits to be, so that

- Learners were excited to learn using the VR
- Learners were in their own environment. There were no disturbances. They learned even better.

When Mary was asked about the advice that she would give someone who was considering using VR, she explained:

- Teachers need to purchase the correct devices for the activities to be successful. She warned not to buy cheap products. Check carefully that the requirements of the devices were appropriate. She shared that she made that mistake.
- She spoke about the value of looking after the devices.
- She suggested the teachers must understand the system and should practise before the lessons with the device, so the teacher knew how they worked.
- She recommended that teachers preview the VR scenarios, so they knew what the learners were going to view.

The viewpoints of these teachers would be useful to those who may not have used VR before. The VR integration challenges teachers expressed are addressed in the next section.

4.2.4 Challenges expressed by teachers

A range of challenges may impede the use of VR in the future by participants, while negatively impacting teacher perceptions and decisions. Participants expressed challenges related to their school context and personal situations. These challenges may be related to the curriculum content, the school's team dynamics, or technical challenges. Figure 34 graphically depicts the challenges teachers expressed, dividing the themes into two subthemes, namely, general classroom challenges when integrating technology, and VR integration challenges. The topics under general classroom challenges include time management, classroom management, curriculum limitations, colleagues' perceptions, and sanitising equipment, including Covid-19 comments. The topics under the heading VR integration challenges include sourcing content, VR setup, negative user experience, lack of technology resources, and lack of Wi-Fi. Figure 34, below, is a mindmap of the challenges the participant teachers expressed related to VR integration.

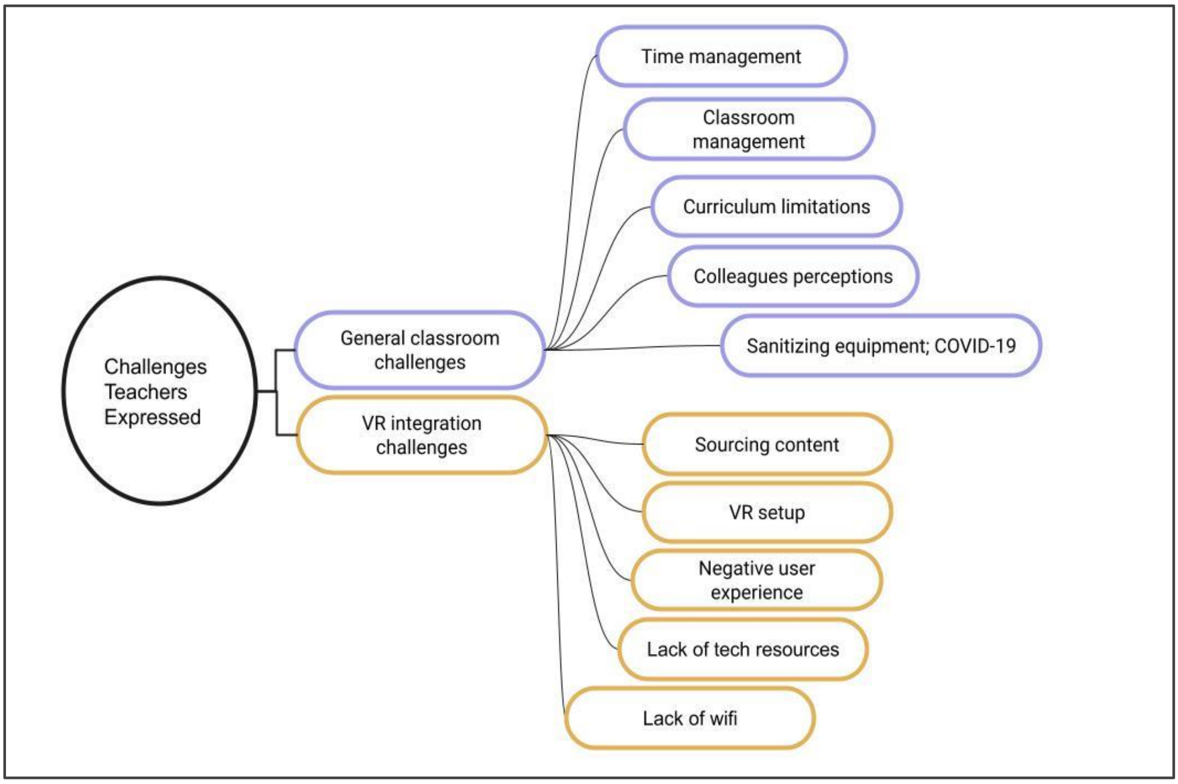


Figure 34: Mindmap of the challenges teachers expressed related to VR integration

The topics of the challenges were extracted from the comments by participants. Figure 35 documents the total number of comments about the challenges teachers expressed when technology was considered included into the lessons under two headings: ‘general teaching challenges’ and ‘VR integration challenges’. Five participants (Kgomotso, Delisile, Sarah, Tammy, Mary) raised 12 comments about ‘general teaching challenges’ and 7 comments about the impact Covid-19 had on the use of devices when integrating technology into a lesson. Six participants (Tammy, Mary, Sarah, Kgomotso, Thandiwe, Dhriti) raised concerns in 13 comments about ‘VR integration challenges’. Figure 35, below, numerically illustrates the challenges teachers expressed, related to general teaching challenges, including those during COVID-19, as well as VR integration challenges.

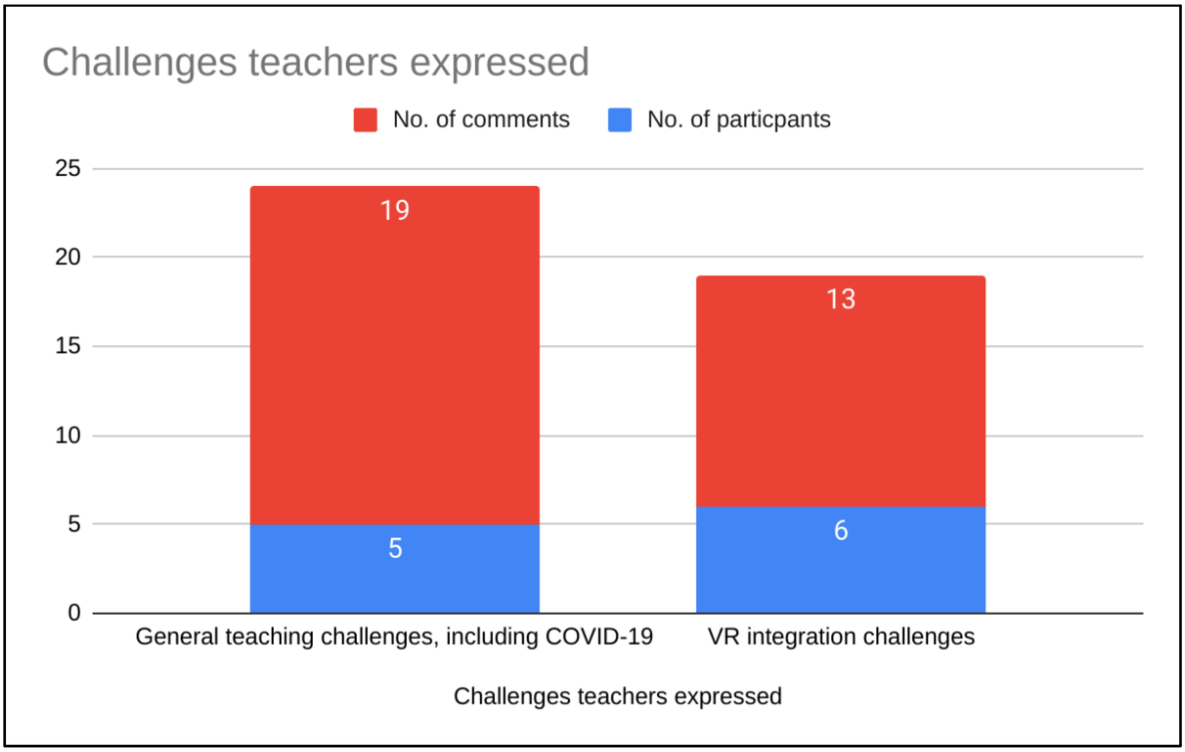


Figure 35: Challenges teachers expressed

The challenges are illustrated in Figure 35 and were explored further in the following section.

- Subtheme 1 - General classroom challenges

The subtheme 'general classroom challenges', forms part of the theme 'challenges teachers expressed'. The challenges voiced reflect the teachers' concerns when conducting and planning the incorporation of VR into a lesson. They need to find the time in the timetable to include VR technology into a lesson, and it is difficult to manage learners who participate in a variety of tasks during the lesson. Teachers also find it challenging to create lessons for a very prescriptive curriculum within a specified time frame. They also had to deal with colleagues' perceptions of technology integration. Because the study was conducted during the Covid-19 pandemic, the practical task of sanitising each piece of equipment became tedious. These issues are discussed in the following section.

❖ Time management

The effective use of lesson time is important. VR in the lessons proved to be relevant, but it seems to be difficult to find the time in the timetable to include the technology into a lesson.

Kgomotso (Grade 6 NS) spoke of challenges when considering teaching strategies for using VR in the future. She was asked, ‘So if we look at introducing this technology, did it make you think about your teaching strategies and how you might use this type of technology in the future?’ Kgomotso responded,

> *I also looked at the time factor. Yes, because I had limited time. If my lesson is one hour and I've got something that I wanted to cover, then I needed to strategically think about how my lesson was going to work. So, I think it would be better for me if I could have half the class with VR headsets. I could divide them into two groups instead of splitting them into groups of five. [Kgomotso]*

Other teachers reiterated the time restrictions; a ‘full’ school day may also add to this concern. Tammy (Grade 6 NS) spoke about the full school day and had to complete all curriculum content. When asked the question ‘Do you think VR technology is worthwhile incorporating again into the lessons?’, she replied:

> *I do, I think the different technology could be used in lessons for kids to interact. And I think sometimes it was finding the time to include the technology; the school was talking about getting headsets but nothing as yet. Today the children really enjoyed viewing the VR, and it tied in well with the lesson’s revision. [Tammy]*

Timetables and limited time were realistic concerns teachers voiced. These may also influence their attitudes towards the incorporation of technology.

❖ Classroom management

The rotation of the learners through various activities or the difficulty of each learner on their own device added more challenges. Sarah spoke about managing her learners and the difficulties they were having with the technology. During the lesson, some of the learners struggled to open the YouTube video, could not find the VR button to begin the experience, or had difficulty inserting the cell phone into the VR headset.

Kgomotso suggested that to reduce the number of groups or increase the number of headsets could improve the lesson flow.

> *Yes, I thought about it. The only challenge I actually thought of was if I could have phones that occupied half the class at one moment, then the other half would be doing something else, then I just swap. [Kgomotso]*

Classroom management challenges and concerns might negatively impact the integration of technology into lessons.

- ❖ Learner behaviour during VR lessons

When observing the lessons, there was no disruptive behaviour by learners in any of the teachers' lessons. The teachers had various activities for the learners to complete or participate in during each lesson, with VR being one of the tasks. Only one comment related to behaviour, when Kgomotso spoke about her learners

> *… going on to watch other videos in VR* [Kgomotso]

She had asked the group to rotate, as they were taking longer than the other groups, and then the learners spoke about viewing other videos. She asked them to continue with the next activity, which is what they did. It was not disruptive behaviour.

Overall, the behaviour of the learners was polite, engaged, responsive and participatory. Disruptive behaviour can hamper a learning environment.

- ❖ Curriculum limitations

The challenges influenced the teachers' teaching practices. The curriculum prescribed the content knowledge, as well as the time when the content should be taught. Sarah (Grade 4 NS) spoke about the challenge of being bound by the curriculum and how difficult it is to innovate within the context of the curriculum. When Sarah was asked 'if somebody had to say to you, they heard about VR, would you suggest they explore it? She replied:

> *Oh absolutely. The difficulty though, as a teacher is you are bound by the curriculum. And the difficulty is to innovate within the curriculum. [Sarah]*

These restrictions or perceived restrictions could hamper the creativity and individuality of the teacher. When regarded as challenges, it could negatively influence their teaching practices.

- Colleagues' perceptions

The challenges extended to staff interactions. The individual choices of teachers working within a restrictive team were evident from the discussions and comments by Sarah (Grade 4 SS). She had previously used VR and AR in lessons with her learners and enjoyed creating interesting lessons with the use of technology. Her frustration was the administrative challenge of teaching a grade with a team that did not want to buy into using new technologies. While they were not keen to use such digital resources, she still had to seek approval from these colleagues to integrate the technology into her lessons.

> *And if you're teaching a grade with a team for the team to buy into that, so you can, I could run with it on my own, but because of the way the school is managed or whatever I include everybody had to approve. [Sarah]*

Sarah spoke of the difficulty of integrating technology across a team of colleagues. When previously preparing a shared grade lesson where she tried to incorporate a VR tour, she realised that her colleagues are reluctant or afraid to integrate technology into the lesson, and therefore, she had to move the VR resources as 'experiential learning' to the end of the learner booklet. She found this frustrating, because she viewed the VR activity as 'part of the process and part of the changing of thinking' for her learners. She wanted the activity fully included, and not just as an extension task.

Delisile spoke about the excitement of the teachers who participated in the study, but their colleagues did not see the value. She was most disappointed about it and considered ways to entice them to use technology more often in their lessons. Mary also raised the concern of teachers not using the VR technology the school owned.

> *The teachers have to come to the party. We got them onto Google classroom because we had to, and then they got complacent. And then I put their names on the timetable, and I put their names there with mine, but no they didn't come near the classroom. It was just me. [Mary]*

- Sanitising equipment

The challenges teachers raised that impacted attitudes were discussed in the previous sections. Additional challenges arose during the Covid-19 pandemic. Mary spoke about the practical tasks of using the VR headsets when the Covid restrictions were reduced. She described,

> *I just spent my whole time sanitising the goggles, you know, I had to breathe and charge the battery. Then wash and clean the goggles and the phones. And so those little things, sort of, got in the way. [Mary]*

The stress of teaching and the potential of getting ill was heightened when considering technology, such as VR was introduced. The general teaching challenges impacted the teachers, as did the practical challenges of VR integration into the lessons.

- Subtheme 2 - Challenges of VR integration

The subtheme ‘challenges of VR integration’, as part of the theme ‘challenges teachers’ expressed.’ Teachers expressed additional challenges of integrating VR into the classroom. The practical and technical challenges caused frustration during the lessons. Teachers had difficulty sourcing VR content. They needed help to set up the VR for lessons. Teachers also discussed that when learners experienced challenges with using the equipment, it affected the learners as well as the teachers’ attitudes. The lack of technology resources and WIFI for some teachers.

- Sourcing content

Participants faced challenges about where to find VR content. They knew what lessons they were teaching, and into which lessons they wanted to incorporate VR, but they were unsure which VR resources should be used. So, when I discussed the lesson topics with the participants individually, especially those who had not used VR before in the lessons, I provided ideas of where to source content and suggestions of potential VR topics. Teachers viewed the examples thereafter and selected the VR scenario they wanted to use. Sarah voiced some concern whether she would find content to use VR in the future. I asked her whether she would use VR in the future, despite her uncertainty.

> *So, yes, I would, I think the difficulty was finding the material, finding that little nugget, that creative nugget, and then running with that and not being afraid to run with it. [Sarah]*

With the limited time available to teachers, the difficulties of sourcing information could curtail teachers from integrating VR into their lessons.

- ❖ VR setup

The five teachers who had not used VR before the study, requested assistance with the setup and use of the VR during their lessons. Afterwards, Dhriti commented.

> *Thank you for assisting with the setting up and helping the technology to work. The children really loved it, I see great value in using it, and want to incorporate it into my lessons. [Dhriti]*

Tammy also noted that teachers should prepare properly.

> *I think it's important that we actually watch it (the VR scenario) and see it and understand and find out how it works. [Tammy]*

The practical usage of the technology, and the uncertainty of how to use it could prevent teachers from using the technology.

- ❖ Negative user experience

The difficulties learners and teachers experienced could impact negatively on teachers' attitudes. Tammy spoke about her learners not being able to move easily from scene to scene within Google Expeditions.

> *Well, I was pleasantly surprised. I really, really was. The children that had difficulty moving from one screen to another were horribly disappointed, so it is something they wanted to do. They really wanted to. [Tammy]*

Tammy was pleased that her learners were keen to do the activity, but disappointed that some had had a negative experience. Mary had similar experiences.

> *. . . when we explored Expeditions. I found that part difficult for the kids to use or to understand. So, I haven't been sold on it. I've never been able to get five kids with me*

in the same expedition, because they are all so different. Um, they'll nod their heads or get distracted waiting for others. [Mary]

She continued to describe the difficulty of

opening the apps to view the experience. [Mary]

Mary also recounted another difficulty when using Expeditions.

It was finicky sometimes. So, you know, it didn't start when you wanted it to. [Mary]

Sarah spoke about the difficulties of using VR, and with learners who do not know how to use the technology. She spoke about the frustration of VR integration when there were

difficulties in using the technology. [Sarah]

Older cell phones proved more difficult to use because they require a longer time to charge. To ensure that the devices were continuously charged and ready for use was important. If devices are not charged, learners become frustrated while teachers are trying to source workable devices.

These frustrations by the teachers when the technology did not work are expected, or learners who had difficulty using the technology, were expected.

- ❖ Lack of VR technology resources

Not all schools (n=2) had resources for participants (n=5) to use for their VR integrated lessons. Because they did not have devices, the researcher (Figure 36) provided VR goggles and mobile phones for them to use with their learners.

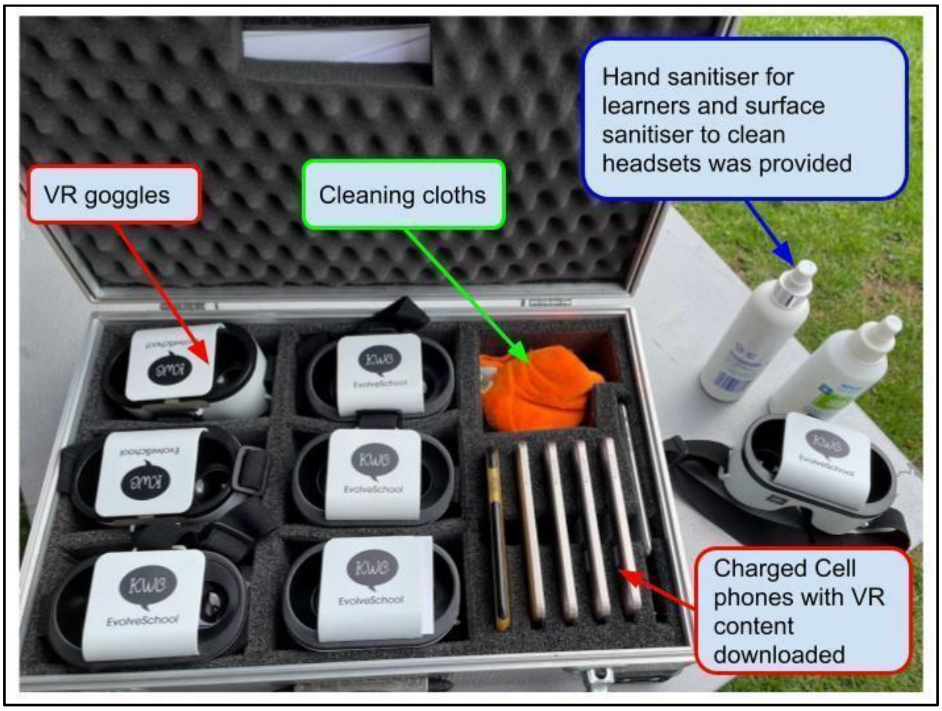


Figure 36: VR Kit research was provided for participants to use

Some participants experienced a shortage of VR resources and commented on it.

> *We did not really have these [VR] gadgets for them (the learners), not having individual goggles. [Thandiwe]*

The lack of devices or access to devices could negatively influence a teacher; they would avoid integrating VR into lessons.

- Lack of WIFI resources

Not all schools had WiFi throughout the school. Ridgeview School had no WiFi in the lower part of the school where some lessons occurred. The researcher was requested to bring WiFi to connect the phones. The selected VR videos were downloaded so that they could be viewed without requiring connectivity.

> *The lack of WIFI was a problem. If content was not downloaded learners could not watch the scenarios. [Kgomotso]*

Integration of technology has many facets to consider. Figure 37 summarises the challenges the participants discussed, such as the lack of connectivity, limited resources, personal obstacles, and colleague reactions when implementing a different technology into classes.

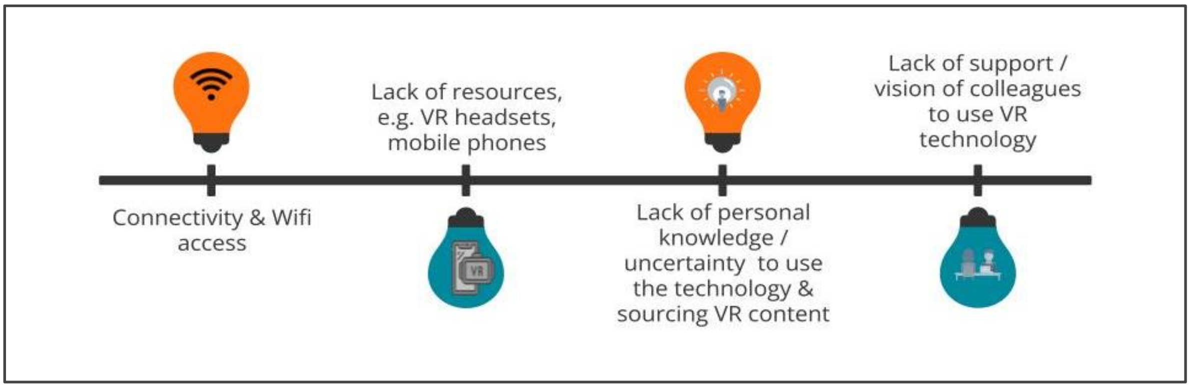


Figure 37: Challenges integrating VR technology

The challenges expressed by the teachers, subsequently influenced their beliefs and attitudes. Integration of technology has many facets to consider. I explored the potential implications of VR simulations that would result in changed pedagogical practices. The connections teachers saw related to teaching theory. The implication of VR simulations for changing pedagogical practices was related to the descriptions by the participants through connections to the teaching theories. They alluded to Constructionism, Dewey's Experiential Learning, Kolb's Experiential Learning Cycle, Constructivism, and Behaviourism. The implications of VR being integrated into lessons explored the value of VR in lessons related to the teachers' self-growth, incorporation into their lesson planning, and the actual use of technology in their lessons. The final implication explored the challenges the teachers experienced when using VR as a resource. Figure 38 indicates the number of comments which addresses the implications of VR simulations for changing pedagogical practices. The VR connections to teaching theory (38 comments) and the value of VR (122 comments) in lessons are considered positive responses, which far outnumber the challenges (19 comments) that teachers expressed.

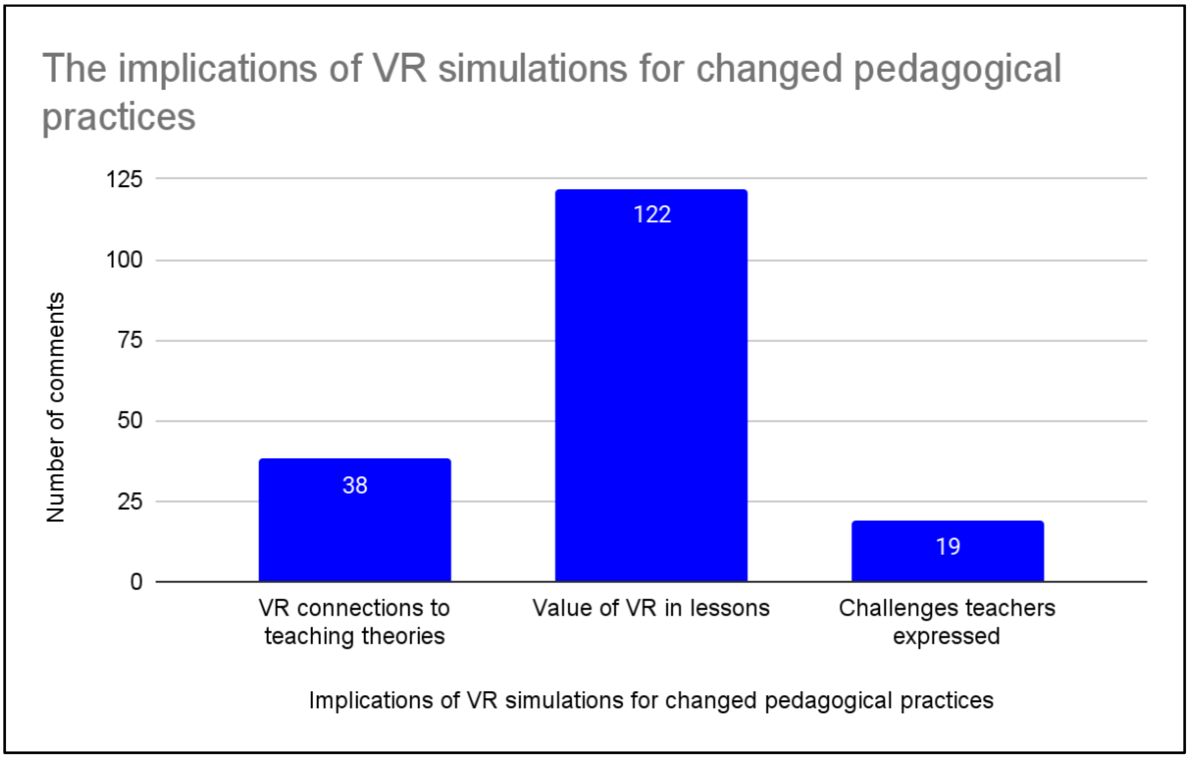


Figure 38: Exploring the implications of VR simulations for changing pedagogical practices

These implications influenced the teachers both positively and negatively as to whether they would incorporate VR into their classroom practices. The participants expressed the value of incorporating VR (n=122) into their lessons, and why they might use VR for their learners, from what they had observed. From the teachers' viewpoint, after the incorporation of VR simulations into their lessons, it may be inferred that changed pedagogical practices are possible. I now discuss how the integration of VR simulation influenced primary school teachers' classroom practices.

4.3 How does the integration of VR simulations influence primary school teachers' classroom practices?

Observing learners using VR in the lessons, participants expressed how they saw learners acquiring knowledge as they built content knowledge. Their knowledge was reinforced with the use of the VR in the lesson; the learners were engaged and involved. They expressed meaningful content knowledge, shared, and communicated about the VR simulation and lesson content. The teachers observed their learners' reaction to the learning as feeling real. The teachers spoke about bringing reality into the classroom, creating a real work context, as well as learning within the context (experiential learning). Finally, the teachers observed an interaction with their lessons (Figure 39), where active, motivated, and immersive learning occurred.

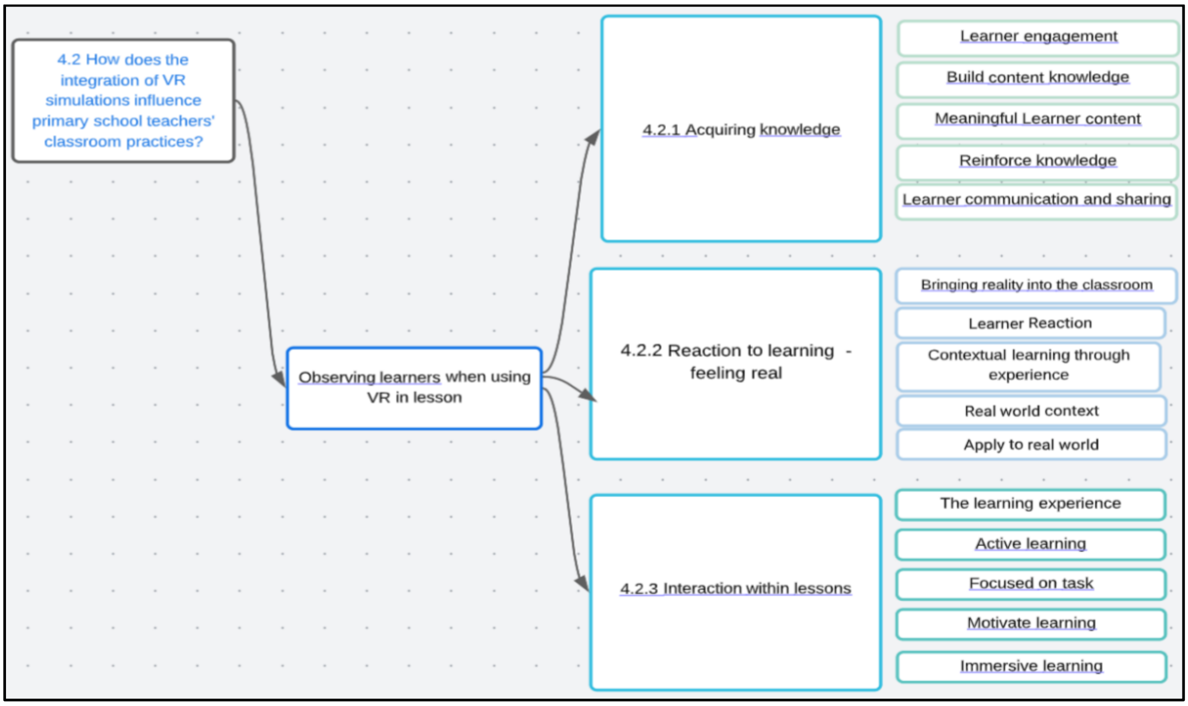


Figure 39: Graphic representation of themes and sub-themes of 'How does the integration of VR simulations influence primary school teachers' classroom practices?'

4.3.1 Acquiring knowledge

Participants described how their learners acquired knowledge in the lessons where VR was integrated. Five sub-themes arose from the discussions. The participants spoke about VR assisting in building learners' content knowledge. They described VR as adding meaningful lesson content. According to the participants, their learners actively engaged during the lesson. Half of the participants referred to how VR resources helped reinforce learners' knowledge. Furthermore, they discussed the communication and sharing that they observed among their learners. Table 17 illustrates the total number of participants and comments made related to each sub-theme that were addressed in this section.

Table 17: Acquiring knowledge themes and sub-themes

Theme	Subthemes	Participants	Comments
Acquiring knowledge		8	62
	Learner engagement	8	22
	Build content knowledge	8	20
	Meaningful lesson content	6	13
	Reinforce knowledge	4	4
	Learner communication and sharing	2	3

4.3.1.1 Learner engagement

The subtheme 'learner engagement', as part of the theme 'acquiring knowledge.' Teachers observed their students' engagement, their involvement during the lessons, and how they responded to their teachers afterwards. In Table 18, participants (n=8) provided information on the terms they used when referring to the learners' engagement and interaction during the lesson, and how many of the participants used the same terminology.

Table 18: Learner engagement terms teachers used

Term	Number of times used	Participants' names
excited	6	Bhavna, Kgomotso, Siara, Mary, Tammy, Thandiwe
loved it	3	Dhriti, Sarah, Mary
engaged	3	Kgomotso, Mary, Siara
questioning	3	Thandiwe, Dhriti, Sarah
participated	2	Kgomotso, Mary

enjoyed it	2	Dhriti, Tammy
related positively	2	Kgomotso, Siara
wanted to do it again	2	Tammy, Kgomotso
interested	1	Dhriti
involved	1	Dhriti
relaxed	1	Mary

Six of the participants referred to their learners as being **excited** when using VR.

Kgomotso (Grade 6 NS) noticed her learners' engagement when using VR.

> *They were excited about it, so they participated even better. And from the feedback, they understood the content, because they were really immersed in it, as they had no other disturbance, because one child was focusing on what they were doing at that particular moment, so they gained a lot of information. [Kgomotso]*

Bhavna (Grade 6 NS) said when her learners had fun while they were learning.

> *They got so excited. And uh, so I tried to do the work that I needed to do with this VR resource and get their next focus. And then we had a bit of fun at the end. [Bhavna]*

Siara, Mary, Tammy, and Thandiwe also referred to their learners being excited to use the technology.

Three teachers (Dhriti, Sarah, Mary) spoke about learners **loving** the VR experience. Dhriti (Grade 5 English) explained how her learners were totally involved and interested in using the VR resource about being on a deserted island during the English language lesson. She related how the children really loved the VR activity. Three participants (Kgomotso, Mary, Siara) commented that their learners were **engaged** during the VR scenario lessons.

Thandiwe, Dhriti, Sarah mentioned that their learners were **asking questions.**

> *I think the kids thoroughly enjoyed it. . . . So, um, but they loved it. And I think it was very immersive and they were able to come up with questions, you know, make comments about it. So, it was brilliant, it got them thinking at least. [Dhriti]*

Kgomotso and Mary expressed their learners' **participation** in the VR lesson. Mary spoke about her learners being excited as they engaged and participated. Siara and Kgomotso referred to their learners as relating positively to the resource. Kgomotso (Grade 6 NS) described her children as **relating positively** to the use of VR in the lessons and being engaged. She spoke about her learners being excited, motivated, and focused during the lesson about nutrition.

Dhriti remembered that her learners were **interested** and **involved** in the VR scenario. When Dhriti (Grade 5 SS) was asked, 'Would you consider using VR in your lessons?' She replied positively.

> *Absolutely. The learners were so involved and interested. They used it individually, but it reinforced what they were doing in the other activities. [Dhriti]*

All the participants noticed this type of learner engagement of interest and involvement in all their lessons.

Dhriti and Tammy observed that their learners enjoyed the VR.

> *I think this technology could be used in lessons for kids to interact… Today the children really enjoyed viewing the VR. [Tammy]*

Mary discussed other benefits of learners; they are relaxed when they are learning, and the learners thought of VR as a 'relaxed' experience. When she was asked, 'how do you think the inclusion of VR impacted the learner's participation?' Mary added aspects about brain function and retention of learning.

> *Well, they (the learners) were relaxed and thought they were just having fun and playing a game. … So, if you're relaxed and happy, you will remember that information because you are in the amygdala and the central part of your brain. That is, if you are relaxed there, you're gonna remember more things. So, it definitely, um, affects the children that way. And I mean, I think that we underestimate the fact that the kids can learn about brains. I think that we should be discussing the brain more and more with the children cuz as an adult I'm going, oh, that's why! Like that's crazy. You know, we should have been doing this at school. [Mary]*

The positive engagement of learners was often tangible throughout the lesson observations; these reactions influenced the teachers' classroom as they considered the technology as adding value and creating an enjoyable, relaxed learning environment.

4.3.1.2 Build content knowledge

The subtheme ‘build content knowledge’, as part of the theme ‘acquiring knowledge.’

A part of acquiring knowledge involves building content knowledge. For this, teachers use resources such as VR in their lessons. The eight participants spoke about how the VR resources added value to their lessons and assisted in building the content knowledge of learners.

Sarah (Grade 4SS) used futuristic travel about various autonomous vehicles as the VR resource. The VR experience demonstrated selecting vehicles needed for various lifestyle requirements, such as going to work or a family weekend away. Figure 40 presents screenshots of VR experience Road Trip 2030 in VR view (Covestro, 2018), which was used in Sarah’s Grade 4 lesson.

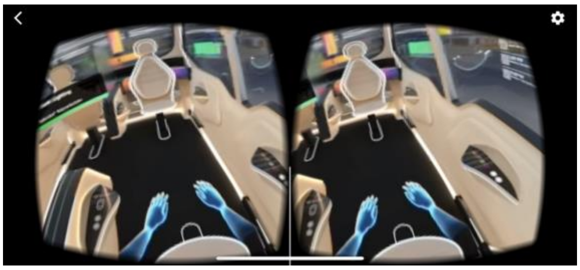
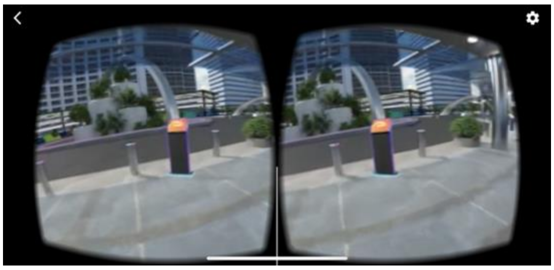
	
Interior of the autonomous vehicle	Hailing the future mobility vehicle

Figure 40: Screenshots of Road Trip 2030 in VR view (Covestro, 2018)

Sarah recounted how her learners began to think about the journey that they would take. Within that context, they began problem-solving and relating the vehicle selection to themselves. They thought about the vehicle’s features and what they would change or improve. She raised the question,

> *So that's kind of what you're hoping to achieve rather than look at this and go, oh, this is it. You know? No, how can I make it better? How can I improve it? [Sarah]*

She encouraged her learners to think creatively to build on the knowledge they already had and the knowledge they had acquired from the VR resources.

When Kgomotso (Gr. 6 NS - Food Nutrition) was asked how she felt about the lesson with its VR activity. She commented,

> *I noticed that my learners were excited. They were motivated, and they were focused. So, I really loved it. [Kgomotso]*

When asked what she thought her learners had gained from the lesson, she expressed that the learners

> *understood the content much better, because they were not disturbed, and there was self-motivation from their side. [Kgomotso]*

She thought the learners understood the lesson content

> *much better than when using other methods. [Kgomotso]*

Thandiwe and Dhriti referred to the VR tasks as adding understanding to the context for the learners, and thereby building content knowledge. Thandiwe found that after watching the cyber bullying VR video, some of her learners said

> *'This is what cyberbullying is', as if they had a better understanding than before watching it. [Thandiwe]*

Dhriti was surprised at how her learners were engaged after watching the VR activity about the San hunt. She expressed how

> *they seemed to show a greater understanding and depth of awareness of the lesson's context. [Dhriti]*

Figure 41 below presents a screenshot from the San hunt in VR mode (BBC Earth, 2009) used in Dhriti's lesson.

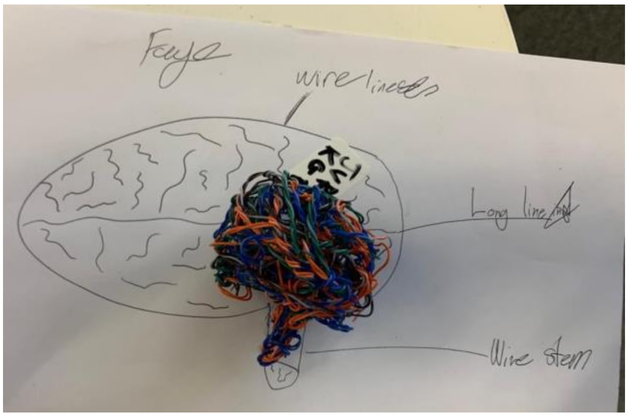
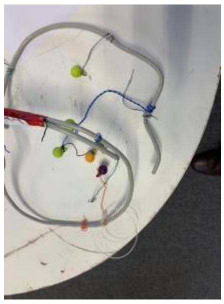
Figure 41: Screenshot from the San hunt in VR mode (BBC Earth, 2009)

Bhavna mentioned that the learners seemed to remember the information better after doing an interactive activity such as a VR task. Tammy's lesson was the NS Grade 6 revision of ecosystems and noticed something positive; that a learner described visiting all different environments and remembered where they were. Siara referred to many of her learners as speaking about how the VR made them feel as if they were physically in the place in Borneo. She thought this helped them to understand ecosystems.

Mary's learners were playing the application InMind2 (Luden.io, 2017), an adventure game where learners assist John (a cartoon character) to react by selecting brain chemicals such as dopamine. The game placed emphasis on human emotion and the chemistry behind it. The learners in a previous lesson had built models of the brain. Mary described these brain models as looking like solid blobs, but in the VR lesson she wanted her learners to understand the dendrites and neurons. Mary explained that the learners understood that there was a chemical reaction, and they grasped that there was a link from one part of their brain to another. Many learners said that they wanted to recreate their brain models and that they wanted to show the connections in the brain. Table 19 illustrates the previous brain models in the image on the left, and the examples of remade models showing the neural connections represented by the wire frame.

These models showed the neurons and dendrites as it was seen in the VR game. Table 19 presents the data of the models of the brain created by the learners before and after the VR lesson.

Table 19: Models of the Brain before and after the VR lesson

Model of brain previous lesson	VR application - InMind2 (Luden.io, 2017)	Model of the brain after VR activity
		
		
Table of various brain models built in previous lesson: Solid structures	Various brain models after the VR lesson showing neurons and dendrites.	

The learners' understanding and content knowledge of the brain, dendrites and neurons was improved after playing the VR game about the brain and the brain's chemicals. This was evident when one compares the initial models to the more accurate, recreated ones.

The five participants (Kgomotso, Thandiwe, Dhriti, Siara, Mary, Bhavna) referred to their learners demonstrating understanding of the content they had explored and viewed in VR. Three participants (Tammy, Thandiwe, Sarah) referred to learners who provided detailed explanations and descriptions of what they had experienced.

Two participants (Thandiwe and Dhriti) described their learners as demonstrating a depth of awareness related to the content they had viewed. Two participants (Sarah, Mary) spoke about the learners thinking about the contexts and how they were asking questions. Bhavna compared learners' knowledge retention between two lessons about the same topic. In the second lesson, when they had access to VR content, her learners remembered the content and answered the assessment questions meaningfully, in contrast to previous learners who had not had the VR tasks in their lessons. Figure 42 provides a visual representation of the terms used by the teacher participants.

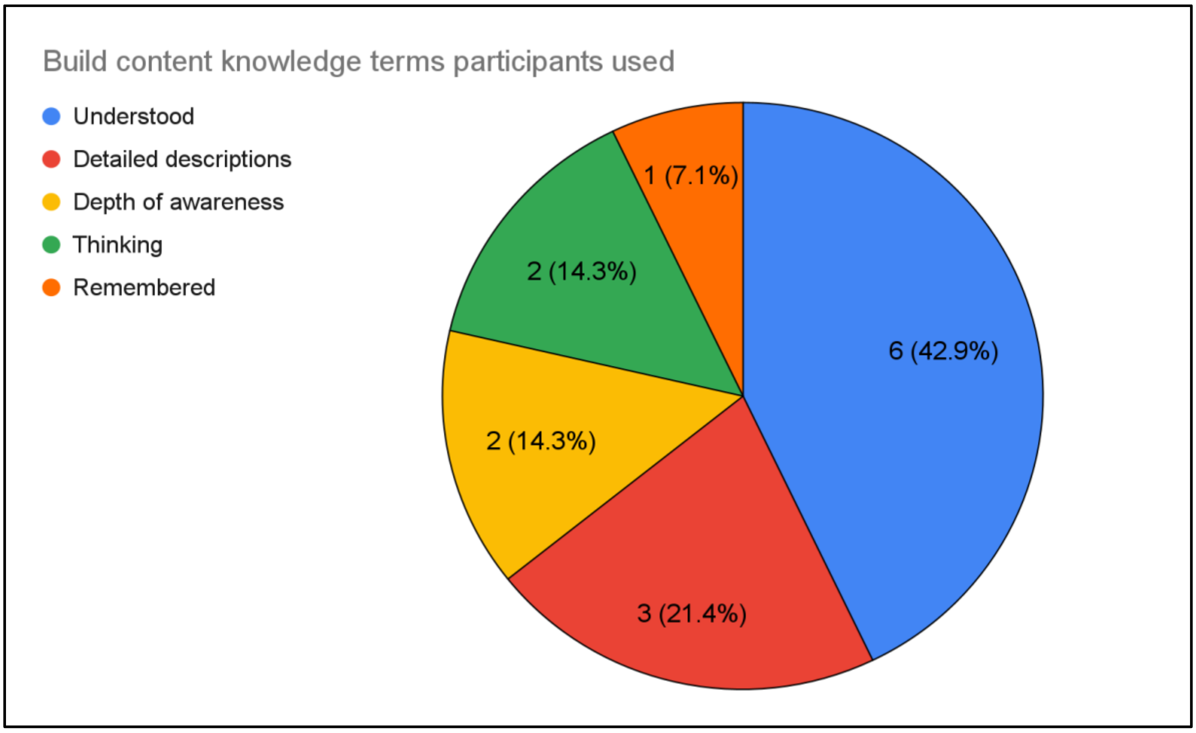


Figure 42: Terms teachers used to describe how learners had built content knowledge

The teachers expressed how the content knowledge of the learners improved by using the VR simulation resource which was integrated into the lesson. These views positively influenced teachers' classroom practices towards including VR resources in the future.

4.3.1.3 Meaningful learner content

The subtheme 'meaningful learner content', as part of the theme 'acquiring knowledge.' Moreover, under the theme of acquiring knowledge, the participants (Bhavna, Dhriti, Kgomotso, Mary, Sarah, and Tammy) spoke about VR content that should be meaningful to their learners. Six of the eight participants shared a total of thirteen comments.

In four comments, Tammy indicated the meaningful lesson content of VR; the VR resource encouraging children to ask questions and to think out of the box and seeing VR tasks as making the lesson content useful; to be another teaching resource. She spoke about a learner's description and said,

> *John said to me afterwards, he said, I know how to use virtual reality glasses. And I got to see all of the different places. He went from the beach. He went to the forest or the jungle. He went here and he went there, he saw everything, and it was so interesting. [Tammy]*

Her second comment spoke about another child

> *There was another little boy who was very quiet in the classroom. He had a lot to say after putting on the goggles, and seeing the different things, which was nice. especially. to see something which was beneficial. [Tammy]*

Mary explained that using VR assisted in putting information into context, which then assisted the learner to understand better. Therefore, VR assisted in providing meaningful lesson content.

> *I think whenever things are put within a context, there's always much more effective learning that takes place, because they (the learners) make the lesson content meaningful to themselves. [Mary]*

Bhavna referred to the meaningful benefit of using VR when remembering lessons she had conducted before the study project, particularly when she was teaching about space.

> *I used VR headsets a lot, especially in the fourth term, in every other lesson, when we explored space, which was great. . . . I could get VR videos . . . we used VR quite extensively where we spoke about planet earth, and I go onto this link. . . we're going to now explore planet earth. And we did that. We explored Saturn, we explored the asteroid belt and I found in my exam, uh, it was last year and the year. No, not the year before the previous year. Uh, where, when I did that, I saw in the answers what they remembered from the VR experience and, you know, they, which is so nice to see, and they actually remembered it more. Um, so the VR really helped in that sense with, I find*

personally, if kids can see something and then they, so I give them information, they see that physically, it actually gels. Well, I meant they still remembered it. [Bhavna]

Dhriti spoke about VR aligning with the lesson content and teaching the learners about the subject topic. Kgomotso described VR as 'reinforcing their [learners'] knowledge in a different manner. The teachers' observations and the learners' reactions reinforced the idea to them that VR was a meaningful learner content resource to integrate into their classroom practices.

4.3.1.4 Reinforce knowledge

The subtheme 'reinforce knowledge', as part of the theme 'acquiring knowledge.' The inclusion of VR experiences in lessons might reinforce a concept or idea by putting it into a context. This way, it provides further support to reinforce the information or build knowledge and understanding. Four participants (Mary, Bhavna, Thandiwe, and Dhriti) indicated with a single comment of how they observed their learners' knowledge being reinforced using VR in their lessons.

Mary commented that VR scenarios 'actually can assist or can supplement [learning] when you can't go out', referring to Covid-19 restrictions and not being able to take learners on outings.

While discussing using VR in her lessons, Bhavna indicated that VR experiences reinforce the learning of information, and that it helps with memory retention. The learners in Thandiwe's class (Grade 4 Life skills) watched the *Cyber Bullying - Create No Hate*, YouTube video in VR mode. They previously discussed different types of bullying and how to cope with bullying. She explained that even though they had learnt about cyber bullying, she realised after they had watched the video that they did not quite understand what cyber bullying was, and therefore, she discussed it with them. She noted that 'the VR video helped them understand what cyberbullying was.'

4.3.1.5 Learner communication and sharing

The subtheme 'learner communication and sharing', as part of the theme 'acquiring knowledge.' Another subtheme flows from 'acquiring knowledge', emerging as that of communication and sharing amongst learners. Two participants (Tammy and Mary) shared incidents where learners communicated their viewpoints related to the VR scenario they experienced. They were encouraged to communicate and how it built self-confidence was inspiring to see in a classroom. Tammy found the use of VR valuable in encouraging a learner who was usually quiet in her class but had ‘a lot to say after putting on the goggles and seeing all the different things.’ She described him as being excited and bubbly after the lesson and she found it inspiring. Mary spoke about the persistence of a learner wanting to use the VR – she was concerned as he had been ill – but she described how the learner insisted that he wanted to use the VR. She explained how he loved the experience as he could relate to it, and he stated he wanted to just do it again. Examples such as this, where a resource provides a positive result for learners who may be reserved or going through a difficult period in their lives, is even more beneficial when it is building knowledge and meeting other learner needs.

The integration of VR simulations influenced the primary school teacher participants' classroom practices. All eight participants experienced their learners’ engagement and viewed how VR assisted their learners in building content knowledge. Six participants (Bhavna, Dhriti, Kgomotso, Mary, Sarah, and Tammy) discussed how they saw the VR resource as meaningful lesson content when added to the lessons they taught. Four participants (Bhavna, Mary, Sarah, and Thandiwe) felt that VR as a teaching resource reinforced their learners’ knowledge. Mary and Tammy spoke about how the VR resource encouraged learners to communicate ideas and share what they observed with them. Therefore, these comments showed the learners had acquired knowledge when they used VR as a resource. These thoughts the teachers expressed could potentially influence their teaching practices.

4.3.2 Reaction to learning - feeling real

VR may create a realistic, immersive learning experience for learners. All participants (n=8) spoke about the influence of VR on the learners where it provided a real-world experience. There were five sub-themes which were combined to create the theme ‘reaction to learning - feeling real’. These sub-themes were ‘bringing reality into the classroom’, ‘learner reaction’, ‘contextual learning through experience’, ‘real world context’, ‘apply to real world’ and ‘apply to real world’. Table 20 below presents the data about the reaction by learners to learning, according to themes and sub-themes.

Table 20: Reaction to learning: Themes and sub-themes

Theme	Subthemes	Participants	Comments
Reaction to learning - feeling real		8	61
	Bringing reality into the classroom	8	12
	Learner reaction	8	11
	Contextual learning through experience	7	29
	Real world context	6	6
	Apply to real world	3	3

Each participant (n=8) commented that VR created the illusion of being linked to a real-world situation or context in some form or other, and that this illusion created or helped to create the reality, or an understanding of the reality.

4.3.2.1 Bringing reality into the classroom

From the theme ‘reaction to learning - feeling real’, the subtheme ‘bringing reality into the classroom’, emerged. All teachers (n=8) mentioned that the VR experience brought realistic situations into the learning experience for their learners. They all described how their learners reacted to the various scenarios used in their teaching. Bhavna (Grade 6NS) mentioned that bringing reality into the classroom was seen as important, as she explained that the VR resource helped create an understanding of reality. It creates an out-of-body experience when travelling in outer space and looking back down to the earth (Bhavna, Grade 6, NS). Mary (Grade 6, GCD) provided her learners with a similar experience by travelling up into the atmosphere with a weather balloon. Mary (Grade 6, GCD) explained, 'Recently we had groups and they moved from station to station. VR was one of the stations. We did the weather, and then I had this great little VR of a weather balloon that goes up. And then the child is taken up into the atmosphere of the earth, and they absolutely loved it.' In both instances, the children could not have done these tasks actually or practically, however, they were able to experience them and feel as if they were real. Mary (Grade 6, GCD) also spoke about a previous lesson where learners were using VR. One of the learners had brain cancer and had recently come back to school after treatment. She explained

> *I was very anxious about him doing it (VR). And he insisted he wanted to, and he absolutely loved it because this was like a real thing for him, you know, he could relate to it. [Mary]*

He asked for another turn as well, and Mary said she explained to him that she did not think he should be due to the visual stimulation. Later in the interview she spoke about the children

> *feeling that they are travelling and moving and exploring new places. [Mary]*

Sarah described learners as being disengaged from school and learning. When asked why she thought the learners would not be disengaged with VR, she explained that the VR was real; it was another reality, where the learners were using their senses and were immersed.

Kgomotso (Grade 6 NS) explained that her learners

> *actually, felt like they were part of the video (YouTube VR view) themselves. So, it means they were part of the learning and teaching that was happening there. [Kgomotso]*

Tammy saw the benefit of bringing reality into the classroom for the learners in her class, especially those who are naturally quiet and withdrawn. One particularly quiet boy came and spoke to her about the experience. She said,

> *He said to me afterwards, he said, I know how to use virtual reality glasses. And I got to see all of the different places, he went from the beach, he went to the forest, the jungle. He went here, and he went there. He saw everything and it was so interesting. [Tammy]*

Siara (Grade 6 NS) mentioned a similar reaction when she discussed her class's lesson. Many children had spoken with her about how the VR made them feel as if they were in the place in Borneo. They mentioned how beautiful the place looked. The VR helped the learners to understand more about ecosystems.

The VR experience may not always provide clarity, but it raises questions. Thandiwe (Grade 4 Life Skills) experienced this with her Grade 4s who watched the VR YouTube video about cyber bullying. The video was created and filmed by Luke Culhane (CreateNoHate 2016), a young boy who addresses cyber bullying. In the story, he illustrates and equates cyber bullying with physical injury, to relay the point that cyberbullying is hurtful. Figure 43 below illustrates through a series of screenshots how cyberbullying was portrayed in the VR video 'Create no hate' (CreateNoHate & Culhane, 2016).

		
Nose bleeding while on cell phone	Nose bleeding while on laptop	Nose bleeding and arm in sling while on cell phone

Figure 43: Screenshots from 'Create no hate' (CreateNoHate & Culhane, 2016)

Thandiwe decided to focus on cyberbullying for the VR integrated lesson after she taught a lesson about various types of bullying with her learners. She thought cyber bullying required further clarity. She found it interesting that most of her learners could not understand the analogy of the boy being beaten up when he was just on his phone or laptop, and how he was 'beaten up' when it was cyber bullying. The VR video helped her learners understand what cyber bullying was. After watching the VR resource as to how cyberbullying is sending digital messages, and these could result in people feeling hurt, they could discuss it further. She explained to them that the boy tried to show the hurt in the video and answered their questions after the viewing. Thandiwe saw the value of using the VR resource and further explained the analogy of the video to her learners. The VR scenario, the questions, and discussion between the teacher and class afterwards, assisted in building understanding while at the same time, created an affordance for the use of VR in lessons for the teacher.

4.3.2.2 Learner reaction

The subtheme ‘learner reaction’, as part of the theme ‘reaction to learning - feeling real.’ Teachers observed their learners and responded to their reactions. These learner reactions towards VR might influence the teachers' affordance to integrate VR into their lessons. All participants (n=8) provided comments about how their learners reacted positively to the lessons, which included the VR resource. Table 21 presents the data about the positive interactions by participants learners to the VR resource used in the lessons.

Table 21: Indicated positive interactions by participants' learners

Participant	**Learner reaction comments by Participants.**
Dhriti	The learners were so involved and interested. … They loved it.
Tammy	Learners gave really nice feedback. Well, I was pleasantly surprised. I really really was. . .. it is something they wanted to do.
Siara	Learners loved it, were very excited to be using VR. Participated and focused on the task.
Thandiwe	Yeah, there was so much excitement.
Kgomotso	They were excited about it, so they participated even better. And from the feedback, they understood the content, because they were really immersed in it. Okay. I noticed that my learners were excited, and they were motivated, and they were focused. So, I really loved it.
Bhavna	They got so excited. Well, some of them had never ever done a VR experience. So it was, it was so nice and heart-warming to see some of them. They were totally totally fascinated.
Sarah	They loved it. They absolutely loved it.
Mary	They were relaxed and thought they were just having fun and playing a game. . . If you are relaxed, you're gonna remember more things.

These positive comments about how the teachers perceived their learners' reactions might sway teachers' beliefs and attitudes. In turn, such responses may impact participants' actions and opinions of using VR in lessons in the future.

4.3.2.3 Contextual learning through experience

The subtheme 'contextual learning through experience', as part of the theme 'reaction to learning - feeling real.' Understanding the context from which information was derived, or the information placed within a context, assists learners in building knowledge. VR created the opportunity to learn through experience. Seven participants (Bhavna, Dhriti, Kgomotso, Mary, Sarah, Tammy, and Thandiwe) in 29 comments, spoke about learning through contextual experiences. The graph (Figure 44) shows the number of comments each participant shared, and the percentage in relation to the total number of comments. Siara had the least input with one comment, while Mary had the highest number of 10 comments. Tammy, Kgomotso and Dhriti had two comments each. While Thandiwe and Sarah contributed three comments each.

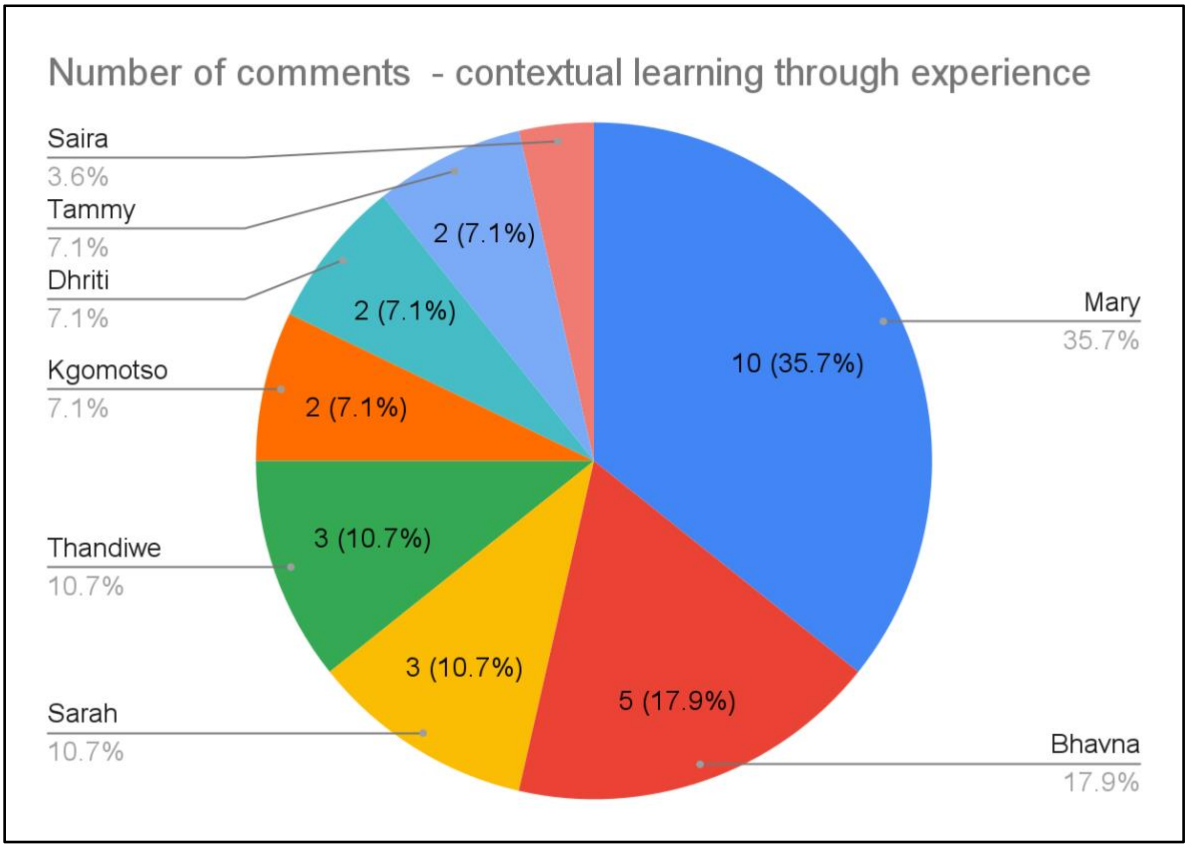


Figure 44: Number of participant comments about contextual learning through experience

Mary used VR to build context through the experience. She made 10 comments related to VR as contextual learning and spoke about lessons where she had used VR before the study, such as taking children into the caves in Egypt, or travelling in a weather balloon. Mary (Grade 6 NS) also commented 10 times, touching on contextual learning experiences.

> *The children learn through the experience, whatever the experience might be. So actually, that's how, that's why I liked the VR experiences… Because they (the learners) made the lesson content meaningful to themselves. [Mary]*

She also explains,

> *The virtual experience in this day and age actually could assist or might supplement when you could not go out. [Mary]*

She continued,

> *And that experience (VR experience) meant that they (the learners) were safe, that it wasn't expensive, but at the same time, they got that feeling that they were travelling, moving and exploring new places. So, they got excited, they engaged and participated. [Mary]*

She described a child who had flown in an aeroplane and enjoyed travelling in a VR spacecraft,

> *He absolutely loved it because this was like a real thing for him. You know, he could relate to it. 'So, I just want to go into space again', he said. [Mary]*

Mary used the VR to create a sense of reality and to build context. She described that when she introduced VR to visiting caves in Egypt, it created surprise and concern among the children as they were going on a trip far away and wondered whether their parents knew. As a teacher, she took her learners into spaces of curiosity and interest. She explained,

> *I know I used VR, when we learnt about Egypt, we went into the caves. You know, I said, we're going to Egypt, did you tell your parents? 'No, no we can't go to Egypt!' And I said 'No, we can go!' Cause we, I sort of like the idea of a road trip or doing it (VR) that way. [Mary]*

Mary recalled experiences of using VR with learners from Grade R to Grade 7. She had been sharing how they were not able to take children on outings due to Covid restrictions, but she wanted to get the children outside. She created workstations of various activities for different grades of travelling, using different transport. I asked, 'If you think you said you use them from Grade R to Grade Seven, do you think VR is still interesting to Grade 7 learners?' Her response was,

> *Actually, I was amazed because it did, but they sort of, um, maybe they were just tired, and they enjoyed it. They thought they weren't doing anything. Um, but I was surprised because they enjoyed the experience even though they've flown in aeroplanes and have some knowledge. But I think for some of them, it was an out of body experience because they could look down. I also had options for, um, skydiving. And there was a sailing one, but that wasn't that interesting. It was just the sea going up and down. [Mary]*

Even outside of the study grade, scope with older children and simple VR, the children's contextual understanding was increased through the experience.

Bhavna made five comments related to VR as contextual learning. She enjoyed using VR when teaching space. For her, the visual experience of VR helped learners because it was practical.

> *I gave them (the learners) more visual aids on the projector. And then we used VR quite extensively where we spoke about planet earth and I was like, right, go onto this link. And we're now going to explore planet earth. And we did that. We explored Saturn, we explored the Asteroid belt. [Bhavna]*

She was delighted at the reaction from learners when using VR.

> *Well, some of them (learners) had never, ever done a VR experience. So it was, it was so nice and heart-warming to see. Some of them they're like totally, totally fascinated. Like they actually felt that they were on that particular planet. [Bhavna]*

She spoke about how the VR assisted learners to remember information better and recall it during assessment. She explained,

> *if kids can see something . . . so, I give them information, they see that physically . . . They still remember it. [Bhavna]*

Thandiwe had three comments related to VR as contextual learning. She spoke about the value of doing different subjects, English and Life Skills, as part of the study, as she then saw the benefits for her learners in more than one context. In the cyber-bullying lesson, she realised that the VR video built contextual knowledge and understanding for her learners as they asked questions about cyber-bullying. She realised she had to repeat the explanation about what cyberbullying was.

Regarding the comprehension lesson, she explained,

> *I think we as teachers, maybe I'm looking for myself, maybe this kind of school that I teach at, we are kind of slow into going into that direction. We are very, very slow. I know there was the first industrial revolution, then the computer revolution or the third revolution. So, we were still slow. We're not catching up with technology.*
>
> *And, but I think also with Covid, it kind of helped us to be open now towards it (technology) going, learning more. We need to do more. I think it can help solve a lot of problems in education. If you can, we can do this. I think going forward, I want to really bring it (VR) in. Cause there are a lot of things that we could do using the visuals and what, and it can help a lot because I see so many gaps, so many gaps and I don't know whether I could be contributed to Covid because the group I'm teaching now is Grade*

4s. I think they are the worst I've taught in my whole teaching career of eight to nine years, they are the worst I've seen, their comprehension, whatever. So, anything that will help enhance their understanding. And bring back the love of education. So, I would definitely recommend it. [Thandiwe]

Sarah also had three comments related to VR as contextual learning. She spoke about her learners not being disengaged when using the VR. When asked 'why do you think they don't disengage with the VR?', she replied

Well, I think because it's real, it's reality. it's another reality. It's something that they were using their senses and they were engaging with on every level. You know, like with the first time I've ever had a headset on. And I mean, you're completely immersed in that and you, and you are guiding your looking on your own! Where you want to look, where you want to go! You are aware of your own body in the experience. So, it's back to experiential learning as opposed to I don't know, not, it's not even tactile learning! When you get a worksheet, you know, it's superficial for me. [Sarah]

She also said,

I think whenever things were put within a context, there was always much more effective learning that took place. [Sarah]

She explained about the learners,

So, I think they enjoyed being surrounded by the experience immediately and sort of lived it that way. [Sarah]

Kgomotso had two comments related to VR as contextual learning. She expressed how the learners understood the content, as they were focused. They gained information as there were no other disturbances when they were wearing the VR headsets. She saw the VR resource as beneficial.

Yes, it was a beneficial resource. It was a beneficial resource, because of what my learners were saying, they actually felt like they were part of the video themselves. So, it meant they were part of the learning and teaching that was happening there. [Kgomotso]

The teachers related how VR was relevant within the context of the topic being taught:

- Dhriti said that to help build context for the written tasks, the VR assisted the English lesson about being shipwrecked.
- Tammy described how the VR built the context of the ecosystem; learners felt they were indeed, in Borneo.

The teachers felt that the VR simulations were beneficial as they put the lesson information within the context with which learners could relate. In turn, these viewpoints potentially influenced further integration of this multimedia into teachers' classroom practices.

4.3.2.4 Real world context

The subtheme 'real world context', as part of the theme 'reaction to learning - feeling real.' As a sensory and immersive technology, VR creates the experience of being within the real-world context. Four of the lessons involved real context with photographs rather than animated visuals, such as Thandiwe's cyberbullying lesson. The other three lessons were all natural habitats: the ecosystems of Borneo (Siara and Tammy's Grade 6 NS classes), the iSimangaliso Wetland Park, South Africa (Bhavna's Grade 6 NS class) and the San Hunter-gatherer's hunt, in the Kalahari Desert, Namibia (Dhriti's Grade 5 Social Sciences - History). These environmental scenarios also included the natural sounds of their environments.

Siara and Tammy's classes (NS Grade 6) viewed the **Ecosystems of Borneo**, a Google expedition scenario that was photographed in the Borneo National Park in Malaysia. This VR experience was an activity within the revision lesson about wetlands. In both classes, the learners were rotated through the activities in groups, and they watched the VR individually. The description of the scenario is stated:

'Within the tropical region of Borneo, there are various and distinct ecosystems that are subject to very different ecological and climatic conditions. Each has their own complement of animals and plants that have evolved to be well adapted to these conditions.' [Google Expeditions, 2020]

The panorama titles of this experience included (1) Beach and Cliff Vegetation, (2) Scrubland, (3) Sundland/Kerangas Dry Heath Forest (4) Sunda Shelf Mangroves, (5) Stream ecosystem, and (6) River ecosystem. Figure 45 illustrates two scenes from the Google Expedition, Ecosystems of Borneo (Sundland/Kerangas Dry Heath Forest and the Sunda Shelf Mangrove).

	
Sundland/Kerangas Dry Heath Forest	Sunda Shelf Mangrove

Figure 45: Ecosystems of Borneo, Borneo National Park Malaysia (Google, 2015)

Siara expressed that her learners were keen to go through the content. Her learners said that the VR made them feel as if they were in the place, in Borneo. The learners explained how beautiful the scenario looked, and some learners mentioned that it helped them understand ecosystems. Tammy spoke about the importance of allowing learners to watch VR content and indicated how the VR impacted individual children. One of her boys said,

> *I know how to use these VR glasses. And I got to see all the different places, I went from the beach to the forest, jungle… saw everything and it was so interesting. [Tammy]*

She thought that VR assisted some learners that 'you lose in a classroom, those that just drift off or they perhaps get bored, those are the sorts of children that you really get with this.'

Bhavna (Grade 6 NS) also revised the ecosystem and used the YouTube experience in VR mode of **iSimangaliso Wetland Park**, South Africa. Figure 46 below provides examples of the iSimangaliso Wetland Park, South Africa (Drink Tea & Travel, 2020) images learners would have experienced during the VR lesson.

	
Grasslands with rhinoceros	Hippopotamus in the river.

Figure 46: iSimangaliso Wetland Park, South Africa (Drink Tea & Travel, 2020)

San people hunting: Dhriti's (Grade 5 Social Sciences - History) learners had been studying the San Hunter-gatherer society in the later Stone Age, with two of the outcomes being to explore how the San lived off the environment, and how they hunt and their respect for natural resources. The learners had already been made aware of how the San lived off their environment, so the lesson was a recap of what was learnt already. They were in four groups of five learners, who rotated through a range of activities. The BBC Earth's The Intense 8 Hour Hunt was watched in YouTube's VR mode as one of the resources for the lesson. Figure 47 below presents screenshots from The Intense 8 Hour Hunt, BBC Earth (BBC Earth, 2009) which learners viewed during the VR lessons.

	
San hunter tracked the kudu (antelope)	San hunter indicated the tracking signs

Figure 47: The Intense 8 Hour Hunt, BBC Earth (BBC Earth, 2009)

Dhriti described how the VR experience related 'absolutely perfectly' to what she was teaching. She went on to say

> *It was aligned with the San and the whole reason that we said we actually taught them about the San. I felt it showed them, you know, to learn about respecting the environment of being grateful for what we have, things like that. So, it definitely was very much aligned with not just their knowledge, but also the skills and values that we'd like to teach them as well. [Dhriti]*

In all three lessons, the teachers reflected on the impact the activity had on their learners and the relevant connections to their lessons. These comments assisted in building positive reasons for integrating VR technology into teachers' classroom practices.

4.3.2.5 Apply to real world

The subtheme 'applies to real world', as part of the theme 'reaction to learning - feeling real.' The teachers observed how their learners reacted to the use of the technology, making connections to the real world. Bhavna (Grade 6 NS) described how the use of VR helped to create the reality, or an understanding of the reality for the learners in her class. In Dhriti's lesson, the San hunt VR experience provided a real-world context for the Grade 6 learners learning about the San. It assisted in creating an understanding and respect for other cultures and the environment. She described her learners as loving the VR activity and being immersed in the experience. Tammy and Siara's students learned about ecosystems who explored Borneo's ecosystem. They said that the 'VR made them feel as if they were in the place' (in Borneo) and they spoke about how beautiful it looked. The teachers (Siara and Tammy - Grade 6 NS) indicated that the VR resource had helped the learners understand ecosystems.

Sarah (Grade 5 SS - History) and Mary (Grade 6 GCD and NS) both mentioned the United Nations (2021) 17 Sustainable Developmental Goals[27] (UN SDG). Sarah explained how learning should be relevant and real, and that teachers should be focusing on items such as the UN SDG and exploring ways to bring innovation into lessons. Mary, on the other hand, spoke about being very proud as they incorporated the UN SDG in their lessons and relating it to the learners, especially

[27] The 17 UN Sustainable Developmental Goals https://sdgs.un.org/goals

with United Nations COP26[28] (2021) meetings taking place. She thought the children realised that it was reality. She explained that as teachers,

> *We have to put ourselves out there. So, at any opportunity, I like to take the children on an adventure, take them outside of their own space, make them excited about learning, and I'm given the freedom to try new things. [Mary]*

These explanations demonstrated teachers' beliefs and perhaps how affordances could be developed when they viewed the learners' reactions; that they are aware how content relates to the real world.

The participants observed integration of VR simulations in the lessons they conducted; they described the learners as having acquired knowledge. They observed the reaction of their learners to learning when using VR and feeling a real interaction within lessons. They used VR to build contextual learning through the experiences. Some participants' VR scenarios provided a real-world context, and a few VR resources were applied to real world scenarios. These observations and comments influenced the primary school teacher participants' classroom practices. The following theme explores the interaction within the lessons.

4.3.3 Interaction within lessons

Teachers were influenced by their learners' reactions when they incorporated resources into their lessons. In this section, five sub-themes that the teachers observed by their learners when they included the VR into their lessons are discussed. The first four subthemes ('active learning', 'focused on task', 'motivated learning and immersive learning') all interlink and merge into the fourth topic of 'the learning experience, experiential learning', which is with what the section begins. The section concludes as it addresses the observation of the learning experience as an experiential manner of learning, which was expressed by all eight participants. Table 22 below gives information about the number of participants and their comments about interactions within lessons.

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[28]United Nations, Climate Action - COP26: Together for our planet
https://www.un.org/en/climatechange/cop26#

Table 22: Number of participants and comments about interactions within lessons

Theme	Subthemes	Participants	Comments
Interaction within lessons	The learning experience - Experiential learning	8	41
	Active learning	5	10
	Focused on task	4	8
	Motivate learning	4	4
	Immersive learning	3	4

4.3.3.1 The learning experience - Experiential learning

The subtheme 'the learning experience - experiential learning', as part of the theme 'interaction within lessons.' The teachers observed their learners experiencing the VR scenarios, which in turn, influenced their inclusion of VR into their classroom practices. VR simulations were multisensory experiences. The VR scenarios used in the study included visual and auditory engagement. VR provided learners with multimodal opportunities to learn about items or situations which were not able to be achieved with resources such as books, videos, or websites.

The teachers observed their learners feeling the experience; being engulfed by the particular VR scenario.

Bhavna

> *They actually felt that they were on that particular planet. You know, when we were doing that or even the moonwalk when we were doing, they were like, this was reality, I feel like I'm on the moon, I guess that was the VR experience. You felt that you were actually in that specific place.*
>
> *So we did the Mars exploration. It was phenomenal. . . . they remembered that when they did their project. They had to build their own Rover that would go on any planet. And, they remembered that VR that we did and they used some of those ideas that we saw on their little robots. So that was quite cool*

Mary

the children learnt through the through experience, whatever the experience might be. So actually, that's why I like VR.

And that experience meant that they are safe, that it isn't expensive, but at the same time, they got that feeling that they were travelling, moving and exploring new places. So, they got excited, they engaged and participated.

Kgomotso

And they actually said they felt as if they were part of what was happening. So, it was like part of them.

Dhriti

And I think it was very immersive and they were able to come up with questions, you know, make comments about it.

The visual experience was highlighted by Bhavna, Kgomotso, Tammy and Mary during the discussions

Bhavna

But with VR it really helped, as it was visual, and it was practical

. . so, the VR really helped… if kids could see something and then they, so I gave them information, they saw that physically, the information actually gels. Well, they meant they still remembered it.

Kgomotso explored that learners were not distracted, as

a child was focusing on what they were doing at that particular moment, so they gained a lot of information.

Kgomotso (Gr 6 NS) described how her learners expressed that

they actually said they felt as if they were part of what was happening. So, it was like part of them.

Tammy

I think that was a nice substitute for actually being able to see things

A child explained that 'he went from the beach to the forest or the jungle. He went here and he went there. He saw everything and it was so interesting.'

There is another little boy who was very quiet in the classroom. He had a lot to say after putting on the goggles. and seeing the different things, which was nice

Mary

> *I know I used them when we did Egypt, then we went into the caves*

When Mary (Grade 6 GCD and NS) referred to the Covid restrictions and complications of not going on outings with her learners. She commented that

> *the virtual experience in this day and age actually could assist or could supplement when you can't go out (Grade 6).*

The participants expressed how their learners felt that they were immersed in the experience. The VR scenarios created an authentic and experiential learning experience. A learner in Tammy's (Grade 6 NS) class explained that the VR got him to see all different places. She says that her learners were 'using their senses and they were engaged on every level' when they were using the VR in the lesson. Sarah (Grade 4 SS) agreed with this thinking where she explained that using VR was

> *experiential learning as opposed to, … not even tactile learning… when you get a worksheet. . . it's superficial for me. [Sarah]*

Kgomotso (Gr 6 NS) described how her learners expressed that

> *they actually said they felt as if they were part of what was happening. So, it was like part of them.*
>
> *The VR learning took the children on a journey that they felt that they were travelling, moving and exploring new places [Kgomotso]*

This too is also supported by Mary's (Grade 6) explanation that

> *so, I think they [the learners] enjoyed being surrounded by the experience immediately and sort of in a lived way. [Mary]*

These quotes highlight the learning experiences the learners experienced and perceived during the lessons.

Bhavna (Grade 6 NS) spoke about VR as an experiential tool which assisted learners who needed further assistance to understand the work. She explained that she had a few learners who had learning needs and they required extra assistance. She explained:

> *We had a few learners who had some learning needs. But with VR it really helped, as it was visual, and it was practical. So, for some of them, I had to take a little bit more time,*

going throughout the unit to explain things such as the science stuff. They would talk about it or create a drawing as opposed to writing down things. So, if we do have learners with learning needs, because we do so much of discussion in terms of school and exposed them to outside experiences it benefitted these learners. [Bhavna]

This example demonstrated the experiential benefits of VR for a range of learners in an ordinary school and how the VR scenario could be used to build understanding and context. The personal and poignant encounters the teachers shared about their learners' experiences positively influenced their opinions of including VR into their teaching practices.

4.3.3.2 Active learning

The subtheme 'active learning', as part of the theme 'interaction within lessons.' The active engagement of VR assisted in offering learning situations where the learners participated actively in sensory interactions. Therefore, VR provides different teaching affordances to other technologies used within a classroom. The interaction and positive experiences the learners exhibited influenced how the teachers reacted. Kgomotso was very pleased with her learners' reaction to the use of VR. She explained that her

… learners loved it, were so excited, and loved the way they engaged, and wanted to know if they could do more with the VR. They wanted to continue using the technology (Grade 6 NS). [Kgomotso]

Tammy spoke about how the inclusion of VR content impacted the learners' participation. She explained,

Yes, it did have an impact on the learners, even those who said they had similar technology at home. They were engaged and enjoyed the VR. They wanted to explain what they had seen and had many questions about the lesson content, more questions that I normally find they ask. [Tammy]

The active involvement and the positive reaction from the learners prompted Kgomotso to go on and say,

I just pray that one day we get a donor again, donate phones. Also, with the internet, I think there are arrangements for us to get the internet down in my classroom. Yeah, down by the church. So, I'm not sure when that would happen, but at least there were some talks around it. [Kgomotso]

Because the researcher supplied mobile phones and VR goggles for Kgomotso's lessons, her comments indicated and reinforced the positive reaction she observed as learners interacted and were actively engaged with the selected VR content. This reaction probably drove the desire for the technology to be available for use in lessons.

Positive reactions were expressed by Thandiwe (Grade 4 Life Skills) when she explained her observations during the emotions and conflict lesson which incorporated a VR activity. There were three rotational activities: a written task, a group discussion about emotions with the teacher, and the VR activity. Her learners were eager to participate in the VR lesson. Due to the Covid restrictions, the VR activity was set up outside the classroom on the grass. Thandiwe expounded on the fact that the learners were enthusiastic to do the VR task. She said,

> *Yeah, there was so much excitement because they [the groups] were doing it in turns. So, the others in the class were also looking forward to doing it [the VR activity], having their turn as they were rotating doing the [VR] task. [Thandiwe]*

Bhavna's excitement about her learners' reaction was tangible. She explained,

> *I tried to do more learner centred teaching where I am. So, what I did in a lesson was I taught a topic and I saw how the kids were reacting to that particular topic. And if I saw, you know, some of them drifting off. I tried to change it to engage them. And then that's where my VR lessons came into play. And I noticed that they thoroughly, thoroughly enjoyed it. You know, they absolutely enjoyed it. [Bhavna]*

These positive reactions impacted decisions teachers made when planning their lessons. They spoke about their learners being focused on the tasks within the lessons where the VR scenarios were integrated.

4.3.3.3 Focused on task

The subtheme 'focused on task', as part of the theme 'interaction within lessons.' The use of VR in lessons assisted teachers in enticing learners to focus on the lesson's content effectively. Four participants (Kgomotso, Dhriti, Sarah, and Tammy) spoke about their learners focusing better than usual when they used the VR resources. Teachers wanted their students to remain on task and not be distracted. This was expressed by Kgomotso (Grade 6 NS) when she was asked if there were benefits of using VR in your lessons, she revealed that as a teacher, she *can't stop them [the learners] from looking at each other [during lessons with no VR activity]. But when they were using the VR goggles, there was no such thing like disturbances. Every learner was focused on what they were doing. So, yes. [Kgomotso]*

there was a benefit. Having the learners engaged and focused on the learning content was seen as beneficial.

Kgomotso later explained two further reasons as to the benefit of incorporating VR into lessons.

Number one, they [the learners] are excited. Number two, they're in their own environment, there are no disturbances. [Kgomotso]

This teaching affordance of learners not being distracted or disturbed during a lesson was supported by Dhriti (Grade 5 SS) when she was asked whether she would consider using VR in your lessons in the future.

Absolutely. The learners were so involved and interested. [Dhriti]

These comments addressed the idea that VR encouraged the learners to be focused on the activity being addressed, as the VR scenarios limited distractions, which might occur in a classroom when non-immersive resources are being used. Other similar comments about learners being focused on the lesson's activity are listed in Table 23.

Table 23: Indicated interactions by participants' learners

Participant Name	**Comments related to learners being focused on task at hand**
Kgomotso	I noticed that my learners were excited, and they were motivated, and they were focused. So, I really loved it.
Dhriti	The learners were so involved and interested [using the VR]. They used it individually, but it reinforced what they were doing in the other activities.
Sarah	So how did your class react? They loved it [VR]. They absolutely loved it. In fact, I started them off on plants. If I remember correctly, adaptations of plants. So, VR of a plant and they saw the different plants and they did the activities. And then they went on and did their own.
Tammy	Do you think VR technology is worthwhile incorporating again into lessons?

	Speaker 2: I do, I think the different technology could be used in lessons for kids (the learners) to interact. . . . Today the children really enjoyed viewing the VR, and it tied in well with the lesson's revision.
Kgomotso	Did you find that learners were more engaged, or more easily distracted using the technology? They (the learners) were more engaged. It was something that they were using for the first time, so because of the excitement, they were more engaged.
Dhriti	Would you consider using VR in your lessons? Absolutely. The learners were so involved and interested. They used it individually, but it reinforced what they were doing in the other activities.

The teachers saw their learners focused on a task and not being distracted; this was another positive that they reflected as to whether they should integrate VR.

4.3.3.4 Motivate learning

The subtheme 'motivate learning', as part of the theme 'interaction within lessons.' Four participants (Bhavna, Kgomotso, Mary, and Tammy) referred to the VR as helping to motivate their learners. Bhavna's personal excitement and enjoyment of using VR came through when she spoke about how she used VR to motivate her learners about a particular topic and get them to interact and engage. She stated that when she was teaching a lesson,

> *I see how the kids are reacting to that particular topic. And if I see, you know, some of them drifting off and up in, I try to change it to engage them. And then that's where my VR lessons come into play. And I've noticed that they thoroughly, thoroughly enjoy it. You know, they absolutely enjoy it. [Bhavna]*

She used the technology to spark interest, and by her account, it worked; her learners became more involved and motivated. Tammy reiterated this. She referred to one learner in her class who spoke about VR and how he had travelled to various places.

> *So, I think children you lose in a classroom, those that . . . drift off or are bored. I think it [VR] was very enjoyable, very nice. I think it is very important and nice for them to see that type of thing, and that those are the sorts of children that you really want them to engage, . . . to see something which is beneficial. [Tammy]*

Mary (Grade 6 GCD and NS) was speaking about her learners and the technological world in which we live, and she supported the value of using VR in lessons.

I think that you need something to motivate children to excite them, and it will, the virtual experience, in this day and age it actually can assist or can supplement when you can't go out. [Mary]

Kgomotso saw something similar after her nutrition lesson which included the VR scenario. She explained that with the inclusion of VR in the lesson, she noticed that her children were excited.

Okay. I noticed that my learners were excited, and they were motivated, and they were focused. So, I really loved it. They understood the content much better, because they were not disturbed, and there was self-motivation from their side. So, I think they understood the lesson much better than when using other methods. [Kgomotso]

Tangible excitement in learners influenced teachers' views about the inclusion of VR in lessons.

4.3.3.5 Immersive learning

The subtheme ‘immersive learning’, as part of the theme ‘interaction within lessons.’ Three of the participants (Dhriti, Bhavna, Sarah) specifically referred to VR as an immersive educational technology which promoted learning, as they observed their learners during the lessons.

Dhriti (Grade 5 SS) had two classes which used the same Social Sciences lesson plan and VR scenario when teaching about the San[29] people. In the discussion of the lessons, she referred to how the learners had enjoyed the lesson and the impact of the VR being immersive.

I think the kids thoroughly enjoyed it [the lesson with the VR scenario]. There definitely, obviously, has to be a briefing at the beginning, let them watch it and definitely a debriefing just to help them understand what exactly it is. So, um, but they loved it. And I think it was very immersive and they were able to come up with information, you know, make comments about it. So, it got them thinking. [Dhriti]

She observed that her learners had benefited from using the VR, and that they had gained information; they commented on what they saw.

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[29] The San peoples are indigenous hunter-gatherer cultures that are identified as the first cultures of Southern Africa.

In a similar response, Bhavna (Grade 6 NS) described the positive impact of VR on her learners as she recounted a previous lesson that she had taught using VR.

> *It was so nice and heart-warming to see them [the learners] totally fascinated, like they actually felt that they were on that particular planet. You know, when we are doing … the moonwalk. They're like, this is really, I feel like I'm on the moon. I guess that is the VR experience. You feel that you are actually in that specific place. [Bhavna]*

Bhavna explained how the learners felt as if they were in outer-space and walking on the moon. At that time the learners experienced the situation to be real, as if they were there, being completely immersed in the situation.

Sarah explored VR herself and described her own experience in a VR scenario.

> *And I mean, you're completely immersed in that [VR scenario], and you guide yourself looking at your own, where you want to look, where you want to go, you are aware of your own body in the experience. [Sarah]*

She experienced how her body felt immersed within the scenario.

The immersive experience influenced how individuals reacted and engaged. Both Bhavna and Dhriti noted how the learners felt part of, and engaged in the digital experience, and how they reacted to the situation with comments.

The teachers observed their engaged learners acquiring and building their content knowledge when VR was incorporated into the lessons. Their learners interacted positively during the experiential learning lessons, communicating, and asking questions more than usual. The teachers indicated that the VR resources provided meaningful learner content which reinforced their knowledge, provided a real-world experience, or assisted the learners in applying the information to reality. They observed their learners as participating within an immersive, multimodal experience, actively learning, being focused on the task, and motivated to learn. These positive reactions from learners due to the integration of VR simulations might influence the teacher's classroom practices, as they see the VR resource as a worthwhile addition to the lesson.

4.4 What are teachers' beliefs and attitudes about the use of VR as a learning tool for teaching?

This study identified teachers' beliefs and attitudes as being optimistic towards the inclusion of VR, due to the impact, results, and reactions from the lessons they conducted.

Teachers observed their learners'

- excitement and enjoyment during lessons, I presumed that these teachers (n=8) too were excited by their reactions and comments and saw benefits in the learners' engagement in the lessons
- being encouraged to think and ask questions (cognitive thinking) after using the VR, I presumed the teachers saw a benefit in using VR to inspire and build cognitive thinking skills (n=4)
- being assisted in building content knowledge and therefore achieving lesson outcomes. They saw a positive impact from the use of VR resources on learners' assessment results, the researcher presumed that these teachers (n=4) were pleased that their learners were achieving outcomes which impacted on their assessment results.
- memory retention of the information they viewed was remembered, and there was evidence of VR assisting the learners' learning. I presumed the teachers (n=3) were delighted that the learners' memory retention relating to the lesson topic was enhanced.

Learning from the observations and reactions of learners to all 3 sub-questions led the teachers to believe that integrating VR technology into their lessons would be beneficial and worthwhile. Table 24 indicates the number of participants and comments for each of the subthemes related to the influence of VR resources on teachers' beliefs and attitudes.

Table 24: Indicates the sub-themes number of comments and participants which influenced teachers' beliefs and attitudes

Theme	Subthemes	Participants	Comments
Influence of VR resource	Learners' excitement & enjoyment	8	15
	Cognitive thinking	4	12
	Achieving outcomes & Impact on assessment	4	3
	Memory retention	3	4

The beliefs and attitudes of the teachers had the potential to be changed by their learners' reactions to the immersive, multimodal experiences. This section narrates the views the participants shared that assisted in shaping their attitudes after the VR integrated lessons.

4.4.1 Learners' excitement and enjoyment

The subtheme 'learners' excitement and enjoyment', as part of the theme 'influence of VR resource.' The influence of a teacher's belief might be impacted by the way their learners reacted to a lesson. Learners' excitement and enjoyment influences a teacher's attitude. Sarah spoke about her own excitement when planning the lesson. Mary spoke about the value of creating excitement in a lesson. All eight teachers detailed observations of their learners' excitement, enjoyment, involvement, and motivation when they used the VR. In this section these occurrences were narrated.

Sarah recounted her reaction when searching for VR resources during her lesson preparation. She was asked if she saw value in adding a VR resource to the lesson.

> *Absolutely. Absolutely. I think, you know, I was excited. I was excited to see how the kids would react. I was excited when I found the VR video about the tyre. So, it sparked creativity in me. And that, that is essential for me, you know, otherwise I become demotivated and if I had to do talk and chalk, I very quickly lose interest and, you know, I'll go downhill. It (VR resource) was very beneficial. It was also beneficial to turn the topic upside down, see it from the flip side, from the innovation, you know, and I think for next year, looking at people who innovated in the world of transport rather than just the history of past transport. So, it's just the semantics that were different, but they, you, the whole feeling coming across is different because I mean, teaching is an emotionally*

driven profession. So, if you're not excited, you may not get the learners to be excited. [Sarah]

Mary indicated the value of getting the learners excited about what they are learning, and that VR assisted with that. She explained,

> *I think that you need something to motivate children to excite them, and it will, the virtual experience in this day and age actually can assist or can supplement when you can't go out. If I just take Covid for example, does that mean we can take them on a journey without leaving the classroom? And that experience means that they are safe, that it isn't expensive, but at the same time, they get that feeling that they are travelling and moving and exploring new places. So, they get excited, they engage and participate. [Mary]*

The comments which both Sarah and Mary described were mirrored by learners in the comments from Bhavna, Dhriti, Kgomotso, Siara, Tammy, and Thandiwe.

Bhavna referred to the learners who were using VR for the first time. They were completely fascinated. Her learners were excited, and she also spoke about how her learners reacted when she brought out the VR headsets.

> *I mean, whenever I get the headsets. They'll see it. They're ahh, oh, are we going to do VR? They get so excited. [Bhavna]*

Dhriti said her learners loved using the VR. They were involved and interested, and she believed that they really enjoyed it. Kgomotso, Siara, Tammy and Thandiwe also referred to their learners as being excited when viewing the VR resource. When teachers experience their learners' excitement about a lesson resource, it positively influences their own attitudes and beliefs towards the technology.

4.4.2 Cognitive thinking

The subtheme 'cognitive thinking', as part of the theme 'influence of VR resource.' The teachers' beliefs and attitudes were positively affected when their learners seemed to be thinking more about the lesson's topic than usual after they had participated in the VR experience. As previously noted, the teachers recalled how learners were asking more questions than usual; they saw greater lesson participation. Dhriti explained that her learners were able to ask meaningful questions and made comments about the San hunt VR that they observed.

They were able to come up with questions and make comments about it. So, it was brilliant, it got them thinking, so it was good.

And that's exactly what they were doing outside during the same activity in different ways, with VR as one of the resources. They had to work in different ways, especially because we used the thinkers' keys, 21st century skills, we used de Bono's hats. So, they completed the thinkers' keys work individually. They worked as groups with the word scrabble task and had a lot of fun doing it. They were trying to get around the world. But when it came to thinker keys, I liked them to work individually, but as they were in a group. They could share their ideas and expand their own thinking, information, and even use their imagination. [Dhriti]

Tammy spoke about,

The VR lessons are enjoyable for the children, not always just take out your book and do that activity. Asking questions about the content. You make them think out of the box, which is quite nice. And again, those VR things provide another opportunity, and the VR resources are nice for NS, getting them to think, linking it to the thinking hats, I think that's nice getting them to think. [Tammy]

Bhavna mentioned that VR was

. . . reinforcing information, it helped with memory retention and all those kinds of things, which was really great. [Bhavna]

Mary explained why she incorporated VR

So, at any opportunity, I like to take the children on an adventure, take them outside of their own space, make them excited about learning, and I'm given the freedom to try new things. So, in my qualifications, I have done I E[30] which is a thinking cognitive thinking and enrichment tool set of tools. So I used that inquiry based learning in my teaching. I actually applied the teaching style of being an art teacher, because nothing is wrong. We found the right way. I've been a much more hands-on practical teacher than academic, and I just feel that the children learn through experience, whatever the experience might be. So actually, that's why I liked VR. [Mary]

She described the example from the lesson

The lesson came at a time when I was a bit frustrated because their models were all so same, same. And I just thought, they're not thinking outside the box. They're not because there's only so much you can guide before you tell them what to do. And what was nice is I didn't have to tell them what to do for that exercise. And subsequently in another group, the one person she's got good ideas, but she can't always manifest them. And using a different material. She took a whole lot of Scooby wire sort of stuff and created the cervical cortex, just the central part. So, and said, I need some elastic bands. And she had figured out that it was an extension. So that was interesting. [Mary]

[30] I E (Instrumental Enrichment) is a cognitive intervention tool for systematic thinking, developing strategies for learning and 'learning to learn'. https://cognitionenrichment.co.za/services#:~:text=Instrumental%20Enrichment%20(IE)%20is%20a,develop%20higher%20order%20thinking%20operations.

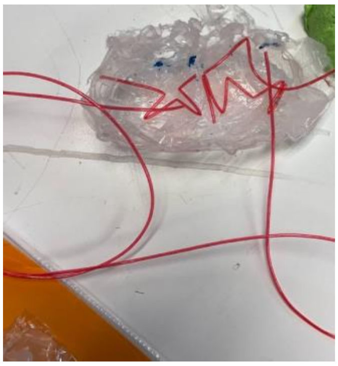
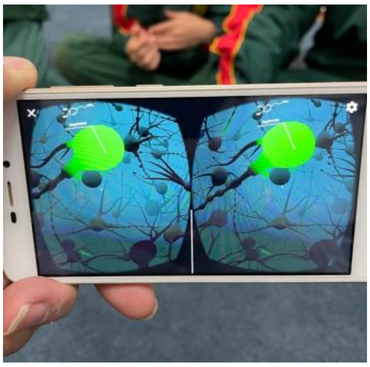
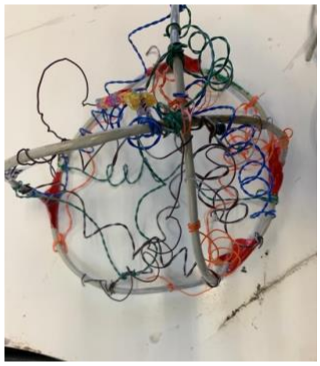
Model of brain previous lesson	VR application - InMind2 (Luden.io, 2017)	Model of the brain after VR activity
		
Brain model made of glue-gun glue and some wire before VR lesson. It was a solid structure.	Screenshot of VR experience. Moving through brain along neural pathways	Brain model after VR lesson: showing neurons, dendrites using wire.

Figure 48: Models of brains before and after VR experience

The learners were thinking about the resources and using the information to answer questions or create models. These observations influenced the participants' attitudes towards the use of VR in their lessons.

4.4.3 Achieving outcomes and Impact of assessment

The subtheme 'achieving outcomes and impact assessment', as part of the theme 'influence of VR resource.'

Teachers' attitudes were positively impacted when they observed their learners achieving the lesson outcomes and the impact on the assessment results related to those lessons. Dhriti, Mary, Kgomotso and Bhavna discussed how the lesson outcomes were achieved. One participant spoke about how the use of VR impacted the learners' assessment results.

Teachers assisted their learners to achieve outcomes in the way they presented or conducted the lessons. Learners reacted and demonstrated their understanding by achieving the outcomes to varying degrees, although no formal assessments were part of this study. Four participants spoke about how they witnessed that the lessons with the VR resource had assisted their learners in achieving the lesson outcomes.

Dhriti (Grade 5 SS) described how the VR scenario about the San had reinforced and related to the lesson outcome ‘The hunt and respect for the natural resources’. When asked how it related to what she was teaching now, she said:

> *Perfectly, absolutely related perfectly because it's aligned with the San and the whole reason that we said we, um, actually teach them about the San. I feel it is to show them how um, how they should learn about respecting the environment, and of being grateful for what we have, things like that. So it definitely is very much aligned with not just their knowledge, but also the skills and values that we'd like to teach them as well. So, I loved it. [Dhriti]*

Mary spoke about her learners understanding the neurons and connections in the brain better after playing the VR application game. She noted that many of the learners wanted to redo their brain models, to show the connections. She quoted them as saying,

> *We don't want to just have a clay model or a crazy clay or a Silicon brain. We want to actually show the connections. [Mary]*

She went on to explain,

> *So they literally made the connection that it was about neurons and they understood there was a chemical reaction too. [Mary]*

This demonstrates that they understood the brain structure better after watching the video and that the outcomes 1) ‘use of conceptual tools for the enhancement of memory’ and 2) ‘emerging use of symbols (drawing, writing, signing) as a response modality’ were achieved as the rebuilt models were more detailed than the models which were built in a previous lesson where video and pictures were used to understand the structure of the brain.

When Kgomotso discussed what the learners gained from the lesson, she replied,

> *They understood the content much better, because they were not disturbed, and there was self-motivation from their side. So, I think they understood the lesson much better than when using other methods. [Kgomotso]*

She continued to explain how well she thought the VR scenario linked with the content topic of her lesson.

> *I think it's played a very important role, because from the experience I got from my learners, the feedback was great. Though I gave them return work as well, so the feedback was great. And they actually said they felt as if they were part of what was happening. So, it was like part of them. So, they really were engaged in the learning. [Kgomotso]*

Bhavna described the use of VR as having an impact on assessment, as learners remembered what they had experienced. Bhavna told a story from the previous school year where she had used VR to teach about earth and the other planets.

> *We explored Saturn, we explored the asteroid belt and I found in my exam, it was last year. No, not the year before the previous year. When I did that, I saw in the answers what they remembered from the VR experience and, you know, they, which is so nice to see, and they actually remembered it more. So, the VR activity really helped in that sense. I find personally, if kids can see something and then they, so I give them information, they see that physically, it actually jells well. They still remember it. [Bhavna]*

She also spoke about another incident of how VR helped learners to remember the content of the lesson and used the information when answering questions in the examination.

> *They had so much fun, and they learnt a lot from that VR, and I also saw the results in the exam. I based questions on our VR experience, and they really liked that, and they answered those questions really well. I think because it was visual, they remembered it better. The kids just love VR. They just think it is the most fun thing ever to do in class. [Bhavna]*

Bhavna also gave another example. She explained,

> *We did exams, we finished last week, and I was marking their exams. Because of my questions, some of them are based on what we've discussed in the class. It's still based on the work that we've done, but it's based on what we've seen and things we've done. And they remember it.*
>
> *When I do like VR or I do videos or like silly things, like taking them outside to look at the tree. They remember that. Whereas I'm not just sitting here, verbally just talking. They don't remember all of those things. [Bhavna]*

These four teachers expressed how their lesson outcomes were met. Bhavna explained how she had observed the value of VR to assist with memory retention and what learners recalled during assessments. These views influence teachers' beliefs and attitudes.

4.4.4 Memory retention

The subtheme 'memory retention', as part of the theme 'influence of VR resource.' Teachers' attitudes and beliefs were influenced when they observed that their learners were remembering the information they had been taught. Three participants described such situations.

Kgomotso spoke about the benefit of using VR technology to provide learners with another viewpoint from that of the teacher's assisted learners in remembering information.

> *Looking at our learners, because most of them are so used to technology these days, and they can operate phones. So, I think it (VR) is a great tool to try and use in schools, because it's linked to their everyday life. In their everyday life, it's not about the teacher narrating every time like you know it and remembering what I explained and if it is explained from another point of view. Certain learners may understand the other person better than they understand you, because it is now bringing variety. I would say it is a great tool for teachers to try and use. [Kgomotso]*

Bhavna (Grade 6 NS) spoke explicitly about the use of the VR scenario reinforcing content information, she described how the incorporation of this resource helped with

> *. . . memory retention and all those kinds of things, which is really great. [Bhavna]*

Mary spoke about a previous NS lesson where her learners recollected using a VR scenario.

> *… initially they said, oh, we are going on another parachute. Because they had been in one when they were learning about air pollution and so they did remember, but it sort of broadens their outlook as well. [Mary]*

The learners remembered the VR resources and could recall what they had seen and how they participated.

These various learner reactions related to lessons which incorporated VR resources seemed to sway the teachers' beliefs and attitudes as to whether they should use VR as a learning tool for teaching. The responses of the participants were positive as they had witnessed their learners' excitement after using VR. They felt VR had encouraged learners to think and question. There was a positive impact on assessment questions and memory recall related to the VR content used. Lesson outcomes had been achieved.

4.5 Findings Inferences

The comments and viewpoints of the study participants indicated how the use of VR simulations as a teaching tool might influence their pedagogy. Figure 49 indicates the percentage of participants' comments related to the main study themes. These themes were the 'value of VR in lessons' with a total of 122 comments (32% of the comments), the 'interaction within lessons' with 67 comments (17.9%), acquiring knowledge with 62 comments (16.5%), reaction to learning - feeling real with 61 comments (16.3%), VR connections to teaching theories with 38 comments (10.1%) and challenges teachers expressed with 25 comments (6.7%). The vast majority (93.3%) of the findings' comments were positive reactions by the teachers towards VR and the reactions they had from their learners.

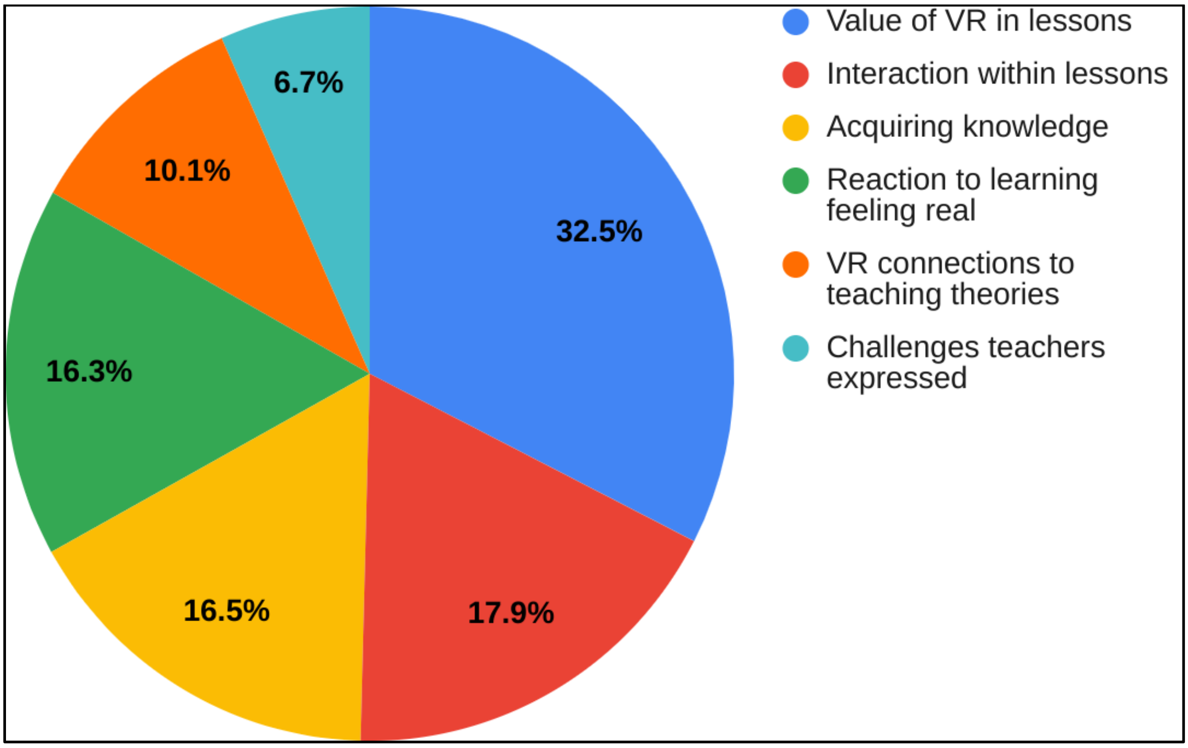


Figure 49: Comment percentages related to the use of VR simulations

32.5% of participants' comments indicated positive value in using VR in their lessons for their learners. This was reiterated by the participants who took part in the focus group. Thandiwe expressed how she found the VR had worked, that she liked the VR, and again she spoke about her learners' excitement.

> *It was an English lesson, Grade 4 learners. They started saying it was boring, but once they had seen it there on the VR. There was so much excitement in the VR. I thought it made a better understanding of the lesson. [Thandiwe]*

Sarah spoke about viewing VR as a valuable resource.

> *I think it's incredible. I really do. Um, just from experiential learning, you know, we (as teachers) are so busy with doing talk and record, you know, or with chalk and talk, that for children to actually see. They are doing these things, anyway, cause they're gamers and they're on screens. And so, for them, it's not a, it's not a fearful thing. It's a valuable tool that will capture their imagination or whatever and get them to engage and participate. [Sarah]*

Mary, the third focus group member, spoke about the value of using VR

> *And I think our learners are very visual, whether you like it or not. We have, that is the reality of the world as we had, I can say, they were involved. [Mary]*

She later expressed,

> *I think you don't overuse the VR. . .. it must be specific, if you had to do it every single week, it would lose its magic. I think. [Mary]*

Challenges were expressed in 6.7% of the comments. The focus group participants explained difficulties they experienced further. Mary spoke about the difficulty of the learners triggering the game by having to centre the white dot to activate it. The learners had to know to stare; that took a little time. It was complicated, but learners were able to complete the task. Another difficulty was that sometimes the phone's battery would not start, but that is because she used groups of three children at a time, and not five. Therefore, two phones were in reserve. Thandiwe spoke about a glitch where learners would not stop watching at the end of their lesson's video but would continue watching a previously downloaded VR. Sarah spoke about the difficulty of the VR experience not opening, and many learners wanting assistance at the same time.

> *And then they can't open the phone, or then this one can't find the video, Johnny needs your help and Suzie can't do it. And you know, and then, so you feel like you are split into 15 different people. So, I mean, we are fortunate we had 15 VR, but still it was frustrating and that really made me anxious. I just wanted it to work. [Sarah]*

Mary suggested having assistance in the class when using VR, whether it was for the other activities, or to have another person to assist where needed.

The themes ‘interaction within lessons’, ‘acquiring knowledge’ and ‘reaction to learning - feeling real’ made up 51.5% of the comments. During the focus group, Thandiwe spoke about the benefit of having conducted lessons in more than one subject (Life Skills and English). Mary referred to the advantage of having VR as an alternative to actual outings, as it was cost effective and there was not a need to transport learners to a venue.

When asked what kinds of influences VR has had on her practice generally, Mary explained,

> *I think the VR made me aware of my little project to try and get them to create things differently, to realise I have to motivate them a bit differently. I can't just say go and research and then make a model. You must give them alternative views of things. [Mary]*

Thandiwe commented that VR was relevant. She thought other teachers needed to be encouraged to use the VR in their lessons, as learners had changed.

> *For me, I would say my school, we are not into technology. Like you ladies teach. When you talk about your technology I'm fascinated. So, it sort-of made me realise that we need more of this technology. You must not be working against the technology, and us as educators as well, we need to learn these things. We have to move with technology, move from this fourth industrial revolution and all that. But I said, I want to use more of this technology. Involve more technology in my teaching, and I want to rewrite the preparation, and add much more visuals. And the visual that they (the learners) want to see now is much more, it is not like the visual that we were doing, like posters, and we did chats in the class, but now it’s more, the more engaging visual kind of stuff. [Thandiwe]*

Sarah added that the VR lesson was great, but that her team only sees value in activities that are for marks towards assessments. VR is not seen as valuable by the team, as they cannot see how the task might be assessed.

> *So, the way that we think of assessing and all of that is just so cut and dried.*
>
> *So, my frustration with VR is trying to actually get the five other ladies that work with me to feel the same excitement and the same sense of wonder. [Sarah]*

Finally, 10.1% of the comments related to teaching theories. In the focus group the ladies spoke about encouraging other staff members to use the VR technology. Mary began by saying,

> *Well, just sitting, listening to you, I realised I've been a bit selfish cuz I haven't really shared too much about it, I should be working with my colleagues. So, I'm going to encourage them to do it (VR). And maybe even insist like once a month or every week a different class. Cause we've got 21 classes, 20 classes. So maybe do something, but it must be with intention. No, not just an arbitrary thing. So I'll drive them. Well, they can't just say we're gonna do a rocket trip or space trip, but for Grade ones, a trip to space, they could do a 10-minute trip because it relates to another topic. It must relate to a topic. I'm just having a jump, but I need the teachers to be on board with me. Maybe I could be during an art lesson for the little ones. [Mary]*

Sarah interjected

> *Yeah. So, team teaching or collaboration more in terms of making it work. [Sarah]*

Mary continued

> *Yes, to let them see how effective activity is. [Mary]*

The Researcher added

> *Ah, that's an interesting idea, Okay. So almost an incidental teacher training.*

Mary concluded

> *Yes. They won't know until they are zapped <laugh> but getting them more involved. [Mary]*

Thandiwe shared,

> *Cause I'm teaching maybe two subjects and English, but I also see it works for other subjects like space and things like that. So, it benefits us all as staff members, instead of it just being me doing and helping with my subject. So, I think what you were saying we need, I also need to think, I feel, I need to share with the other teachers and tell them there's this technology. And hopefully I will be able to make a connection with all that or I can invite you to <laugh> share and present. [Thandiwe]*

Thandiwe continued,

> *Yeah, so slowly, a way of introducing it slowly. And yeah, I think it'll work. Cause I know we have one extramural club or something. We can tell the class, get them into teams, and try to do something like that. [Thandiwe]*

The discussion moved onto the impact the VR lessons had had on the teachers' practices.

Sarah

> *Hmm. Impact? I think for me it lifted the lid on, my own, um,*

Mary

> *resistance or*

Sarah

> *not even, not resistance. I think. Yeah. It lifted the lid on, on me being more creative in my classroom. So, whereas I kind of always felt that I needed to conform or needed to do everything by the book because that's what everybody's doing. It was kind of, lifted the lid on that, and actually I began to appreciate my own creativity and what I can bring to a school, you know? And yeah. So, in terms of, I'm just gonna run with it and it could be VR or it could be, it's essentially adventure thing back in my teaching. . . . but if I think, if I really sit and rationalise whatever, it's that sense of wonder, that sense of adventure in me, that will be imparted to the learners.*

Mary

> *Maybe it also affirms your, if you're passionate about teaching, it gives you just a bit of impetus because we do get jaded. So I think that excites you again.*

Sarah

> *And I think it goes back to why we teach, you know, it's not to impart knowledge. It's, it's more than that. It's exactly what you're saying. It's a passion for learning and for opening up children's minds to, to see further and more than, than this! To think and to think critically.*

The focus group affirmed the identified themes. When discussing the results of the learning theories, Mary said

> *. . . but I think that's what's happening, for us experiential learning cycle. Yeah. even constructivist learning. [Mary]*

The value of the study was demonstrated by a school that integrated technology resources into their lesson preparation documents. Sarah commented,

> *So remarkably, we got, at the end of the term, a document for preparation, and one of the columns for is technology integration in the lesson. So, Bhavna and I being involved in the research, was a spin-off of that (tech inclusion on the preparation document) for the school. [Sarah]*

Thandiwe saw including the VR resources in the lesson plan as beneficial, as it was valuable for the learners in the various ways she had already explained, and in exposing them to different technologies. Thandiwe added,

> *When you plan, okay, I've got the lesson plans, none of them have this VR. So, I had to now do a plan to incorporate this into the plan. So, I had to make a new lesson plan. I made sure that the principal agreed, but yeah, I think it's nice to have that integration on the plan. [Thandiwe]*

In the primary school lessons, VR technology was seen as a beneficial inclusion by the study participants in a way it impacted their learners' learning. There were a few challenges described, however the participants' expressed substantial opportunities and saw value for incorporating VR into their teaching. They observed their learners' positive reactions, greater engagement, and communication within the lessons. The learners' content knowledge was built and reinforced by the multimodal experiences. It may therefore be inferred that the teachers displayed positive beliefs and attitudes towards VR integration, which in turn may influence their pedagogical practices.

4.6 CONCLUSION OF THE FINDINGS

The findings address the study's main question ''How does the use of Virtual Reality simulation as a technology tool influence teachers' pedagogy?'?' (See Figure). The aim was to create an understanding of the implications of using VR simulations in lessons from primary school teachers' point of view. The teacher participants identified the incorporation of VR simulations into their lessons as impactful and beneficial, as they observed their learners' enjoyment and heightened participation levels within activities. The teachers also reacted positively to seeing their learners acquiring knowledge and being responsive during the multi-sensory, immersive experiences. After the scrutiny of the teachers' comments and interactions it may be implied that the use of VR resources as a learning tool may have positively influenced their pedagogical practices.

5. CHAPTER 5: CONCLUSION

The discussion places the results into a broader educational context and reflects the implications of methodological (theoretical) and substantive (practical) findings for the main question and three sub-questions explored in this thesis to address how the use of Virtual Reality simulations as a learning resource influences teacher's pedagogy. Using a case study approach and comprehensive qualitative research methodology, I studied eight primary school teachers integrating VR into their lessons. This section begins with the summary and limitations and is followed by a discussion. The study generated results that contribute towards the general understanding of these questions, as well as demonstrating the findings within the eight unique themes of the study. These unique themes are 'VR connections to teaching theories', 'self-growth', 'planning', 'use of technology', 'challenges teachers expressed', 'acquiring knowledge', 'reaction to learning - feeling real', 'interaction within lessons', and 'influence of VR resources'. The chapter concludes with recommendations for both further research, policy-making, and practice.

5.1 SUMMARY OF MAIN RESEARCH HIGHLIGHTS

The findings of the three sub-questions point towards the outcomes of the main research question.

5.1.1 First sub-question 'What are the implications of VR simulations for changed pedagogical practices?'

The themes correlated and answering this question are 'VR connections to teaching theories', 'self-growth', 'planning', 'use of technology', and 'challenges teachers expressed'.

- VR lessons related to different learning theories: Constructionism (Papert, 1992), Theory of Experience (Dewey, 2016), aspects of the Experiential Learning Cycle (Kolb, 1984), as well as Constructivism (Piaget, 1964) and some Behaviourism (Skinner, 2003), were evident.
- A variety of teaching strategies and approaches were used. One participant preferred teacher-centred teaching methods, four participants used a

combination of teacher-centred and learner-centred approaches, and three participants used learner-centred approaches.

- Professional development, self-growth and learning, and the importance of continuous learning were discussed among the participants.
- Through the observed lessons and the titles of the VR scenarios, teachers demonstrated Technological Pedagogical Content Knowledge. Using relevant technological resources, teachers planned lessons that addressed the relevant content of the curriculum.
- In the augmentation and modification stages of the SAMR model, teachers were confident that the integrated technology resources selected had a positive impact on their learners during the lessons and that they considered the safety of the learners while using VR headsets.
- All participants had integrated technology as a teaching resource in their lessons before VR lessons began.
- All teachers spoke about the value of using VR technology in their lessons.
- General classroom challenges, including time management, classroom management, curriculum restrictions, colleagues' perceptions, and sanitising equipment were discussed.
- They mentioned the challenges of VR integration, incorporated content sourcing, VR setup, negative user experience, lack of WIFI, and VR resources.

5.1.2 The second question 'how does the use of Virtual Reality simulations as a learning resource influence teaching practice?'

The data identified the themes of 'VR connections to teaching theories', 'self-growth', 'planning', 'use of technology', 'teacher challenges expressed', 'acquisition of knowledge', 'reaction to learning - feeling real', 'interaction within lessons' and 'influence of VR resources'.

- All participants noticed active learner engagement and involvement in all VR lessons.
- After doing the VR task, the learners remembered the information better, and their content knowledge improved after using the VR simulation resource in the lesson.
- Learners learn about the topic of the subject through VR, with VR content aligned with the lesson content.
- Through VR, learners were able to reinforce their knowledge and retain information better.
- VR resources encouraged learners to share their observations and communicate ideas about the VR scenario they experienced.
- VR brought reality into the classroom for learners, made them feel as if they were in the setting. VR may not always provide clarity but may raise questions that need to be explored.
- In response to learners' reactions, teachers' attitudes and beliefs may be influenced, as learners were engaged, excited and enthusiastic about using VR. Teachers shared their views about the responses they observed and what learners said.
- Teachers felt VR simulations provided a valuable learning opportunity Because they placed lesson information in a context in which learners could relate.
- As a result of VR, the learners felt as if they were in a real-world context. The VR experience gave the learners an understanding of how people lived in their environment.
- In VR, learners were able to experience a sense of reality or get to understand it better.

- Through VR, learners had the opportunity to learn about items or situations through multimodal experiences that they would not be able to achieve through books, videos, or websites.
- In a classroom using VR, learners were actively involved in the class, creating a different learning environment than with other technologies.
- VR encouraged learners to pay attention during the task by focussing them on what they were doing.
- Using VR in the lesson, the learners were enthused and motivated about topics.
- The learners experienced VR as an immersive educational technology that promoted learning. They experienced the situation as real and were completely immersed in it.

5.1.3 The final sub-question is 'What are teachers' beliefs and attitudes about the use of VR as a learning tool for teaching?'

This question has one theme: The 'influence of VR resources'.

- Teachers described their learners' excitement, enjoyment, involvement, and motivation when they used virtual reality.
- Learners asked meaningful questions and made comments during class. Teachers reported that their students asked more questions than usual. It was evident that the learners were thinking about resources and using the information to answer the questions.
- VR revealed a positive effect for teachers when it helped learners recall lesson content and use it to answer assessment questions. Teachers observed learners achieving lesson objectives, as well as how VR lessons positively affected assessment.

- VR provides learners with another point of view, helps them remember information, and allows them to recall what they had seen and how they participated.

5.1.4 Summary of the main question

The purpose of the study was to explore the implications of using VR simulations in primary school lessons from the perspective of primary school teachers. The findings address the main question, ‘‘How does the use of Virtual Reality simulation as a technology tool influence teachers’ pedagogy?’’ Incorporating VR into the participants’ teaching practice was positively influenced by their personal and poignant encounters with their learners. It could be inferred that the opportunities outweighed the challenges.

As teachers observed their learners experiencing the VR scenario, they built contextual learning through the experiences. Some VR scenarios provided a real-world context, and some VR resources were applied to real-world scenarios. The observations and comments influenced the classroom practices of the primary school teachers. It was through these comments that teachers were able to build positive reasons for integrating VR technology into their classrooms.

The teacher participants identified the incorporation of VR simulations into their lessons as impactful and beneficial, as they observed their learners' enjoyment and heightened participation levels within activities. In addition, teachers were happy to see their learners acquire knowledge and respond in multisensory, immersive environments. As a result of teachers' comments and interactions, it may be implied that VR resources have positively influenced their pedagogical practices.

5.2 General Limitations and Restrictions of the Study

The study was based on a limited number of eight teachers from four schools who participated in the investigation. Additionally, the number of teachers per school varied. In the four schools, all intermediate phase teachers were females; all participants were females. Despite this limitation, I concluded that teachers' perspectives on integrating VR resources into their teaching pedagogies were reasonable. This limitation was reduced by having teachers from different schools and adding various teaching experiences and technologies that they had available to them and could relate to. Its impact was further reduced as there were teachers who had used VR before the study and those who used it for the first time. This provided varying perspectives to the responses and discussions, and therefore provided richer content. The teachers were also from various socio-cultural backgrounds, therefore drawing on a culturally diverse pool to provide wider and richer perspectives and views.

When conducting qualitative case study research, the varying views and opinions of individuals are interpreted and analysed; therefore, it is important to be aware of the limitations to establish the exceptions and limits inherent in a study (Creswell et al., 2007). These limitations and restrictions must be considered.

The subjectivity of the researcher's opinions may have influenced the case study. Some teachers lacked technological confidence and knowledge. Another restriction was that the researcher demonstrated how to use VR goggles with mobile phone applications. Teachers were also shown how to search for VR applications in the application stores, select scenarios, download, and access VR scenarios for lessons. For teachers to know how the technology worked, to conduct the lessons, and to participate in the study, these demonstrations and discussions were necessary. Bracketing was used to minimise limitations by monitoring preconceptions (Ahren, 1999) throughout the cascading process of the study.

The timing and distribution of the technology were considered potential limitations. Covid-19 interruptions and load shedding were limitations in the number of lessons observed and viewed. Covid-19 changed the mindset of school leaders and teachers. The pandemic made it more difficult to get access to schools. This limitation was minimised by extending the study period and increasing the geographic circle of the study.

Case study situations may be difficult to replicate and are time consuming. Because it was a limited case study, conclusions could not be generalised to the wider population. However, suggestions may be made. I realised that when the interviews were conducted, not all the information was relevant and not all related to the study. Qualitative data analysis was influenced by my (the researcher's) interpretation and subjective opinion (Creswell, 2014; McKinley, 2015; Mcleod, 2019). A restriction was that as the researcher, spoke about herself, noting her choices, experiences, and actions during the research process (Mruck & Breuer, 2003). This reflective practice aims to make the researcher's decisions and choices during the research process visible to the reader, creating a constructed nature of the study results (Mruck & Breuer, 2003). Yin argues that 'most qualitative researchers not only believed that there are multiple perspectives or views of the case that needed to be represented, but that there was no way to establish, beyond contention, the best view' (2002, p. 108). He adds that due to ethical obligations, qualitative researchers need caution to minimise misrepresentation and misunderstanding (p. 109) of the data.

5.3 DISCUSSION

The discussion reflects on the implications of methodological (theoretical) and substantive (practical) findings for the research questions of this study. According to this study, VR resources can have a positive impact on teachers' pedagogy.

5.3.1 Methodological reflection

This qualitative research focuses on the phenomenon of teachers in their natural classroom setting, integrating virtual reality resources into existing lessons and explores the influence of VR as an educational tool on teachers' pedagogy. The instrumental case study addresses three questions; the implications of VR simulations for changed pedagogical practices, how the integration of VR simulations influences the pedagogy of primary school teachers, and teachers' beliefs and attitudes about the use of VR as a technology tool for teaching. Table 25 below provides information demonstrating the implications of the research choices made in this study.

Table 25: Implications of research choices made in this study

Research choice	Advantage for	Disadvantage or constraint	Implications
Qualitative research	Studying social phenomena of teaching in the natural setting of a primary school classroom	Time-consuming to engage with each individual teacher.	Individual experiences of teachers related to the research questions are shared. Contributing to the body of knowledge related to how the use of Virtual Reality simulations as a learning resource influences teaching practices, within the primary school.
Instrumental case study	The case gains insights into the phenomenon of the influence of VR as an educational tool on teachers' pedagogy of eight Intermediate Phase primary school teachers.	Limited to a small number of Intermediate Phase teachers, therefore providing little basis for generalisation of results to the wider population. Lacking scientific rigour compared to a qualitative method, as interviews and lesson observations main methods of data collection.	Direct focus on the individual teacher's experiences when using VR within their specific lessons. Contributing to the body of knowledge related to VR as an educational tool for teachers' pedagogy, exploring
Existing VR research focuses on pre-service training of teachers (Seufert et al., 2022) and in-service training of the use or evaluation of VR technology (Billingsley et al., 2019).	There is a literature gap on how the incorporation of VR into lessons impacts teacher teaching practices, therefore, case study research was conducted.	Limited, small sample of eight teachers used in the research	The findings provide valuable data and findings on the viewpoints and perceptions of the actual teachers and the impact of using VR simulations as teaching resources within their teaching contexts.
Data collection method: Observations of teacher's lessons	Being in the classroom viewing the lessons and seeing the interaction provided context and helped to build the relationship between the	Juggling times and finding the times to observe the lessons	Ability to observe the participant within their teaching environment. Created awareness of the pedagogical approach each participant used and could be reflected upon

	researcher and the participant.		when analysing the interviews. Able to share the experience with the participant teacher, which added to creating a rich picture of the teacher within their space.
Data collection method: Interviews with teachers before and after lessons.	A rich source of information. The open-ended questions allowed for in-depth discussion, and information. Assist in creating a better understanding of participants' opinions and the phenomenon	Interviews are time-consuming. Completely dependent on the participants' time, the participants' accuracy and willingness to share,	The interviews provided rich and in-depth data on participants' views, perceptions, opinions, and experiences of the phenomenon.
Teacher views on the integration of VR technology into existing lessons	VR technology is relatively new, and not many schools use it in their learning and teaching environment.	Teachers interested in trying the technology to be part of the study were limited due to their lack of knowledge, fear of using a new technology, or uncertainty of the time required to implement the technology.	Creating awareness of VR technology in schools, particularly primary school. Contributing to the body of knowledge on how the integration of VR simulations influences primary school teachers' classroom practices from a teacher's point of view
Qualitative data analysis method: Thematic data analysis	Analysis across a data set - systematically identify and organise data; identify and interpret repeated patterns; select, analyse, and interpret codes; construct, and create themes. Thematic analysis is very versatile.	Flexibility of thematic data analysis may be seen as negative, by many definitions. Lack of focus and rigour would result in poor data for analysis.	Enabled the generation of new insights and concepts derived from data about the phenomenon.

The qualitative case study design was ideal for creating the framework to explore the subject of the study, how does the use of Virtual Reality simulation as a technology tool influence teachers' pedagogy?'. The views of the eight participants provided a range of perspectives. The case also provided the opportunity to gain a greater understanding of the phenomenon, rather than the view of an individual. The potential for bias was also reduced by framing open-ended questions, which allowed longer answers than just ‘yes’ or ‘no’. The study attempted to remain objective and to minimise bias throughout the research process.

The discussion moves on to the research questions, describing the correlations and differences between the research findings and the existing literature.

5.3.2 Substantive reflection

5.3.2.1 The implications of VR simulations for changed pedagogical practices

This discussion addresses the sub-question, ‘What are the implications of VR simulations for changed pedagogical practices?’ The study identifies the implications of VR simulations for changed pedagogical practices by seeing the connections of VR to teaching theories, through their teaching techniques and approaches when incorporating VR resources in lessons.

Participants made connections to Constructionism and the Theory of Experiential Learning, the Experiential Learning Cycle, Constructivism, and Behaviourism tendencies when using VR technology as a teaching resource.

There was an increase in questions and types of questions that learners raised after the VR experiences. The effective integration of the lessons into the curriculum was also evident. Participants indicated the value of VR in lessons through self-growth and professional development, detailed lesson planning, and effective use of technology, specifically VR technology that includes learner safety.

General teaching challenges were defined on the inclusion of VR resources and Covid-19 challenges were explained. Teachers expressed practical VR integration and usage challenges; these teaching variances are supported by various researchers. Table 26 below provides evidence of the position of the implications of VR simulations for changed pedagogical practices relative to the literature.

Table 26: The position of the implications of VR simulations for changed pedagogical practices relative to the literature

Research sub-question: What are the implications of VR simulations for changed pedagogical practices?		
Problems/Answers from the literature	Researchers' answers	Implications
Range of learning theories used in VR educational research: theory of experience (Dewey, 1997); theory of Constructionism (Papert, 1992); Experiential Learning circle (Kolb, 1984); Constructivism (Piaget, 1964); social Constructivism (Vygotsky, 1978)	Learning theories indicated: Constructionism and theory of Experiential Learning was evident in all lessons. Evidence of aspects of the Experiential Learning cycle, in the various majority of lessons. Constructivism by most participants. Behaviourism, by some participants	Teachers were linking their lesson planning with learning theories, which seemed to influence their pedagogical practices.
Meaningful consideration of pedagogy, lesson outcomes, and integration of VR for effective use, rather than just a distraction or for entertainment (Lege & Bonner, 2020)	Participants seemed to consider the pedagogy, learning outcomes, and lesson content when selecting the VR resource.	Detailed planning and purposeful VR selection resulted in meaningful lesson integration.
It is suggested that further studies be conducted with a larger sample size from different regions to get a better view of the challenges and prospects of VR and AR (Alalwan, et al., 2020)	1) This study partially adds to the knowledge gap identified, as is in another region, Africa, and focused on VR only, Across 4 Primary school subjects (NST, English, SS, Life skills), not just science as in Alalwan et al.'s (2020) case. 2) Challenges (classroom management, sources VR content, lack of resources) and prospects (teachers experienced learner engagement, participation, enjoyment and interest) were provided by participants.	This study adds to the body of knowledge from a different region, providing challenges and prospects described by the participants when using VR in lessons.
More research is needed on ICT-related challenges across the country to provide a holistic picture of the future.	VR is a form of ICT, within the context of SA, noting the challenges the participants have expressed.	This study could be used to add to other ICT data to share with the government.

Problem: provide more data for government action going forward (Munje & Jita, 2020)		
Need for teachers to think holistically before teaching with VR resources (Cheng & Tsai, 2019) Complexity of technology integration between pedagogy, technology, and content (Koehler & Mishra, 2009)	The lesson plans included the information about the VR resource and the learner or group tasks in the plan, which was related to the content of the curriculum. All 8 participants demonstrated TPACK within their planning and teaching.	There is a benefit for teachers to create lessons which incorporate technological knowledge, content knowledge, and pedagogical, when planning lessons with VR resources, before conducting the lessons.
Benefit of VR professional development to assist teacher teaching practices (Huang, Richter, Kleickmann & Richter, 2021) The development of teachers' knowledge of virtual environments may allow teachers to incorporate VR into their pedagogy (Xiaorong, 2018)	The participants referred to the benefit of professional development on VR.	The creation of professional development on VR resources and the integration of lessons would be beneficial.
SAMR model, technology integration by teachers (Puentedura, 2006).	The planning and execution of the lessons align with the SAMR model of teachers that incorporate relevant VR technologies to address their teaching and learning needs.	The SAMR model could help teachers think about the role of technology in engaging learners in lessons.
Educators should begin to consider appropriate ways to include VR (Jowallah, et al., 2018)	Teachers discussed and searched for relevant VR resources, considering which were relevant to their lessons.	The value of the diligence of the teacher in selecting appropriate resources for lessons.

Pedagogical practices were considered or implied by participant teachers for their VR lessons. Teachers’ views align with the description of Constructionism that is built on the assumption that learners 'do best by finding (fishing)’ for themselves the specific knowledge they need (Papert, 1992, p. 139). The interpretation of Constructionism (Papert, 1992) which emphasises participation in the space of reason and indicating the connection between reason and engagement (Jurik et al, 2014) is validated as participants observed the engagement and participation, in relation to the lesson context by their learners. This is reinforced by Parmaxi et al. (2017) as learners build their own knowledge within both Constructionism and Piaget's Constructivism points of view. The study infers lessons that are well-planned with sound pedagogical reasons, and where lesson outcomes and content are considered, use VR resources purposefully (Lege & Bonner, 2020). The participants' lessons incorporated contextual, pedagogical, and technological aligning with both the TPACK and the SAMR models.

Niţu et al. (2018) provide a VR application based on the Constructivist teaching and learning approach, as they link their study to the Kolb Experiential Learning model. The concrete experience mode of the Experiential Learning Cycle (Kolb, 2015) of the here and now in their teaching practices was described by participants. This is underpinned by Dewey's learning model (Shen et al., 2018), as all participants referring to their learners have been immersed in VR experiences. Participants cited Constructivism as a theory of learning they incorporated into their teaching of VR lessons. Four participants mentioned the active assimilation within Constructivism (Piaget, 1964) as learners interacted with the VR resource, cognitively processed the information they were viewing, and demonstrated understanding as the information was being reinforced. Learners asking questions and having discussions about the experiences demonstrated Social Constructivism (Vygotsky, 1978). Al Farsi et al. (2021) supports the value of Constructivist learning regarding the use of VR applications by learners. They explain how opportunities are provided for learners to enhance their knowledge. Five participants recalled that their learners were building content knowledge and demonstrated an understanding of the information content they experienced in VR; this view is also echoed in the study by Al Farsi et al. (2021) and demonstrates the value of Experiential Learning and Constructivist principles with teaching methods.

Not only Constructivist-related thinking was used, but some teachers also referred to Behaviourist teaching methods. Three participants describe the use of Constructivist and Behaviourist teaching methods, such as the Behaviourist principles of reinforcement by providing tasks which bolster information and promote retention of learning material (Van Wyk, 2015). VR was used in the lessons to reinforce the information being taught or to build a better understanding. The learners gained information from the VR content while asking questions to the teacher and the group members.

The findings of this question that explored teaching pedagogy, revealed that teachers had greater preferences for Constructivist, learner-focused pedagogical practices, which were strengthened by their inclusion of VR as a teaching resource.

VR resources are considered immersive, accessible resources, and capable of being used in different school contexts (Cooper & Thong, 2018). This was evident among the participants, as the different teachers used teaching theories that they were familiar with within their teaching and learning environments. The teachers that their teaching methods with the use of VR technology positively influenced their teaching practices.

This study included four subjects (NST, Social Sciences, English, and Life Skills), and builds onto the study by Alalwan et al. (2020), which used only science as subject for their study. More studies should be conducted in different regions of the world with larger sample sizes to gain a deeper understanding of the challenges and prospects of VR and AR (Alalwan, et al., 2020). This small study adds to the global knowledge base, being focused on VR alone in three grade primary schools, and within a different region, South Africa. The challenges indicated in this study were like previous studies (Jowallah, et al., 2018 & Philippe et al., 2020) with respect to financial constraints, health and safety risks, and technical frustrations. The challenges of integrating VR technology into participants' classrooms (such as lack of WIFI and devices) add to the body of knowledge on ICT challenges within South Africa (Munje & Jita, 2020).

A value in planning lessons based on curriculum content using relevant VR resources found teachers to be motivated either for, or against the use of VR technologies based on their curriculum knowledge and professional development (Fransson et al., 2020). To efficiently teach with VR resources (Cheng & Tsai, 2019), teachers are encouraged to conceptualise how technology can be integrated into the curriculum topic (Dahlstrom et al., 2015), and to be aware of the complexity of technology integration (Koehler & Mishra, 2009). This study corroborated these findings as participants demonstrated a holistic teaching process, considering pedagogical, technological, and content knowledge when executing the lessons. Teachers in this study identified challenges and successes within their VR lessons. Figure 50 illustrates the teachers' process of a lesson, from planning to execution. They identified the outcomes and curriculum topics, sourced VR content and applied it to lessons. Once in the class, the applications were opened on mobile phones. The phones were placed in VR headsets. The learners observed the VR scenarios as users, while the teachers facilitated the lesson.

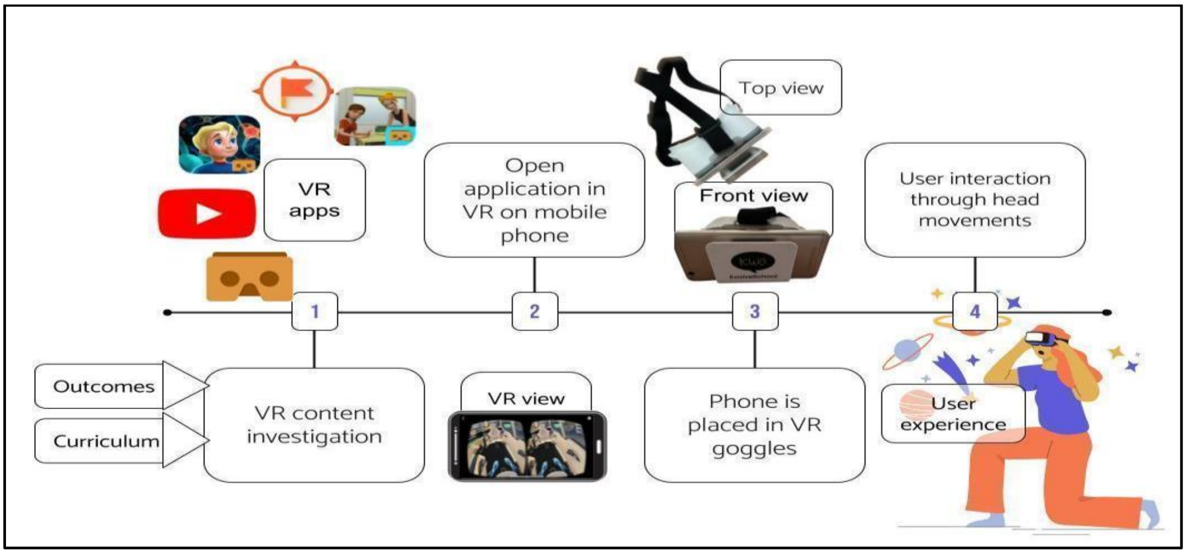


Figure 50: Lesson flow when integrating resources from VR technology

By incorporating resources into the lessons, participants affirmed the efficiency of positive learner reactions. The planning and execution of the lessons align with the SAMR model of teachers incorporating relevant VR technologies to address their teaching and learning needs (Puentedura, 2006), and embedding the resource within the curriculum context (Padayachee, 2017; Tudor et al., 2018 &). Professional development also affected VR integration.

The advantages of professional development and the willingness of teachers to learn continuously build teachers' confidence. Teachers perceive themselves to be less competent with VR than other digital tools (Cooper et al., 2019), indicating that the inclusion of VR technology could positively impact teaching practices.

Developing teachers' knowledge of virtual environments may allow teachers to incorporate VR more readily into their pedagogy (Xiaorong, 2018). Participants who had attended VR professional development workshops were confident in understanding and using the technology in their lessons, while participants who had limited exposure requested a greater amount of research assistance. Educators need to consider appropriate ways to include VR in lessons (Jowallah, et al., 2018), reflecting on the way participants were considered, integrating the technology within their lesson plans, considering where the group of learners using VR would be located in relation to the rest of the class. Practical and pedagogical considerations should be considered.

These observations add to the need for further exploration of the use of immersive VR technology in teacher education of in-service teachers by addressing the transferability of VR training to actual classrooms of teachers (Billingsley et al., 2019). The value the participants expressed indicated that the inclusion of VR simulations in their lessons led to conducive implications of VR simulations for changed pedagogical practices. Since the study period was limited, continued use of VR could not be verified. In addition, it is known that two of the schools did not have the resources; one of the schools was exploring purchasing the devices, but this was not verified. The teachers' observations reinforced and highlighted their pedagogical opinions. Teachers expressed the need for ongoing professional development, and they saw themselves as lifelong learners, particularly in the changing technological world.

5.3.2.2 The integration of VR simulations influences the classroom practices of primary school teachers

All teachers found that including VR experiences in their lessons had an impact on the experiences of their learners. These reactions have the potential to incorporate VR technology into teachers' lessons in the future. Evidence of the position of the integration of VR simulations influencing classroom practices relative to the literature is provided in Table 27 below.

Table 27: The position of the integration of VR simulations influencing classroom practices relative to the literature

Research question: How does the integration of VR simulations influence primary school teachers' classroom practices?		
Problems/Answers from the literature	My answers	Implications
The relevance of VR is immersive, accessible and capable of being used in different school contexts (Cooper & Thong, 2018)	Teachers observed the immersive nature of VR and reacted positively	Positive and impactful teachers' reactions. The benefits they discerned from their learners, who constructively influenced their classroom practices.
The inclusion of VR and AR technologies helped learners improve their learning capabilities (Dick, 2021).	Participants expressed how their learners acquired knowledge from using VR as a learning resource.	Teachers saw the benefits in using VR to help acquire knowledge and context about the topic.
Improved engagement of learners when using VR (Nesenbergs et al., 2021)	Teachers referred to their learners being involved and engaged in VR lessons.	VR was considered beneficial in increasing learning interaction and participation
VR assists in building the content knowledge of learners (Madrigal et al., 2016; Pieterse et al., 2018)	Teachers discussed how their learners' understanding of lesson information seemed to improve and how their content knowledge was built from using the relevant VR resource.	VR was found to help students develop an understanding of the lesson content.
VR technologies contribute to creating tangible understandings of abstract concepts for learners and observed an increased success rate (Fernandez, 2017)	The participants described the VR resources as helping learners create meaning from the learning material.	VR might be used to assist learners to create meaning of learning material
Teachers identified opportunities for learners to visualise complex processes and scenarios, making teaching and learning more interesting, varied, and experience-based as pedagogical possibilities when integrating VR into lessons (Fransson et al., 2020).	Learner interaction experienced during the lessons, expressed by the teachers as experiential, immersive, and active learning.	VR is described as immersive, experiential, and provided active learning.
VR experiences increased the learner's confidence in the knowledge of the content (Dick,	Teachers spoke about learners who were quiet or who did not normally participate in lessons, sharing	VR was noted to have encouraged discussion.

2021; Madrigal et al., 2016; Pieterse et al.,2018)	ideas, and expressing thoughts after interacting with the VR experience.	Especially with quieter learners.
VR provides interactive environments and authentic learning situations (Al Farsi et al., 2021 & Philippe et al., 2020)	All participants referred to VR as providing a real-world experience, bringing reality into the classroom, creating contextual learning through experience.	VR might assist in creating an authentic, real experience
Consider the use of VR environments as a balance between cognitive, skill-based, and affective learning outcomes, for learners to benefit from a well-rounded and enriched learning experience (Di Lanzo et al., 2020)	The importance of detailed planning related to results, considering learners' skills development, affective and cognitive learning experiences.	VR may be seen as a beneficial resource to be added to lessons, helping to improve cognitive, skill-based, and affective learning outcomes.
Cybersickness was identified when using HMD VR, as the physical reaction of feeling nauseous or dizziness (Fransson et al., 2019; Oak, 2018; Kwon, 2019; Moro et al., 2017; Zantua, 2017), due to sensory overload or mismatch (Rebenitsch & Owen 2016; Kawai & Häkkinen, 2019).	Safety was discussed before tasks. A very small number of learners spoke about feeling dizzy when viewing the VR.	Creating awareness of safety among users (learners) is the most important thing.
VR seen as a transformative educational tool (Asad, et al., 2021; Cooper & Thong, 2018)	The findings of these studies were not considered transformative but were impactful in how teachers reacted and the benefits they discerned for their learners.	The influence or impact of VR is seen as a beneficial resource to include in lessons.

The findings of this study align with the view that VR is immersive, mobile (Schott & Marshall, 2020), and is capable of being used in different school contexts, as demonstrated in the study's lessons and participants' responses. The participants' detailed comments indicate the influence VR resources could have on their classroom practices:

- During the study, the participants expressed how their learners acquired knowledge by using VR as a learning resource. Dick (2021) supported this thinking by stating that the inclusion of VR and AR technologies in learning assisted learners to improve their learning capabilities.

- The teachers referred to their learners being involved and engaged in VR lessons. Nesenbergs et al. (2021) also noticed improved engagement of learners when using VR.
- The teachers discussed how their learners' understanding of lesson information seemed to improve and how their content knowledge was built by using the relevant VR resource. Madrigal et al. (2016) and Pieterse et al. (2018) referred to VR as helping to build the content knowledge of learners.
- The study participants described the VR resources as helping learners create meaning in the learning material. Fernandez (2017) described the VR technologies that contribute to creating tangible understandings of abstract concepts for learners and that it increased their success rate.
- The interaction experienced within the lessons as expressed by the teachers as experiential, immersive and active learning. This adds to the body of knowledge by Fransson et al. (2020) where teachers identified opportunities to visualise complex processes and scenarios to make teaching and learning more interesting, varied, and experience-based as pedagogical possibilities when integrating head-mounted VR devices into lessons.
- Teachers spoke about learners who were quiet or who did not normally participate in the lessons, sharing ideas and expressing thoughts after interacting with the VR experience. Madrigal et al. (2016) and Pieterse et al. (2018) refer to VR experiences that increased the learners' confidence in the knowledge of the content.
- This study agreed with Al Farsi et al. (2021) and Philippe et al. (2020); that VR provides interactive environments and authentic learning situations, as the study confirmed the impact of VR on learners; providing a real-world experience and 'bringing reality into the classroom', 'learner reaction', 'contextual learning through experience', 'real world context', 'apply to real world', and 'apply to real world'.

Virtual reality environments provide learners with a well-rounded learning experience that is a balance between cognitive, skill-based, and affective learning outcomes (di Lanzo et al., 2020). The findings indicate that teachers' perceptions of VR's advantages were influenced by teachers' lesson consequences. VR is described as a transformative educational tool (Gadelha, 2018). However, the findings of these studies were not considered transformative, but were impactful in how teachers responded and the benefits they discerned for their learners, thus constructively influencing their teaching practices. Although the study did not last long enough to determine whether it transformed classroom practice, teachers reflected on how VR was a positive influence on their teaching practices. In the next section, the discussion is how teachers' beliefs and attitudes were also affected.

5.3.2.3 Teachers' beliefs and attitudes about the use of VR as a learning technology tool for teaching

Teachers' beliefs and attitudes vary from individual to individual. Teachers' beliefs about how they teach and learn are shaped by their past experiences (Gilakjani & Sabouriit, 2017). Throughout this study, teachers expressed their pedagogical viewpoints and their opinions on how their learners responded to the VR lesson resources. Table 28, below, provides information about the position of teachers' beliefs and attitudes about the use of VR relative to the literature.

Table 28: Position of teachers' beliefs and attitudes about the use of VR relative to the literature

Research question: What are teachers' beliefs and attitudes about the use of VR as a learning tool for teaching?		
Problems/Answers from the literature	My answers	Implications
Teacher participants expressed seeing their learners' excited reactions when using VR (Szabo, 2021)	Teachers' beliefs and attitudes were positively impacted as they observed learners' excitement and enjoyment and saw the benefits of VR as they enhanced the engagement of learners in the lessons.	Potential for teachers to include VR in lessons to encourage learning engagement.
Brom et al. (2017) expressed that positive feelings when using VR can increase cognitive activation, while simultaneously creating a distraction during lessons.	The belief and attitudes of the teachers were positively impacted as the learners seemed to be encouraged to think about the content that they had engaged with in the VR scenario and as they asked more questions than usual about the lesson content.	Potential for VR to be used in classrooms by teachers to provide discussion and develop learners' questioning skills

Billingsley et al., (2019) and Graeske and Sjöberg (2021) questioned whether learning outcomes developed from traditional pedagogy could be transferred into a virtual space	The belief and attitudes of teachers were positively impacted as they observed their learners achieving lesson outcomes and the learners' assessment results improved in areas where VR was integrated.	The potential for VR to be incorporated by teachers to assist learners in achieving results and improving assessment results
Xiaorong (2018) and Sinha et al. (2012) discussed how to improve memory retention of learners using VR.	Teachers' beliefs and attitudes were positively impacted as they observed evidence of VR on their learners' learning and their memory retention of the information they viewed.	Potential for VR by teachers in lessons to assist in facilitating memory retention of content being viewed.

The findings of this study were correlated with the viewpoints reflected in the literature. These observations identified further aspects of how VR can modify their teaching beliefs and attitudes.

- The **excitement and enjoyment of the learners** during the lessons of the participants were correlated with the reactions of the learners of the Szabo (2021) teacher participants using VR. A positive reaction was recognised.
- Several study participants expressed that learners seem to be **encouraged to think** about lesson content due to engagement with the VR scenario, more questions than usual about the lesson content were asked, and learners were not distracted. Positive feelings when using VR can increase cognitive activation, while it can simultaneously create distraction during lessons (Brom et al., 2017). The study identified with Brom et al. (2017); that learners were actively thinking but disagreed about VR distracting learners from the task on hand.
- Questioning whether learning outcomes developed from traditional pedagogy could be transferred into a virtual space. Therefore, learning outcomes from traditional pedagogy had been achieved when using VR (Billingsley et al., 2019; Graeske & Sjöberg, 2021) as one of the resources. Motivation from virtual experience may positively influence learning outcomes, whereas perceived enjoyment may negatively influence learning outcomes (Brom et al., 2017). VR technologies can improve the academic success of learners (Fernandez, 2017). Observed improved results and better understanding of the content have been identified (Lee & Wong, 2014; Alhalabi, 2016; Akman

& Çakır, 2023), but not all VR studies found an improvement in learner performance (Winn et al., 2005; Klingenberg et al., 2023). As to whether integrating VR resources would improve lesson outcomes and learners' results, researchers have differing opinions. In this study, learners were assisted in **achieving lesson outcomes** and the use of VR resources impacted on **learners' assessment results.**

- Using VR simulations, learners demonstrate improved memory recall (Krokos et al., 2018; Li et al., 2020), and improved memory retention of learners using VR (Sinha et al., 2012; Xiaorong, 2018). This study supported these views, as evidence of the learning of learners and their **memory retention** of the VR content information viewed.

When addressing the question of what the potential beliefs and attitudes of teachers about the use of VR as a teaching learning tool are, the participating teachers expressed that their learners were excited about using VR resources, which aligned with the findings of the literature. The beliefs and attitudes of teachers had the potential to be changed, which in turn would impact the learning of their learners.

- Where teachers observed excitement and enjoyment during lessons, there is potential for teachers to include VR in lessons to encourage the engagement of the students.
- Where teachers noted that learners were encouraged to think and ask questions (cognitive thinking) after using VR, there is potential for VR to be used in lessons by teachers to provide discussions and build learners' questioning skills. I presumed the teachers saw benefit in using VR to inspire and build cognitive thinking skills.
- Where teachers described learners being assisted in building content knowledge and therefore achieving lesson outcomes, there is potential for teachers to incorporate VR to assist learners in achieving outcomes and improving assessment results.

- Where teachers observed memory retention of the information they viewed, there is potential for teachers to integrate VR into lessons to assist in facilitating memory retention of the content being viewed.

These responses and observations from the students may alter teachers' beliefs and attitudes about the use of VR to incorporate it into their lessons on a regular basis. In addressing the three sub-questions, it is evident that the teachers have been made aware of VR opportunities to encourage them to change their pedagogical practices. Responses related to these questions are used to address the main research question in the next section.

5.3.2.4 The use of Virtual Reality simulations as a learning resource influences teachers' pedagogy

This section reflects on the main research question, 'How does the use of Virtual Reality simulation as a technology tool influence teachers' pedagogy?'' The overall gain of this study is that all participating teachers found that including VR experiences in their lessons has a beneficial and positive impact on their students. The participants realised the potential of VR as a useful technology in education. When researching how IP teachers integrated VR into the curriculum context, individual teachers' planning and approaches varied. When planning, teachers considered what learners needed to learn and how the lesson would be conducted. They planned the lesson to be related to the curriculum and sourced relevant resources.

In the way the lesson was presented, the teachers considered the teaching strategy or methods to be integrated. The planning and teaching method helped the learners build their content knowledge. Teachers expressed the benefits for their learners with the use of VR and acknowledged that their learners understand some technological aspects better. They seemed to grasp the concepts after using the VR experiences. The diagram (Figure 51) explores the iterations that teachers go through when teaching. The cycle that emerged related to the four areas of planning, teaching strategies, building learner knowledge, and personal self-growth for the teacher. As teachers progressed, they learnt from what they experienced and considered whether to attend additional professional development training, which, in turn, impacted the reiteration of this planning cycle.

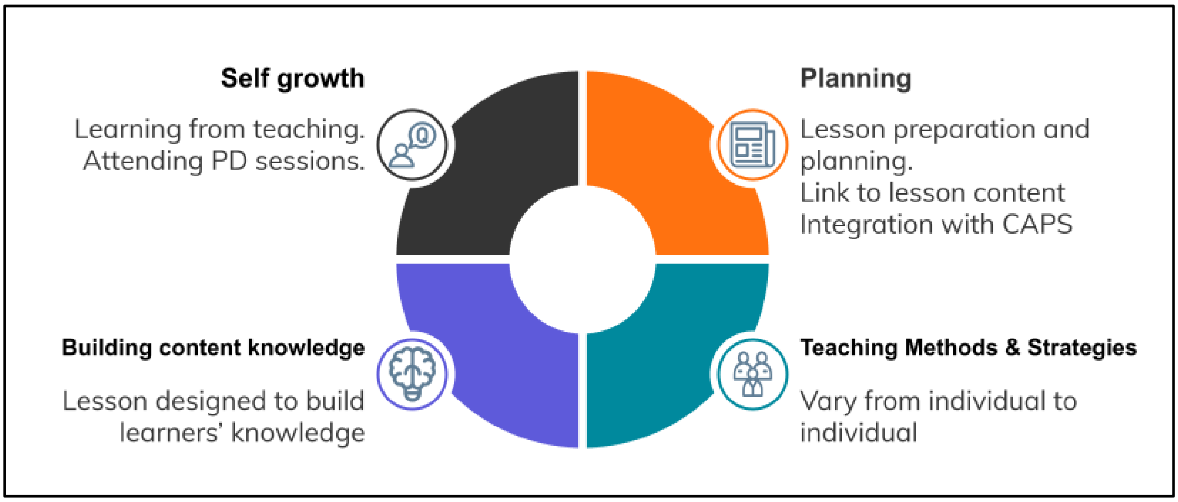


Figure 51: Planning cycle

Planning and teaching lessons, observing learners build content knowledge, and relating observations to self-development, influenced teachers' pedagogical practices while simultaneously impacting teachers' beliefs and attitudes toward using VR as a learning tool.

5.4 THE CONTRIBUTION OF THIS STUDY

There is a lack of understanding about integrating VR technologies to improve teaching and learning in a variety of subjects (Alalwan et al., 2020). Much of the existing research focus is on pre-service training of teachers (Seufert et al., 2022) and in-service training of the use or evaluation of VR technology (Billingsley et al., 2019). There is a gap in the literature on how the incorporation of VR into lessons impacts teachers' teaching practices. Billingsley et al. (2019) suggested research on the transferability of VR training to the classroom by teachers. The significance of this study is to gain insight into the educational value of VR related to practising teachers in their classrooms.

This study contributes to the field of educational virtual reality, and specifically teachers' perceptions of VR in primary school education. It explored how the use of

Virtual Reality simulations as a technology tool can influence teacher pedagogy. The section below draws conclusions from the three sub-questions and finally, the main research question. It can be inferred that the use of VR simulations as a digital resource has had favourable influences on teachers' classroom practices, attitudes, and beliefs, and in turn these have the potential to allow for and influence changed teachers' pedagogical practices. Due to the limited time frame of the study, inferences for changed practices were evident, however, could not be substantiated because more research would be required to confirm the actual changed pedagogical practices.

- Research sub-question 1: What are the implications of VR simulations for changed pedagogical practices?

The findings related to the implications of VR simulations for changing pedagogical practices include:

- The inclusion of VR as a teaching tool strengthened constructivist and learner-focused pedagogical practices.
- Professional development is critical for teachers' self-development, especially in a technologically changing world.
- Detailed lesson planning is needed to include relevant teaching resources such as VR.
- Further exploration of the teaching strategies relevant to the content of the lesson and the resources used, is needed.
- Learners should be provided with learning resources to develop their knowledge of the content.

- Research sub-question 2: How does the integration of VR simulations influence primary school teachers' classroom practices?

  - An influence the participant teachers recounted related to planning, including learning outcomes where they observed learners acquiring knowledge by incorporating a balance of outcomes which include cognitive, skill-based, and affective learning.

  - Learners' reactions to the *learning feeling real*, having the potential to influence classroom practice.
  - An impactful influence on how teachers responded and the benefits they discerned for their learners, thereby constructively influencing their teaching practices.

- Research sub-question 3: What are the beliefs and attitudes of teachers about the use of VR as a teaching learning tool?
  - The reactions and observations of learners can alter teachers' beliefs and attitudes about the use of VR to incorporate it into their lessons on an ongoing basis; there is evidence that teachers have been made aware of VR opportunities to encourage them to change their views.
  - The teachers' beliefs and attitudes about using VR as a learning tool were affected by the value they observed and the challenges they expressed in response to sub-question 1, and the real immersive learning experiences observed related to sub-question 2.
- The main research question of how the use of Virtual Reality simulation as a technology tool influences teachers' pedagogy, was summarised in four areas:
  - The detailed lesson planning, aligned to the curriculum, integrated relevant VR resources, and assisted learners in building their content knowledge.
  - Teaching methods and strategies, correlated to learner-centred, experiential learning and constructivist theories, evoked positive, engaged learner responses.

- Teachers expressed the benefits for their learners with the use of VR and acknowledged that their learners understood some technological aspects better after using the VR.
- The benefits of self-development and learning about VR resources, integration of lessons, and technical understanding of the technology.

The summary of the study's findings is illustrated in figure 52 below.

Figure 52: Summary of findings

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Research from the teacher's perspective on integrating VR technology within the primary school is limited. Additional long-term research focussing on this subject would be beneficial. Participants reported incidents of improved learning related to VR. However, these were not formal studies. There is a need for further long-term research focussing on teachers' evaluation of whether VR resources facilitate the achievement of learning outcomes and improve learners' assessment results. If the use of VR increases within the schooling sector, further investigations into educators' professional development related directly to VR resource integration could assist teachers in the incorporation of corporate VR technology into their daily pedagogy. A closer exploration is needed to understand the deeper underlying reasons for the enthusiasm of learners to use VR and the impact of this reaction on teaching and learning as a whole. Perhaps exploring the comparison of the use of VR with high-resolution video and 3D images within the primary school classroom would add to this field of study. Another area of further research might be conducted about teachers' VR lessons, addressing the question, what similarities or differences are observed in the learners' prior VR experience and content lesson knowledge, when correlated with the motivations and reflections on their VR experiences? Due to the continued development of immersive and interactive technologies, newer versions of VR should be researched to examine whether the integration of fuller immersive VR technology could create a meaningful and collaborative learning environment, as well as explore the cost-effectiveness of these high-tech technologies within the primary school environment.

5.6 CONCLUSION

Although this exploratory study has a limited sample size and case study design, it illustrates how these primary school teachers perceive VR mobile technology as an effective learning resource, which correlated with their subject matter and assisted the learners in achieving learning outcomes. Participants expressed an impactful awareness of virtual reality after integrating the technology into their lessons despite having little or no exposure to it prior to the study. After the lessons, some participants expressed positive perceptions of VR in their teaching, despite their initial concerns and obstacles. Three areas of consideration were identified for teachers who integrate VR into their lessons effectively, namely, the importance of personal self-growth and learning about new technologies, the meaningful incorporation of relevant, curriculum-aligned VR resources into the lesson plan, and considering the most effective teaching strategy to be used to address the focus of the lesson. If these three foci are considered, the potential for building learner knowledge through engagement and interaction is possible with the incorporation of VR into the teaching and learning experience. As teachers observed the positive reactions of their students, this study adds to the body of knowledge suggesting that teachers should consider the transformative potential of VR (Cooper & Thong, 2018). It provides an important contribution by eliciting teachers' perceptions of VR's use in the primary school's intermediate phase classroom across a range of subjects in South Africa. This study demonstrates that VR technology simulations have a positive influence as an educational tool on teachers' pedagogy, inferring the potential for VR technology to positively influence teaching practices.

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7. ANNEXURES

7.1 LITERATURE REVIEW FUNNEL

Figure 53: Annexure A: Literature review funnel

7.2 DIGITAL LEARNING FRAMEWORK CONTEXT AND SCOPE OF DIGITAL LITERACY (DBE, 2017)

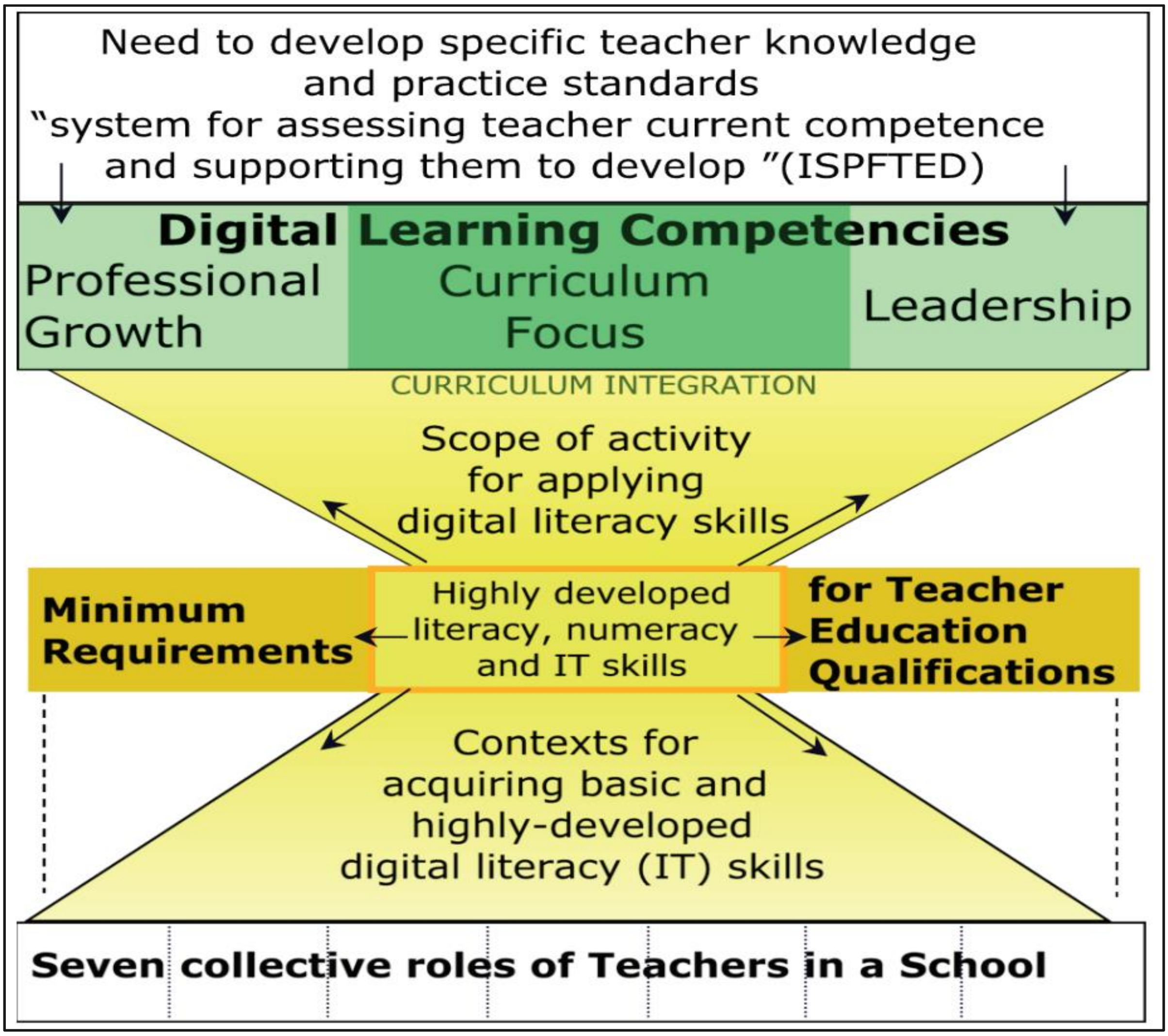

Figure 54: Digital Learning Framework Context and scope of digital literally (DBE, 2017)

7.3 FOCUS GROUP INTERVIEW DISCUSSION

VR Focus Group Interview instrument

Participants and Reason for Focus Group

1. The focus group topic: Affordances of incorporating VR into teaching practices.
2. This focus group will be conducted towards the end of the research once the lessons have been completed, with all the participants from the various schools.
3. Participants in the Focus Groups consist of the group of teachers who are taking part in the research and are asked about their perceptions and opinions about the research topic.
4. The questions would relate to the teachers experiences and perceptions of the incorporation of VR into their teaching practices as a teaching resource.
5. The discussion would be to acquire their inputs, feedback and comments about VR and their teaching strategies.
6. As the moderator, I am not a neutral person
7. As the researcher, I will record my own thoughts in writing, not express them as part of the discussion.

Focus group topic: 'Affordances of incorporating VR into teaching practices'

Welcome

Welcome to this focus group discussion. Thank you, *names the teachers*, for taking the time to join us to talk about ***the lessons you have been conducting in which VR was used as an additional resource.***

I am Karen Walstra and the PhD candidate from the University of Pretoria conducting research on the impact of VR in the Intermediate Phase on teaching strategies. I want to know what you have observed and learnt when including VR into your lessons, what you liked, what you did not like, and how you feel about using VR in your lessons going forward.

All participants were invited, because each of you was one of the participating teachers who have been conducting lessons where you have included VR into your existing lessons.

My role is to moderate the discussion and listen to your views and opinions. Our topic is to discuss incorporating VR into the intermediate phase classroom.

There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we are just as interested in negative comments as positive comments, and at times the negative comments are the most helpful.

You have probably noticed the microphone. We are recording the session because we don't want to miss any of your comments.

People often say very helpful things in these discussions, and we can't write fast enough to get them all down.

We will be on a first-name basis during the discussion, and I will not use any names in the research documentation. You may be assured of complete confidentiality.

The results will be used for inclusion in the research data and your comments and views will impact the findings of this reason, so thank you for your time and for participating in this discussion.

The Guidelines

- No right or wrong answers, only differing points of view
- We're recording the discussion to record all the various viewpoints and ideas accurately. Only one person speaking at a time
- We are on a first-name basis
- You don't need to agree with others, but you must listen respectfully as others share their views
- Rules for cell phones. Please turn off your phones. If you cannot and if you must respond to a call, please do so as quietly as possible and rejoin us as quickly as you can.
- My role as moderator of this focus group will be to guide the discussion
- Talk to each other

Let's begin.
I've placed name cards on the table in front of you to help us remember each other's names. Let's find out some more about each other by going around the table.
Tell us your name, which grades and subjects you teach.

Probe Questions:

- Before the research began, how familiar were you with VR technology?
- Having experienced VR in your lessons, what do you think of the technology now?
- What is your view of using VR in lessons?

Follow-Up Questions:

- What are your favourite and least favourite aspects of using VR in lessons?
- What influences did you use when selecting the VR scenarios for your lessons?
- How has having used VR in lessons influenced the way you teach or affected your teaching strategies?
- How do you think the integration of VR simulations might influence teachers' classroom practices?
- Has your involvement in this research, with creating the awareness of VR simulations, created affordances or opportunities for a change in your pedagogical (teaching) practices? Even beyond the research scope.
- Would you continue using VR in your lessons and why?

Exit Question:

- Is there anything else you'd like to say about VR as a teaching resource?

Adapted from:

- Krueger, R. (2002). Designing and Conducting Focus Group Interviews. Retrieved from https://www.eiu.edu/ihec/Krueger-FocusGroupInterviews.pdf

- Prasad, M. (September 11, 2017) How to Conduct a Successful Focus Group Discussion. Humans of Data. Atlan. Retrieved https://humansofdata.atlan.com/2017/09/conduct-successful-focus-group-discussion/

7.4 INTERVIEW PROTOCOLS

7.4.1 Initial Interview

Introduction of the Initial Interview

I am Karen Walstra, I am conducting a study on using Virtual Reality as a tool for teaching an Intermediate Phase classroom. I would like to thank you for being a part of this study. Please note that you are at liberty to withdraw from this research at any time. There are no consequences to your withdrawal.
What do I expect from your participation:

- Collaboration and engagement, feel free to make suggestions and comments at anytime
- Interviews are each lesson, preferably 3 lessons
- Observations, preferably 3 lessons
- Training, ask questions or phone me whenever you have questions
- Journal - record your thoughts and ideas. As a said these could be voice notes or a written journal or a mixture of both, whatever suits you

What can you expect from me:

- Open to suggestions and ideas for the research, to engage with you about teaching ideas.
- In your classroom
  - Respect your working conditions.
  - Not interfere or hinder your day-to-day functioning
  - Anonymity
- Confidentiality
- I would like to learn from your experiences, your teaching strategies and how you use technology.

To understand who you are? I will be asking you a series of questions.
Please note that there are no correct or incorrect answers.

May I please audio record our discussion?
The reason being I would like to listen/be attentive to what you say. It will also help me stay focused on our conversation and it will ensure I have an accurate record of what we discussed. Please also feel free to ask me for clarity on questions. This discussion may be about 45 mins long, however we may terminate anytime you become tired.

Demographic information – Life History
Please tell me about yourself?
Prompts:

- Qualifications
- Years of experience
- Specialisations?
- ICT Qualifications? Experience? Skills? Workshops?
- Please describe your role, responsibilities and areas of interest in the school?
- How many years have you been teaching prior to this year?
- How long have you been at this school?
- How long have you been teaching for?
- What subjects do you teach?
- How long have you been teaching in the Intermediate Phase?
- What is your favourite subject/grade to teach? Why?

These questions are about your teaching and planning?
Tell me about your teaching preparation and planning
Prompts:

- Could you please describe how you plan for your teaching?
    - Own lesson planning
    - School team format lesson?
    - Team lesson Planning?
    - Theme Lesson Planning?
- Do you plan technology integration? Why? Why Not?

What methods/strategies do you use when teaching?

- Teacher focused / teach from the front of the class?
- Group work? Constructivist?
- Favourite method of teaching

What technology resources do you use in teaching

- What Technology do you have access to?
- Which Technology do you use mostly? Why
- What online resources do you use?
- Do you know anything about VR? Please describe
- Did you ever use VR as a resource in your lessons? Why? Why Not
- Do you have an opinion/perspective about VR for teaching/learning
- Are you interested in using VR? Why?
- How did you use the VR in your lessons?
- How did the VR resource impact your learners?

- Did using VR impact your teaching methodology?
- Do you think it is a technology that teachers should use more?

These questions are about your learners and how you plan for learning:
What type of learning activities do you usually plan for in your teaching?
Prompt:

- Individual /Collaborative/ Inquiry based / Project Based Learning /etc.

I'd like to know a bit more about the learners in this class.
Prompts:

- What is the age range of the learners in your class?
- Tell me about the ability levels of learners in this class.
- Are there any learners with special needs in this class?
- Are there any learners for whom English is not their first language?
- Are there any learners with learning disabilities?

7.4.2 Additional thoughts

- Is there anything else you wish to add?
- I would like for you to look at your responses, once I have transcribed, just to note that I have captured a true reflection of your experiences.

Thank you for your time.
If you have any additional questions or need further clarity please contact me, here are my contact details.

My Contact details: Karen Walstra
Tel:xxxx - phone or whatsapp, whatsapp message or voice note Email:xxxxx You may contact me whenever it suits you. Thanking you in advance. Regards, Karen

7.4.3 Open-ended Interview Instrument

Beginning of the Interview

Hi . . . . , I appreciate you letting me observe your lesson, and for being involved with the pilot. This interview is to find out your opinions about the lesson, what you observed and learnt. I have some questions I'd like to ask you related to this lesson. Would you mind if I recorded the interview? It will help me stay focused on our conversation and it will ensure I have an accurate record of what we discussed. We will go through a series of questions, and the interview should last about 45 mins to an hour.

Preliminary Questions

- Which class took part in this lesson which incorporated VR?
- Which subject was being taught?
- What was the topic being taught?
- Can I have a copy of the lesson plan and the teaching materials you used for this lesson?

The Learners in the Class

I'd like to know a bit more about the learners in this class.

- What is the age range of the learners in your class?
- Tell me about the ability levels of learners in this class.
- Are there any learners with special needs in this class?
- Are there any learners for whom English is not their first language?
- Are there any learners with learning disabilities?

Please help me understand where this lesson fits in the term/year plan

- What was the aim/objective of the lesson?
- How do you feel about how the lesson went?
- What do you think the learners gained from today's lesson?

Content/Topic

- What led you to teach the content in this lesson?
- Is the content included in the CAPS curriculum?
- Is it included as a CAPS assessment task?

Resources Used to Plan the Lesson

- What resources did you use to plan this lesson? (Get details about resource materials and activities.)
- Were these resources assigned to this grade or did you choose to use them?
- Which VR experience / scenario did you select for this lesson?
- Why did you select the particular VR experience / scenario you did?
- How did the VR experience / scenario link to the lesson content/topic?

- Did you have an option of more than one VR experience / scenario to choose from?
- What do you like about the VR resource/s?
- What do you not like?
- Did any of the other resources support or enhance the content in the VR scenario?

Participant Teacher

- How do you decide what is going to be taught in the VR lesson?
- How do you decide which resources (VR and other resources) would be most appropriate for the lesson being planned?
- How do you use group work in your lessons?
- How do you feel about teaching this topic and including VR into the lesson?
- How well prepared do you feel about including and using VR goggles and scenarios with your learners in your lessons?
- What opportunities have you had to learn about this particular technology? (Explore if there were professional development opportunities.)
- Were they required or encouraged by the school?
- How helpful was the training session?
- What teaching pedagogy did you use in the lesson?
- How do you feel about teaching with this pedagogy?
- How comfortable do you feel using the learning strategies involved in teaching this lesson?
- How did you become involved in these professional development opportunities?
- Have you taught this lesson before? If yes: How different was today from how you have taught it previously?
- How did the inclusion of VR into the lesson affect the way you taught this lesson previously?
- What did the other learners do who were not in the VR scenario?
- How did you divide your class into groups? (Group sizes)
- How did this change the way you normally teach this lesson?

- Did you see a positive reason for including VR into a lesson? If yes, what did you find beneficial / of value to the learners with incorporating VR into the lesson? If not, what would you change for the next lesson?
- Has introducing this technology made you think about your teaching strategy? If yes, in what way? If no, please explain your response
- Has introducing VR technology into lessons been beneficial

Context

- Using the six VR headsets and tablet for the guide changes the context of your classroom.
- Did the available equipment and supplies have an influence on your choice of this lesson or how you taught it?
- What did the other children do who were not in the VR scenario, how did you divide your class?
- Were there any problems in getting the materials you needed for this lesson?
- Sometimes other people in the school and district can influence your planning of a lesson. Did other teachers have an influence on what / how you teach?

Thank you very much for your time. If I have any additional questions, I will contact you.

7.5 VR Lesson Observation

7.5.1 VR lesson observation instrument

Observation Details

Date		Time	
School Name		Teacher Name	
Grade		Class size	
Subject		Topic of lesson	
VR Scenario		Group size using VR at a time	

Map of the classroom

Draw a layout of the classroom. Indicate where the VR is positioned within the learning space.

Safety Issues

Observe and record any safety concerns, or effective layout where safety has been considered

Describe the overall impression of the experience observed by participants, having/using VR in the classroom as a resource

As the teacher	

As the learners	
As small groups of learners using the VR	

Use of the VR in the lesson by the teacher

Classroom management method How many groups were class divided into?	
How was the VR used in the lesson, by learners?	
How were the groups rotated/moved through the lesson?	
How did learners get turns to experience VR?	
How was VR included in the lesson?	
How were learners instructed to use the VR?	
Were learners informed of safety considerations?	

Developmental flow of the Lesson during observing

Considerations when observing	Write comments about observations
What lesson activities are present, and what is their sequence? Lesson began with some sort of introduction, learners' interest grabbed Teacher provides sense of lesson focus Lesson activities - group activities Learners move between activities comfortably End of lesson, does teacher summarise? Does the teacher find out how well learners have learned / grasped content of lesson?	

Teacher helps learners to broaden their understanding of content	

Areas of Observation

Topics to be observed during a lesson.

Topic and Observation Comment	**Select a tick box**			**Comment**
	Comple ted most effectiv ely	Comple ted effectiv ely	Could be better	
Preparation				
Provides and follows a lesson plan				
Has knowledge of lesson content				
Is organised				
Teaching resources				
Attitude towards learners in class				
Respects learners				
Listens to learners				
Is enthusiastic				
Sense of humour				
Is patient and sensitive				
Helps learners when needed				
Effectiveness of lesson				
Motivates through instruction and presentation				
Meets lesson outcomes				
Pace of lesson. All learners get a turn at the VR				

Encourages class participation				
Carefully explains expectations				
Manages groups effectively				
Correlates VR scenario to content				
Teacher's Effectiveness				
Speaks clearly uses proper grammar				
Attentive to detail				
Maintains control / authority				
What is role of teacher in VR lesson? What evidence is there to indicate how learners are actively involved in learning?				
Use of Questions				
What types of questions were asked? Higher order thinking questions? By whom? Who responds? How often?				
Use of a range Learning Resources during lesson				
Virtual reality resources? Audio-visual materials? Other resources How effectively are resources used?				
Classroom Management And Behaviour				
Does not embarrass learners, use sarcasm, or argue with learners				
Does not tolerate or dwell on inappropriate behaviour				
Keeps lesson flowing and knows when to stop or wait				
How does teacher establish 'tone' of lesson?				
What contributes to lesson being				

effective learning space?				
If negative incident happens how did it develop? What did learner(s) do? What did teacher do/not do?				
How did the learners' transition in and out of using the VR station in the lessons?				
Do learners actively participate in-class activities and discussions?				
Are learners involved, engaged, and interested?				
Are learners co-operative?				
External Factors				
Interruptions during the lesson How many? For what? By whom? Did teaching time become 'non-teaching' time? Explain				

Adapted from: Cox, J. (August 04, 2019). Student Teacher Evaluation Criteria. An example observation guide for teachers in training. Thought.co Retrieved from https://www.thoughtco.com/student-teacher-observation-checklist-2081421

7.6 MINDMAP OF THEMES AND SUB-THEMES

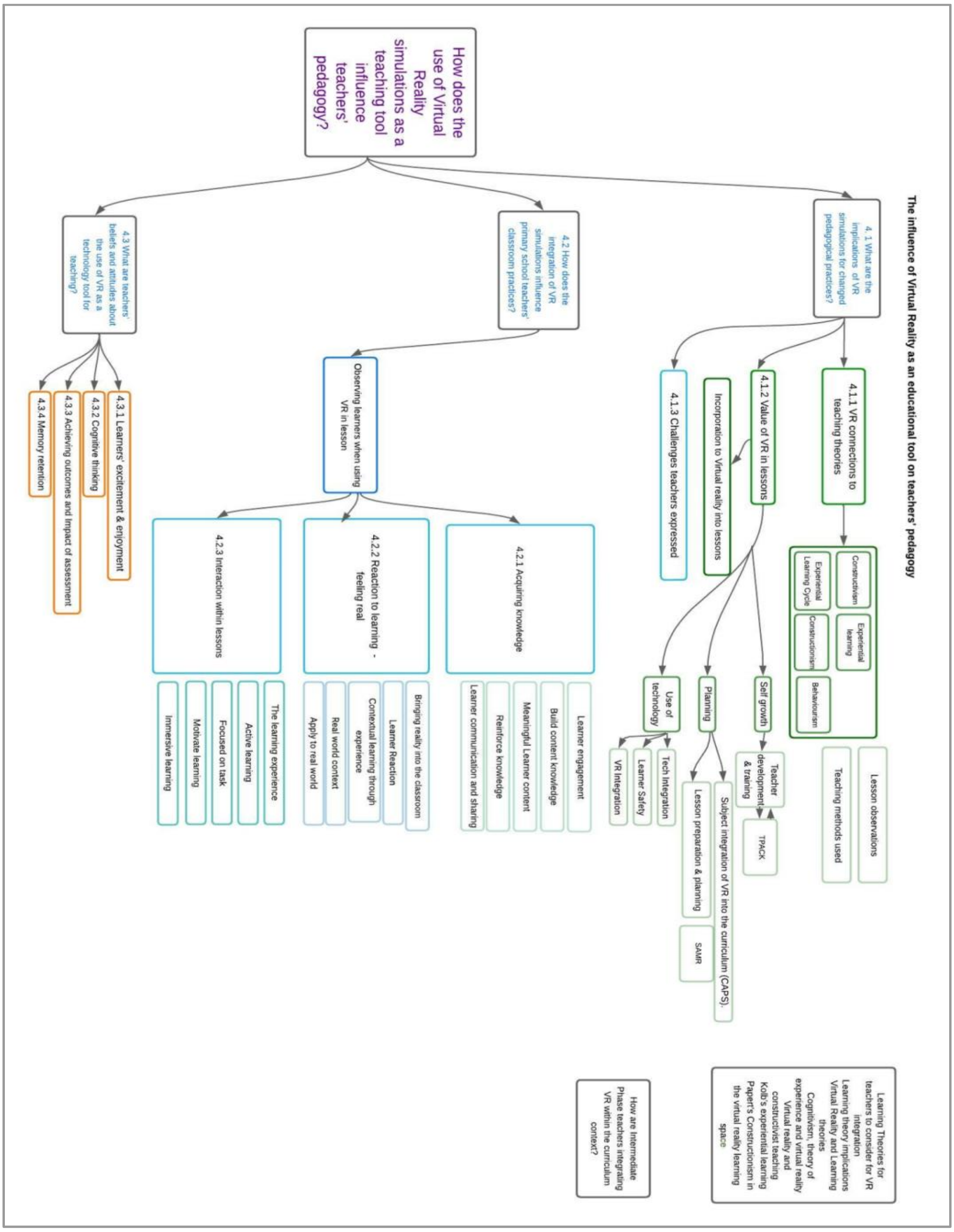

Figure 55: Mindmap of themes and sub-themes

7.7 TABLE OF THEMES AND SUB-THEMES

Table 29: Table of themes and sub-themes

What are the implications of VR simulations for changed pedagogical practices?			
Themes	**Sub Themes**	**Participants**	**Comments**
VR connections to teaching theories	Teaching techniques	8	14
	Approaches to teaching	8	8
Themes	**Sub Themes**	**Participants**	**Comments**
Overall concept: Value of VR in lessons			***114***
- Self growth	Teacher PD	6	19
- Planning	Subject integration of VR into the curriculum (CAPS).	8	10
- Teaching methodologies and strategies	Lesson preparation & planning	8	38
	VR linked to lesson content	8	11
- Use of technology	Tech integration	8	15
	VR integration	8	14
	Learner Safety	4	7
Theme	**Sub Themes**	**Participants**	**Comments**
Challenges teachers expressed	General teaching challenges	5	12
	- Covid-19 Impact	4	7
	VR integration challenges	6	13
How does the integration of VR simulations influence primary school teachers' classroom practices?			
Theme	**Sub Themes**	**Participants**	**Comments**
Acquiring knowledge	Learner engagement	8	22
	Build content knowledge	8	20
	Meaningful lesson content	6	13
	Reinforce knowledge	4	4
	Learner communication and sharing	2	3
Theme	**Sub Themes**	**Participants**	**Comments**

Reaction to learning - feeling real	Bringing reality into the classroom	8	12
	Learner reaction	8	11
	Contextual learning through experience	7	29
	Real world context	6	6
	Apply to real world	3	3
Theme	**Sub Themes**	**Participants**	**Comments**
Interaction within lessons	The learning experience - Experiential learning	8	41
	Active learning	5	10
	Focused on task	4	8
	Motivate learning	4	4
	Immersive learning	3	4
What are teachers' beliefs and attitudes about the use of VR as a learning tool for teaching?			
Theme	**Sub Themes**	**Participants**	**Comments**
Influence of VR resource	Learners' excitement & enjoyment	8	15
	Cognitive thinking	4	12
	Achieving outcomes & Impact on assessment	4	3
	Memory retention	3	4