INTEGRATING SOCIAL NETWORKS IN THE TEACHING AND LEARNING OF MATHEMATICS IN RURAL SECONDARY SCHOOLS

BY

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SUBMITTED IN ACCORDANCE WITH THE REQUIREMENTS FOR

THE DEGREE OF

DOCTOR EDUCATIONIS

IN THE SUBJECT

PHILOSOPHY OF EDUCATION

AT THE

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF MZ RAMOROLA

2021

DECLARATION

I Lindiwe Carol Mthethwa declare that INTEGRATING SOCIAL NETWORKS IN THE TEACHING AND LEARNING OF MATHEMATICS IN RURAL SECONDARY SCHOOLS is my work and that all the resources used or quoted have been acknowledged and referenced

SIGNATURE:  DATE: 15 November 2021

STUDENT NUMBER: 34975675

DEDICATION

This thesis is dedicated to my two vessels of honour, Nonsikelelo, and Vuyile

ABSTRACT

In rural secondary schools, usage of social networks is still lagging, yet the persistence of poor performance is still concerning. This study explored integrating social networks **in teaching and learning mathematics in rural secondary schools, in uMkhanyakude District, KwaZulu-Natal Province in South Africa.** Data were collected from participants using semi-structured interviews, online discussions, non-participating classrooms observations, focus group interviews, and document analysis. Connectivism theoretical framework as the lens was used together with social constructivism, cognitivism, and constructionism. Three rural secondary schools opted to use WhatsApp as the out-of-school learning platform due to affordability and easy accessibility. Data were analysed thematically.

WhatsApp as an emerging technology offered participants new forms of engagement that made sense to the participants. Given the historic cultural and economic stratification of the South African public schools, findings confirmed poor communication in rural secondary schools which has aggravated poor performance of learners in mathematics. The findings of the study suggest that using social networks should be recommended in rural secondary schools, considering heterogeneous needs, ease of use, and affordability. Adopting a connected networked learning perspective in educational settings enhances participants technologically. Despite teachers' skepticism and poor technical skills, their beliefs and leading role could not be underestimated. Their responsibility paved epistemological access to the ways of knowledge construction that sustained mathematics knowledge. Further, teachers' facilitation of out-of-school teaching and learning using WhatsApp created networks that became the source of consistent engagement about mathematics. The learners' cognitive and social presence were observed to be in a transactional space, i.e., WhatsApp out-of-school context.

Lastly, findings presented the projection of communicative codes, such as the educational emojis, which are anticipated to expand networking and articulate quick teaching and learning responses.

Keywords: - social constructivism; social networking; rural secondary schools; collaboration; connectivism; constructionism; cognitivism; sense making; out-of-school; informal learning

ISIQINISEKISO

Ezikoleni zamabanga aphezulu, zasemakhaya, ukusetshenziswa kwezinkundla zokuxhumana kuseyivelakancane, ekubeni ukungenzikahle kwezomnotho kusagqamile. Lolu cwaningo luhlole ukuhlanganisa izinkundla zokuxhumana ekufundiseni nasekufundeni izibalo ezikoleni zamabanga aphezulu zasemakhaya, esifundeni uMkhanyakude KwaZulu-Natal, eSifundazweni saseNingizimu Afrika. Idatha yaqoqwa kubahlanganyeli kusetshenziswa izingxoxo ezingahleliwe, izingxoxo ze-intanethi, ukubonwa kwamakilasi angahlanganyeli, izingxoxo zamaqembu okugxilwe kuwo, nokuhlaziywa kwemibhalo. I-Connectivism theory framework njenge-lensi yasetshenziswa kanye ne-social constructivism, cognitivism, kanye ne-constructionism. Izikole ezintathu zasemakhaya zamabanga aphezulu zikhethe ukusebenzisa i-WhatsApp njengenkundla yokufunda ngaphandle kwesikole ngenxa yokufinyeleleka kalula. Idatha ihlaziywe ngokwetimu.

I-WhatsApp njengobuchwepheshe obusafufusa inikeze ababambiqhaza izindlela ezintsha zokusebenzelana ezizwakalayo kubahlanganyeli. Uma kubhekwa umlando wokuhlukaniswa ngokwesiko nezomnotho kwezikole zikahulumeni waseNingizimu Afrika okutholakele kuqinisekise ukuxhumana okungekuhle ezikoleni zamabanga aphakeme zasemakhaya osekubhebhethekise ukungenzi kahle kwabafundi ezibalweni. Okutholwe kulolu cwaningo kudalula ukuthi ukusebenzisa izinkundla zokuxhumana kungase kunconywe ezikoleni zamabanga aphakeme zasemakhaya, kucatshangelwa izidingo ezihlukene, ukusebenziseka kalula, kanye nokuthengeka. Ukwamukela umbono wokufunda onenethiwekhi exhunyiwe ekulungiseleleni imfundo kuthuthukisa ababambiqhaza kwezobuchwepheshe. Naphezu kokungabaza kothisha kanye namakhono angamafuphi ezobuchwepheshe, izinkolelo zothisha kanye nendima eholayo akubukelwanga phansi. Umsebenzi wabo wavula ukufinyelela kwe-ephistemologi yendlela yokwakha ulwazi olusekela ulwazi lwezibalo. Ngaphezu kwalokho, ukugqugquzelwa kothisha ekufundiseni nokufunda ngaphandle kwesikole besebenzisa i-WhatsApp kwakha amanethiwekhi aba umthombo wokuxhumana mayelana nezibalo. Ukuqonda kwabafundi kanye nokuba khona komphakathi kuhlonzwe endaweni yokushinthiselana ngolwazi, umongo wosizo lwe-WhatsApp ngaphandle kwesikole.

Okokugcina, okutholiwe kwethule inhlolo yamakhodi okuxhumana, ama-emoji okufundisa, okulindeleke ukuthi andise inethiwekhi futhi aveze izimpendulo ezisheshayo zokufundisa nokufunda.

Amagama abalulekile: i-social constructivism; izingosi zokuxhumana; izikole zasesekhondari zasemakhaya; ukusebenzisana; ukuxhumana; ukwakha; i-cognitivism; ukwenza umqondo; ngaphandle kwesikole; ukufunda okungakahleleki

USHWANKATHELO

Kwizikolo zamabanga aphakamileyo ezisemaphandleni, ukusetyenziswa konxibelelwano lwezentlalo lusadodobala, ukanti ukuqhubeka kokuqhuba kakubi kusengundoqo. Olu phononongo luphononongе ukudibanisa amanethiwekhi oluntu ekufundiseni nasekufundeni imathematika kwizikolo zasesekondari ezisemaphandleni, kwisithili saseMkhanyakude Kwa-Zulu Natal, kwiPhondo loMzantsi Afrika. Idatha yaqokelelwa kubathathi-nxaxheba kusetyenziswa udliwano-ndlebe olulungelelanisiweyo, iingxoxo ze-intanethi, uqwalaselo lwamagumbi okufundela angathathi nxaxheba, udliwano-ndlebe lwamaqela ekugxilwe kuwo, kunye nohlalutyo lwamaxwebhu. Isakhelo sethiyori ye-Connectivism njengoko ilensi yasetyenziswa kunye nonxibelelaniso loluntu, icognitivism, kunye nolwakhiwo. Izikolo ezithathu zamabanga aphakamileyo ezisemaphandleni zikhethe ukusebenzisa i-WhatsApp njengeqonga lokufunda ngaphandle kwesikolo ngenxa yokufikeleleka nokufikeleleka lula. Idatha yahlalutywa ngokwemixholo.

I-WhatsApp njengobuchwephesha obuvelayo inike abathathi-nxaxheba iindlela ezintsha zothethathethwano ezinengqiqo kubathathi-nxaxheba. Ngenxa yokuhlelwa ngokwembali ngokwenkcubeko noqoqosho kweziphumo zezikolo zikarhulumente zaseMzantsi Afrika zaqinisekisa unxibelelwano olulambathayo kwizikolo zasesekondari ezisemaphandleni nto leyo ethe yayenza mandundu indlela yokuqhuba kakubi kwabafundi kwiMathematika. Iziphumo zophononongo zidiza ukuba ukusebenzisa iinethiwekhi zoluntu kunokucetyiswa kwizikolo zasesekondari zasemaphandleni, kuthathelwa ingqalelo iimfuno ezingafaniyo, ukusebenziseka ngokulula, kunye nokufikeleleka. Ukwamkela imbono yokufunda enxibeleleneyo yothungelwano kwiindawo zemfundo kuphucula abathabathi-nxaxheba ngokwethekhinoloji. Ngaphandle kokuthandabuza kootitshala kunye nezakhono zobugcisa ezisezantsi, iinkolelo zootitshala kunye nendima ephambili ayinakujongelwa phantsi. Uxanduva lwabo lwavula ufikelelo lwe-epistemological kwiindlela zolwakhiwo lolwazi olugcina ulwazi lwemathematika. Ngaphaya koko, ukuququzelelwa kootitshala ekufundiseni nasekufundeni ngaphandle kwesikolo besebenzisa i-WhatsApp yenze unxibelelwano oluye lwaba ngumthombo wothethathethwano olungaguqukiyo malunga nemathematika. Ubukho babafundi ngokwasengqondweni nangokwentlalo bachongiwe kwindawo yetransekshini, imeko kaWhatsApp yangaphandle kwesikolo.

Okokugqibela, iziphumo zibonise intelekelelo yeekhowudi zonxibelelwano, i-emojis yezemfundo, ekulindeleke ukuba yandise uthungelwano kunye nokucacisa ukufundisa nokufunda okukhawulezayo iimpendulo.

Amagama angundoqo: - i-social constructivism; inethiwekhi yokuncokola; izikolo zasesekondari zasemaphandleni; intsebenziswano; ikhonkco ukwakha; icognitivism; ukwenza ingqiqo; ngaphandle kwesikolo; ukufunda ngokungekho sikweni

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to the following people for their invaluable roles in the completion of this research project and their endless support: -

- To my mentor and supervisor, Prof M.Z. Ramorola; I am deeply obligated for the patience, support, trust, critique and guidance she always gave me.
- The University of South Africa Research office for financial aid, UNISA staff, and M&D workshop coordinators for their warm welcoming hearts when attending seminars, conferences, and colloquiums. Your caring professionalism, smiles and courtesy lifted me high.
- I would like to thank the District director and Ward manager for allowing me to work effectively at uMkhanyakude District, moreover, the teachers who were highly willing to support me in this research together with their learners, may the good Lord richly bless you.
- My mentors and colleagues from the University of Zululand you played your role in capacitating me.
- My beloved mother Mildred K. Buthelezi for her humor and confidence in me. No words enough can thank my parents, my late dad, for naming me and giving me life, encouragement, and support. Thank you and I love you.
- My lovely two daughters Nonsikelelo and Zethembiso played their role as the source of inspiration and motivation, reminding me of Ecclesiastes 9 verse 11 “being at the right place at the right time”.
- I am honoured by warmth from the siblings, my sisters, and brothers, Lucky-girl, Langelihle, Lethiwe, Lungani, Londiwe, Lindokuhle, Lungelo, you always foster my academic growth by challenging and inspiring me to go deeper, think critically, and widen my knowledge. You allowed me to express my views openly and to disagree where it was applicable.
- To all my friends Zulu and Ntuli families for taking care of my children whilst I was away busy with my studies.
- On overall I thank the Almighty Jehovah Jireh, for providing me health and endurance throughout my study.

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LIST OF ACRONYMS

ANA	Annual National Assessment
DBE	Department of Basic Education
DTPS	Department of Telecommunications and Postal Services
HOTS	Higher Order Thinking Skills
ICT	Information Communication Technology
IGII	Internet and Global Information Infrastructure
LMS	Learning Management Systems
MIM	Mobile Instant Messaging
NSC	National Senior Certificate
PIRLS	Progress in International Reading Literacy Study
SACMEQ	The Southern and Eastern African Consortium for Monitoring Educational Quality
SMS	Short message services
SMT	School Management Teams
SNS	Social Network Sites
TIMSS	Trends in International mathematics and Science Study
WAEL	WhatsApp Enabled Learning
UNISA	University of South Africa
UNESCO	United Nations Educational, Scientific, and Cultural Organization
VGN	Vignette

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CHAPTER ONE

BACKGROUND AND CONTEXT OF THE STUDY

1.1 INTRODUCTION

In the modern world, people interact with algorithms to support their daily activities. The advent of social networks has permitted easy access to a daily convenient form of networking (Mefolere, 2016; Castells, 2000). This results from the changing world of Internet communication such as blogs, podcasts, tags, and file-swapping available to learners (Murawski & Scott, 2020; Ramorola, 2018; Jenkins, 2007). It has been noted in the literature (Ottenbreit-Leftwich, Kopcha & Ertmer, 2018) that the Internet and Global Information Infrastructure (GII) development in the world changes the main paradigms in education, learning enhancement, and research. Hence, education is becoming a convener and initiator of emerging technologies and arenas facilitating new strategies of effective communication (Sharples et al, 2017; Anderson, 2008).

These changes are also taking place in the African countries where the penetration and usage of technologies such as smartphones are rising. There is tremendous growth in the use of smartphones in Africa. Smartphones have increased by 43 percent every year since 2000 to 69 percent by 2014 (Labrooy, 2013). South Africa (SA) as one of the developing countries has also been undergoing some major transformation in its education system since the adoption of the *White Paper on e-education* (2004).

One of the major challenges of effective technology integration in teaching and learning as Ramorola (2018) attests includes the digital divide in terms of technology distribution in schools. The notion of the digital divide is also supported by the *Financial and Fiscal Commission* (FFC) which states that

> [t]he performance of e-education across the education system appears to be sub-optimal, which could exacerbate the 'digital divide', marginalising further poor and rural children from participating in the emerging knowledge economy. Yet, if properly funded, e-education can contribute to improving the quality of education in general (2012, p. 1).

Given these ideas, one has observed that the financing of e-education is limited nationally in South Africa (SA). For this reason, only two provinces (Gauteng and the Western Cape) in SA have been upfront with the issues of digital learning (Abrahams & Sibanda, 2013, p. 60-61). In support of this, Gauteng announced its transition to digital learning (Moore, 2014). It is expedient to note that the *National Integrated ICT Policy White Paper* published on the 3rd of October 2017 outlined "the overarching policy framework for the transformation of South Africa into an inclusive and innovative digital and knowledge society…policies to protect the open Internet policies to address the digital divide" (DTPS -PMG, 2017, p. 4). Disparities in the digital divide and ICT resources, shortage of electricity, and landline connections were identified especially in KwaZulu-Natal (KZN) province (Howie & Blignaut, 2009). Literature points out that the "majority of schools are still in their infancy regarding the acquisition of ICT and most of those who have access are still in the process of trying to integrate ICT into their teaching and learning" (Howie & Blignaut, 2009, p. 345). This has hindered the province from meeting the demands of the White Paper on e-Education, of ensuring quality education to learners regardless of who they are and where they live (DTPS -PMG, 2017). It is from this digital divide challenge that Ramorola (2018) saw it as a disgrace to learn that for twenty-three years of democracy, some schools are still struggling with the integration and the harnessing of technology for teaching and learning. However, the African Internet Rights organisation (2019) identified growth in internet access in South Africa and the rise of those who actively access the internet. This confirmed the 13 million (24%) rise of active social media users across the web and 10 million (18%) of mobile social networks (Hypertext, 2016). This could mean that, since the technology infrastructure and pass performance in mathematics is poor (Botha & Herselman, 2018), the rise of social media could pave the way for e-learning. In short, the innovative use of ICT can assist in addressing inequalities in education across South African schools (Zulu, 2020).

Moreover, the availability of social networks seemed to have influence in the twenty-first century (Gillwald, Mothobi & Rademan, 2018a). This is verified by 26.8 million internet users who spend almost three hours a day on social media in South Africa (HyperText, 2016). It has been appreciated that "there are young South Africans who used cell phones as an essential tool for both fun and educational activities" (UNESCO, 2013). The United Nations Educational Scientific and Cultural Organisation (UNESCO) guidelines of creating a mobile learning environment in the South African context, have slowly begun its influx in higher education (Aluko, 2017). Given these indicators in this study, there are cell phones that have been used

in South African education institutions, including those in rural areas. However, the usage of these technologies in secondary schools had drawbacks due to different constraints. To mention a few, MXit has been a popular Mobile Instant Messaging (MIM) in South Africa used by learners to communicate with tutors and do some education exercises (O'Hagan, 2013). Its penetration into the rural places hindered its continuity due to media distorted communication which resulted in having negative publicity (Ramorola, 2018; Chigona, Chigona, Ngqokelela & Mpofu, 2009; Chigona & Chigona, 2008). Dr Math, which was developed by the Meraka Institute at the Council for Scientific and Industrial Research (CSIR), got popular where learners could chat, ask questions, and get real-time support from qualified tutors. For this reason, schools are adapting to new teaching methodologies depending on economic, cultural, political, and social features. Social networks are used by learners to connect to the world, inform and set up learning opportunities, and create and share information (Chirinda, Ndlovu & Spangenberg, 2021; Gillwald, Mothobi & Rademan, 2018b, Gillwald & Moyo, 2017). A statement from e-school news indicated that

> [i]t is with the right infrastructure in place, that schools can maximize the impact of technology and prepare students effectively for the world of tomorrow (E-School News, 2013).

The *Public Expenditure Tracking* study conducted for the DBE (2013) investigated the inefficiency of spending in all four key areas which include ICT, textbooks, infrastructure, and teachers (DBE, 2013). Poor management of currently available resources indicated the need to explore minimal cost digital means that can enhance education (Moreno-Guerrero, Aznar-Díaz., Cáceres-Reche & Alonso-García 2020). Given the importance of teaching and learning with technology, social networks in this regard, this study explored whether social networks can offer opportunities for extensive communication and advance education beyond the lesson hours. The next section discusses the study context.

1.2 THE STUDY CONTEXT

This study took place in uMkhanyakude District, KZN province of South Africa. This district is located on the northern coast of the eleven districts of the North-eastern part of KZN, extending from the uMfolozi River up to Mozambique and Swaziland borders. Figure 11 shows the geographical location of the uMkhanyakude District.

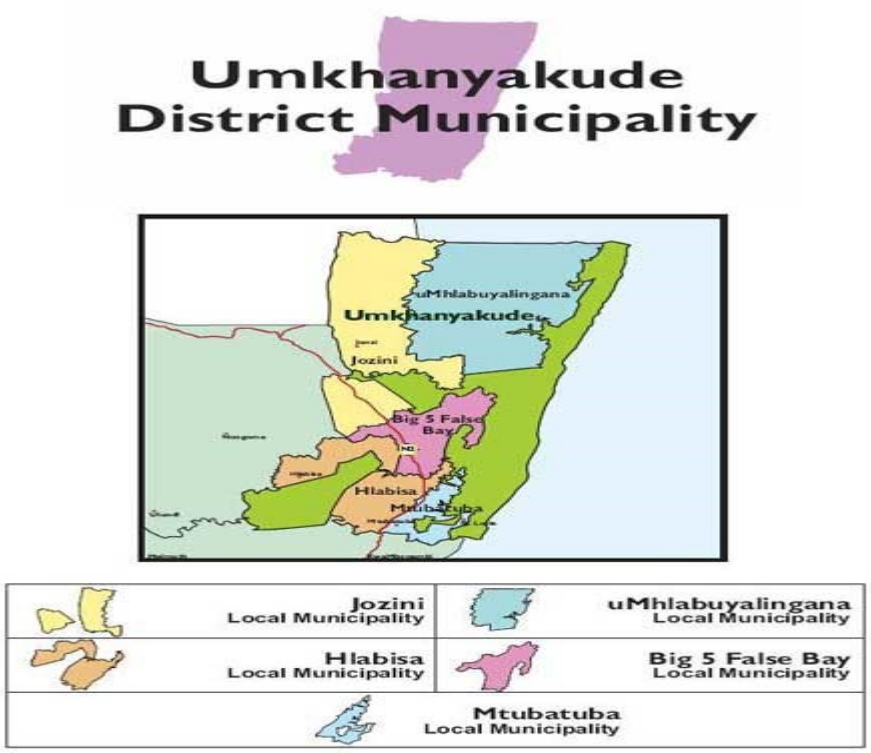


Figure 1.1. UMkhanyakude district, geographical representation (GoogleMaps, 2014)

UMkhanyakude has five municipalities namely Jozini, uMhlabuyalingana, Hlabisa, Big 5 False Bay and Mtubatuba. The area is characterised by a low population density because of its rural communities. The education standard in the area is low. This was confirmed by the Annual National Assessment (ANA) results of 2014, see Table 1.1:

Table 1.1 School's 2012 report National Senior Certificate (NSC) Examination and report on ANA of 2014

DISTRICTS		YEARS	
	2012	**2013**	**2014**
AMAJUBA	12	13.0	8.3
ILEMBE	13	12.3	9.8
PINETOWN	12	15.0	10.8
SISONKE	12	15.1	13.1
UGU	9	11.0	7.5
UMGUNGUNDLOVU	12	14.8	10.6
UMKHANYAKUDE	10	11.3	9.2
UMLAZI	16	17.4	12.3
UMZINYATHI	14	17.7	14.7
UTHUKELA	11	15.1	9.8
UTHUNGULU	11	12.9	10.2
ZULULAND	12	15.8	12.0

Table 1.1 indicates an average pass percentage of 9, 2 percent in mathematics grade 9 (DBE, 2014). According to Table 1.1, the performance is the same in all districts. Results improved in 2013 across the board but dropped in 2014 across the board. So, Umkhanyakude performed just the same as all other districts. Research has exposed factors that contribute towards poor mathematics performance of learners who attend rural schools in KZN (Vadachalam & Chimbo, 2017; Ngqengelele, 2016; Mlambo, Pillay, Mngoma & Anthony, 2015). These include inadequate communication ability of learners and their teachers in the Language of Teaching and Learning (Howie et al., 2016), difficulties experienced by teachers in managing their classrooms, overcrowded classes (Chirinda & Barmby, 2018), poor communication between policymakers and practitioners and lack of resources. The disadvantaged learners from seriously impoverished learning environments lacked the necessary informal mathematical knowledge needed to help them to develop their strategies for solving non-routine mathematical problems (Lavie, Steiner & Sfard, 2019; Lavie & Sfard, 2019). Schools were highly under-resourced whilst teachers were expected to implement mathematics curriculum with no excuse (Zulu, 2020). The teacher engagement with mathematics in a highly constrained

environment of resources could guide the utility of other relevant pedagogies (Anthony & Walshaw, 2009). The suggested teacher engagement was anticipated to benefit teachers at uMkhanyakude where there was a shortage of resources. Learning is not simply a matter of getting resources, passing tests, and, earning credentials, but it involves too much innovation and creativity (Salminen-Saari, Enrique, Moreno-Esteva, Haataja, Toivanen, Hannula & Laine, 2021; Gergen, 2015; Downes, 2012).

The problem of poor performance makes no excuses that learners were from rural areas or not (Brown & Czerniewicz, 2010). Teachers were highly challenged to design mathematics for learners to close the historical and cultural gaps (van Staden & Howie, 2014). This involved intrapersonal (private learning time and choice) and interpersonal (learning which includes group work, peer sharing, and discussion) means of teaching (Robinson & Lomofsky, 2015). It is worth noting that the South African Minister of Basic Education, Angie Motsheka, has unveiled a plan to allow learners to leave grade 9 after obtaining a General Education Certificate, which raised concerns to South Africans (TIMSSSA, 2019). This announcement followed the mathematics Teaching and Learning Framework for South Africa (DBE, 2018) which intended to change how learners are taught.

The challenge of the digital divide was also experienced in the district. For example, both learners and teachers could not access computer technology for academic purposes. There was poor internet supply in the region. The situation does not differ much from what other studies found, that in areas where technology is claimed to be used, the facility is used more extensively for administrative purposes rather than for teaching and learning (Muzurura, Chigora, Mutambara, Zvavahera & Ndlovu, 2021; Drossel, Eickelmann & Vennemann, 2020). Non-governmental organisations attempted to come up with a remedy but were unable to reach everyone with their programs to supply equipment and training.

In addressing the previously stipulated digital challenges, the then Minister of Science and Technology, Naledi Pandor, handed over mobile computers to schools around uMkhanyakude District in January 2016. The reasons were to boost mathematics and science education in this rural area. The belief was that ICT could make a difference in the learning and teaching of mathematics; hence, teachers added minimal effort when receiving training to teach computer-based curricula from these mobile labs (Ngqengelele, 2016).

Given the description of the education status in uMkhanyakude District, I saw the need to participate in the global knowledge economy by conducting an in-depth study about the use of social networks in the teaching and learning of mathematics in rural schools. This notion is in line with Castells' (2009) view that

> the present global knowledge economy, knowledge production, and technological innovation are the most important productive forces that categorise the country's effort towards participation in the global knowledge economy (p. 3).

This contributed to my passion for teaching and learning through social networks. Firstly, it was a passion for mathematics which grew after I studied Statistics, a modular course-based Associate in Management (AIM), the advanced certificate in education (ACE) (Mathematical Literacy) and studying Euclidean Geometry while attending Summer School at Oxford University. It was through the use of social networking sites that I performed well.

Secondly, it was the notion that learners today are 'digital natives' since they are born surrounded by computers and they prefer learning in a digital way (Prensky, 2005). This study was driven by the assumption that if social networks could be incorporated in the teaching and learning of mathematics, this could bring better results in secondary education.

This study referred to informal learning as learning that results from daily life activities related to work, family, or leisure (Kreutzer, 2009a, 2009b; Pettenati & Cigognini, 2007). This reality in learners' lives was not established as learning (Naismith, Lonsdale, Vavoula & Sharples, 2006). Young people in all socioeconomic levels excel in using social networks for various reasons and needs (Castells, 1999), for offline sharing habits (Carew, 2016) and as tools for informal learning (Greenhow & Lewin, 2016). The importance of social networks is seen as critical in education. In this regard researchers are exploring its integration to higher education (Bere & Rambe, 2019; Rambe & Bere, 2013; Dalvit, 2014; Kreutzer, 2009b), urban areas (Bouhnik & Deshen, 2014), other countries (Awada, 2016; Davis & Chaiklin, 2015) and in their secondary schools (Al-Aufi & Fulton, 2014). This study recognized a knowledge gap that is aimed to be addressed in the rural schools of KZN in SA (Vadachalam & Chimbo, 2017). Above all, there is a call from the South African government to explore mobile devices such as cell/mobile phones and tablets to have rural consumers exposed to the choice of operators like urban users (Gillwald & Mothobi, 2019) in distributing learning content (Bicen & Cavus, 2010). Literature (e.g. AlDahdouh, Osório & Caires, 2015) has confirmed that there are

educators who have turned their social communication tools to be used with learners to promote the creation, collaborating on, and sharing content.

There have been ICT initiatives intended to enhance digital education such as Siyavula project, Nokia education, MoMath, HeyMath, Khanya project, GeoGebra, and Vodacom e-school. These initiatives have proved to benefit marginalised communities (Vadachalam & Chimbo, 2017; Jablonka *et al.*, 2013). The education sector is lagging because of teachers who cannot use these platforms due to the lack of confidence and resistance in adopting them (O'Hagan, 2013). Scholars' findings call for the need to train teachers and learners together with the firm adoption of ICT policies (Vadachalam & Chimbo, 2017; Chigona & Chigona, 2008). This thesis addresses the research gaps in rural KZN schools while generating knowledge to be used by teachers and learners who are using emerging technologies and social networks since it is a noted endeavor in other urban places and higher institutions (Naidoo & Kopung, 2020).

1.3 PROBLEM STATEMENT

Rural schools have been described as lacking resources to connect to the internet (Dube, 2020) together with poor teaching and learning (Mutodi & Ngirande, 2014). This includes numerous psychosocial challenges (Ramorola, 2017) poor support for learners at home (Adler & Sfard, 2017), shortage of resources in education, literacy, and numeracy. Poor ICT resources and policies in schools that support ICT adoption have hindered educators from adopting ICT constructivist pedagogies. To date, rural schools are facing challenges of (Saal, 2017) theft and vandalism (Ramorola, 2017). There is hope that intervention will begin since introducing the improvement of rural schools' policies (Government Gazzette, 2018). However, minimally differentiated strategies have been attempted as means to disseminate and implement the integration of classroom strategies for mathematics framework (DBE, 2018). The Sustainable Developmental Goals (SDGs) as set by UNESCO (SDG4), aim to "develop education systems that foster quality inclusion education and promote lifelong learning opportunities for all" (UNDP, 2019; UNESCO, 2017). KwaZulu-Natal is among those provinces still lagging in economic development (Modisaotsile, 2012) to an extent that there are very minimal developments regarding the improvement of education in rural schools (Dube, 2020).

Despite the national department's call to increase access to mathematics for more learners, poor-performing learners are usually advised to drop pure mathematics and take mathematical literacy (Adler & Sfard, 2017). The situation is even worse in provinces such as KZN where

this study was conducted. During the apartheid system, education favored white people and disadvantaged black people; hence, after democracy, rural education was not prioritised as a separate category (Samuel, 2014; Taylor, 2008; Robbins, 2005).

Poor parental involvement is the problem (Chirinda et al., 2021). This further escalates the problem since problem-solving skills are initially groomed by parental involvement in learners' education. There are teachers who could not perform specific problem-solving skills (Chirinda & Barmby, 2018; Schunk, 2012). It is assumed that secondary schools around uMkhanyakude District do not perform well in mathematics because of the shortage of extensive communication between teachers and learners during and even after school hours (Ngqengelele, 2016). Contributing to these factors might be lack of access and connectivity, which, according to Dalvit (2014), appear to be persisting challenges in South African education (Bere & Rambe, 2019; Abrahams & Sibanda, 2013). It is hard to think of the performance of disadvantaged areas about the alarming results of Trends in International mathematics and Science Study (TIMSS) 2011 (Reddy et al., 2016) and Progress in International Reading Literacy Study (PIRLS) 2016 (Howie et al., 2016). This notion was confirmed and recent numerous studies have shown that social networks have the potential of making a difference in uMkhanyakude (Dube, 2020; Zulu, 2020). Further, the diagnostic report of uMkhanyakude National Development Plan still identified among 9 key challenges two important education-related challenges namely: (i) the standard of education for most black learners is of poor quality (ii) infrastructure is poorly located, and poorly maintained and insufficient to foster growth in line with KZN vision 2035 (UMkhanyakude, 2021, p. 25).

Given this information and in line with Castells' (2009) argument, it is believed that the standard of education in rural schools could be improved through the integration of emerging technologies and new pedagogic models (Anthony & Walshaw, 2009). Moreover, code-switching teaching and learning of mathematics using technological devices; especially in poor and disregarded schools have long been proposed (Jantjies & Joy, 2016; Setati, 1998). Interestingly, the local newspaper, *Zululand Observer,* noted that in most cases, schools use workbooks rather than using computers for teaching and learning (Makwakwa, 2014; Howie & Blignaut, 2009). However, there are some measures that need to be considered in order to improve matric pass rate to more than 75 percent for mathematics and science and implement the usage of the latest ICT technology by the year 2035 (UMkhanyakude, 2019).

1.3.1 Main research question

Given the problem of the study, the main research question was: "What are the users'

perceptions of mathematics pedagogy on social networking platforms?" This was achieved by employing connectivism, social constructivism, cognitive, and constructivism theories.

1.3.2 Sub-research questions

To attain the answers to this problem, the following sub-questions were generated:

1. What types of social networks do teachers connect with learners to share mathematical content?
2. To what extent have learner-teacher interactions taken place?
3. What technological methods prevail in the learners' discovery of mathematics content knowledge?
4. To what extent has teaching and learning taken place through social network interaction?

1.4 PURPOSE OF THE STUDY

The purpose of this research was to explore the experiences of teachers and learners in teaching and learning mathematics through social networks. Thus, the main purpose of this study was to find out "the user's perceptions of mathematics pedagogy on social networking platform?"

Therefore, this study aimed at education that focused on proposing research that explores issues of disempowerment and agency, constraints and possibilities in the context of emerging technologies. The findings are articulated to shift the focus from a discourse of deficit and helplessness towards a discourse of possibilities in the struggle of equity and quality education for all (Saal, 2017; Robinson & Lomofsky, 2015; Clark, 1994). This attempted to redress deep inequality, and reforming pedagogic approaches which were inflicted by apartheid (Adler & Pillay, 2016; Samuel, 2014), by reconstructing appropriate 21st-century teaching and learning practices. Informal learning after school hours was viewed as a good method of encouraging educational activities (Royle, Stager & Traxler, 2014).

1.5 OBJECTIVES OF THE STUDY

The objectives of the study were:

- To explore the different social networks that teachers use to connect with learners to share mathematical content.

- To find out the extent of learner-teacher interactions that have taken place.
- To ascertain technological methods that prevailed in the learners' discovery of mathematics content knowledge.
- To identify the methods prevalent in teaching and learning through social network interaction.

1.6 DELIMITATIONS OF THE STUDY

It could not be underestimated that my research has been conducted since 2016, hence online developments have escalated drastically expanding new possibilities for researchers to work with participants. Further, the study was not going to focus on observable external behaviour but on what participants were capable of doing in the digital space.

1.7 REVIEW OF LITERATURE

The South African education system has been undergoing tremendous changes since 1994. One of such changes is transforming teaching and learning through technology integration (Ramorola, 2018). Ramorola (2018) further argued that learners in the 21st century are digital and have to be taught digitally. This was confirming what Prensky said that the difference between learners and their teachers is in terms of what and how they learn and how they assimilate information (Mutodi & Ngirande, 2014; Prensky, 2010). Learners spend their recreational time online using digital technologies for leisure and to play games (Sinclair, 2009; Sipos, Battisti & Grimm, 2008). The knowledge of Technological Pedagogical Content Knowledge (Koehler & Mishra, 2008) or Technology Pedagogy And Content Knowledge (TPACK) (Koehler & Mishra, 2009) would equip teachers with how to incorporate digital skills in their teaching.

In light of these, learners and social networks are two inseparable entities and must be utilised more constructively. This is due to the rise of mobile internet whereby youth are using social networks as key tools in their identity formation (Greenhow & Lewin, 2016). It is expedient to identify platforms promoting the human rights of learners, guarantee their right to education and protect them against any harm (Tondeur, van Braak, Ertmer & Ottenbreit-Leftwich, 2017; Modisaotsile, 2012). Bower (2008) offered a methodology to support the selection of suitable out-of-school platforms, suitable for the e-learning and scaffolding learning process. Therefore, effective teacher implementation of the out-of-school platform could be described as online presence for all participants which produce positive teacher-learner relationships, crafted from

a ‘learning’ rather than a ‘social’ attitude towards a suitable platform (Callaghan & Bower, 2012, p. 14).

To achieve this positive teacher-learner relationship, an accurate pedagogy was suggested (Putnam & Borko, 2012). This pedagogy would promote negotiation as the basis of a learning design that will be ‘transmissive’ (able to have a stream of information which is broadcasted to learners); ‘dialogic’ (discourse between participants); ‘constructionist’ (learning occurs and develop a product) and ‘co-constructive’ (learners’ ability to reconstruct on their own) (Bower, Hedberg & Kuswara, 2010, p. 182). New communication technologies have the potential to transform teaching and learning (Putnam & Borko, 2012). These pedagogies prepare learners’ future towards digital citizenship (Ankiewicz, Batchelor & De Beer, 2015) Curriculum and leveraging digital technologies are used to improve learners’ learning experiences (Foulger, Graziano, Schmidt-Crawford & Slykhuis, 2017). Therefore, to achieve digital citizenship, teachers have to align themselves with their digital resources and content together with learners’ potentials and context (Siemens & Tittenberger, 2009).

South Africa has passed ICT Vision 2020, which has driven the country to revisit its ICT policy (DTPS -PMG, 2017; Gillwald & Moyo, 2017, Gillwald, Moyo & Stork, 2012; Modisaotsile, 2012). It cannot be underestimated that at times, there are challenges and negative aspects of using these skills among teachers and learners (Odeyemi, 2020; Yilmazsoy, Kahraman & Köse, 2020; Mupezeni & Kriek, 2018; Abrahams & Sibanda, 2013, Mumtaz, 2000) According to Ramorola (2014), schools experience the challenges such as integrating technology into a coherent framework of teaching and learning because they do not have the common policy on integration; do not know what is permissible and implementable; have no sufficient equipment to utilise technology in their integration; teachers are not qualified in technological integration (Roberts, 2014; Spaull, 2015). Beside other factors that inhibit teachers and learners from acquiring knowledge, there is lack of understanding the purpose of computers in education (Gitau, Marsden & Donner, 2010), isolation from the global world and its economy, lack of funding, lack of available trained staff about the usage of computers, insufficient building space, absence of electricity, and poor security (Dalvit, Kromberg & Miya, 2014; O’Hagan, 2013). To address challenges, learning in the digital age has new technology that is rapidly evolving. The youth is the most committed user of new technologies especially social networks in cell phones (Siemens & Tittenberger, 2009; Siemens, 2004; Picciano, 2002). The idea of digital learning is not new to the educational context. It can be traced back to the generation that has thought patterns that have changed to multitasking and they can be called the Net-gen

or the Digital Natives, receiving information fast, thriving for frequent rewards, and prefer games rather than serious work (Prensky, 2010).

Contenders of emerging technologies maintain that computers avail various effective and powerful opportunities for teaching and learning like, building skills, learning reciprocally, discovering learning, and using a dynamic multitude of instructional resources (Chen & Bryer, 2012). Thus, today the vocabulary of computing is all around a learner (Shelly, Cashman, Gunter & Gunter, 2007)). A learner must be taught "legacy" which is traditional content and the "future" which is digital and technological (Prensky, 2001, p. 3). Learning in the digital age can encourage communication outside classroom walls, thus allowing schools to incorporate cooperative learning (Shelly et al., 2007, p. 12). Teachers presently must communicate with their learners using their language and style. The Language of Learning and Teaching (LOLT) in most rural secondary schools is English which implies the hegemonic traces of apartheid (Adler & Sfard, 2017). Language has been documented as a challenge in learning since it is a key learning resource (Planas, 2021; Lerman, 2000). It is therefore vital to use technology appropriately to enhance learners' achievement and assist them in meeting learning objectives (Prensky, 2010). In return, the learners who are involved in the digital age are acquiring new skills, becoming mature, and can engage in critical reasoning (Hairon, 2020; (Braun, Clarke & Gray, 2017a; Wang, Chen & Anderson, 2014).

Learning has been solely understood to be ICT-related. This included understanding the Assessment and Teaching of the 21st Century Skills (ATC201S) which involved:

- Ways of thinking: creativity, critical thinking, problem-solving, decision making and learning, ways of working: communication and collaboration;
- Tools for working: ICT and information literacy and
- Skills for living in the world: citizenship, life and career skills, and personal and social responsibility (UNESCO, 2013, p. 8)

Teachers needed to be more oriented on how to use technology to improve education and increase equity since technology has the potential to transform education by extending learning space beyond the four walls of the classroom (UNESCO, 2013, p. 10). Aluko (2017) indicated the lagging behind of SA about UNESCO guidelines, which is an urgent call to teachers to pursue conducive strategies of teaching learners during these challenging times. Siemens outlined new thinking about learning which has some advances in information technology

(Siemens, 2004). His new theory of Connectivism, superseded previous learning theories including, behaviourism, cognitivism, and constructivism (Kimmons & Veletsianos, 2014; Boyd & Bargerhuff, 2009; Klinger, 2009; Pettenati & Cigognini, 2007). Some scholars alluded that there is a need for the development of a new theory that meets the needs of learners nowadays, and also focuses on the future needs of learners (Kop & Hill, 2008).

In light of the above, this study employed Siemens' Connectivism theory. Siemens defines Connectivism as the "integration of principles explored by chaos, network, and complexity and self-organisation theories" (2004, p. 5). It is from this definition that the theory of Connectivism was used to understand the teaching and learning process in this study. This was based on the notion that the interaction between teaching and learning began when learning occurred in a learning community. It was during this cyclical process that learners' beliefs were modified by new learning and were then connected in a network to share new realisations and new information. For this reason, every individual within the networks somehow specialised and demonstrated personal intelligence (Siemens, 2004). Thus, every learner's learning network was formed by how each learner arranged his/her connections to learning communities (Kop & Hill, 2008, p. 2). Despite the critics, Verhagen (2006) refuted connectivism by stating that knowledge was not learning or education. The researcher used the connectivism framework and applied it in real situations; exploring whether it does involve cognitive development among learners. Concentration in a network as related to the maturation of learners' knowledge was explored (Kop & Hill, 2008, p. 2).

The affordance of the connective framework can be used to build new and effective teaching and learning digital practices (Pettenati & Cigognini, 2007, p. 42). Therefore teachers "adapting to new learning environments may turn to learn theories." (Goldie, 2016, p. 4). This suggested that there is a need for the development of new theories that would guide teachers. I, therefore, argue that perceptions of learners and teachers in rural secondary schools can be explored by using social networks to enhance learning after school hours.

1.8 SIGNIFICANCE OF THE STUDY

Literature on the integration of social networks in the teaching and learning of mathematics is limited, particularly literature about rural regions of South Africa. While the integration of social networks has not been researched in rural schools, it has been in urban schools (Jere, Jona & Lukose, 2019) and universities (Chirinda et al., 2021; Naidoo & Kopung, 2020).

Foulger et al (2017) realized that researchers have not discussed competencies that will lead to change or high-quality instruction. In the same breath, Bicen and Cavus (2010) recommended that studies should be made on how social networks are used in education. This prompted me to explore how the integration of social networks in the teaching and learning of mathematics in rural secondary schools, might improve its poor performance among learners.

The findings of this study would be useful to:

- Teachers' outcry of how to improve poor performance in mathematics.
- Teachers' ability to choose a digital programme that will enhance among themselves, learners, and policy planners informal teaching and learning while capacitating them on how to improve performance in mathematics in their area.
- Policy planners and curriculum designers to incorporate training teachers on how to use social networks to facilitate effective learning.
- Teachers and learners to bridge the gaps of connectivity, discussions break, and not accessing information after hours while interaction among themselves is also improved.
- Help learners to use social networks as means to drill and practice what they have learned in their class.

It was anticipated that if educators and learners could participate fully in using all these social networks for the benefit of education, good results might be achieved. This notion was supported by different scholars in the integration of social networks or any connectivity to enhance the motivation of teaching and learning (UNESCO, 2013; Brandt, Terzoli, Hodgkinson-William, 2005). In short, this study evolved not just from only identifying gaps in the literature alone or from topics that grabbed me and provoked my curiosity (Creswell, 2013), but also from the call to determine the most effective and cost-efficient strategies for teaching and learning (UNESCO, 2013).

1.9 ETHICAL CONSIDERATION

In ensuring the ethical requirements, the following was understood in this study. The University of South Africa Research Ethics Committee approved the research. The certificate appears as REF 2015/11/18/34975675/49/MC in **APPENDIX: 1**. Thereafter, permission to conduct research in schools was granted by the KwaZulu-Natal Provincial Department of Education

(**APPENDIX: 2**). I asked the district manager for permission to conduct research in uMkhanyakude District. This was important since "a credible research design involves not only selecting informants and effective research strategies but also adhering to research ethics" (McMillan & Schumacher, 2010, p. 338) (**APPENDIX: 3**). I asked the circuit manager, for permission to conduct a study in the circuit (**APPENDIX: 4**). The letter was written to the principals to ask permission to conduct a study in their schools. I elaborated in the letter the reason why the school was chosen, the purpose of the study, and the freedom to withdraw should they feel uncomfortable. Attached to their letters was the consent letter which was signed before the commencement of the research. This was done to comply with the ethical requirement, informing the principal that the data to be collected would be confidential (**APPENDIX 5**). The mathematics teachers in the identified schools were asked to sign consent forms. I met each teacher face to face and asked their permission to work with them in their schools, giving them full clarification about the procedure. According to (Giles, 2017, p. 195-7), ethics is a highly contested domain that involves the Association of Internet Researchers (AoIR) and Ethical Decision Makers. Therefore, it was imperative to agree on written rules. To monitor the interviewing session, basic rules were to be observed during the process, e.g., asking the cell phones to be switched off. Participants were not to be disturbed or influenced in their responses. A venue that was quiet and conducive for the interviews was organised. Participants were to stick on set time frames, which was between thirty to forty-five minutes. Pomodoro timer was used for assistance. The participants were relaxed knowing that they would not spend much time answering interview questions (**APPENDIX 8 and 9**). These were letters written to the parents and the learners. (Fox, 2017, p. 282-3) and stipulated the guidelines to be followed when formulating the focus interview groups which included consent, participants' identity, potential conflict, participants' distress, online safety, and distractions (Greeff, 2011, p. 342).

Learners were further asked to sign the focus group's consent forms (**APPENDIX 10**). In short, this empirical study was governed by some of the following ethical considerations (Braun, Clarke & Gray, 2017b)

- An essential aspect was to protect the identities of participants and familiarise me with ethical policies (Maree, 2016, p. 44)
- All participants were respected and given the right to refuse to take part in the

research and to freely withdraw at any time (De Vos, Fouché & Delport 2011, p. 116)

- I ensured that the research topic proposed was viable and that adequate research design together with the adequate data collection techniques were guided by the principle of autonomy, beneficence, wide immersing questions, non-maleficence, and justice (Giles, 2017, p. 203-6).
- Benefits of participating were structured such that they outweigh risks, deception and participants shared in the benefit of the study (Suter, 2006, p. 79).
- It was of utmost importance that before the interview or during the opening of the discussion, I communicated the importance of the consent information, the purpose of the research, and that participation is voluntary (Daymon & Holloway, 2021; Gehl, 2018).
- I was ethically obliged to ensure that competency and adequate skills to undertake the research were displayed (Bernard, Wutich & Ryan, 2016). The spirit of trust was shared amongst all participants (Daymon & Holloway, 2021; Gehl, 2018).
- Acknowledging that the use of social networks in research poses important ethical concerns. As a non-participant observer, it was crucial to inform the participants that I was in a group silently observing them (Bernard et al., 2016; McMillan & Schumacher, 2014; Creswell, 2013).
- Indicating that a credible research design involved not only selecting informants and effective research strategies but also adhering to research ethics. (Giles, 2017, p. 203).

In light of the detailed ethical steps, I acknowledged that I was entering a situation replete with ethical challenges (Setlalentoa, 2012). There was a constant need to explore ethical matters that might crop up during my research period and avoid hurting participants (Fox, 2017; Giles, 2017; Marshall & Rossman, 2016; Mertens, 2014). Moreover, working with digital issues involves possible interference with people's privacy, and one needed to be more considerate in this when undertaking e-research (Bernard et al., 2016).

Tondeur et al. (2017) indicated that researchers needed to be reductionists of their own beliefs. The whole discursive construction of data from the research was positioned at the forefront of the theory (Marshall & Rossman, 2016) as a complete package of this research. This study was highly informed by my curiosity about intellectual and political issues. Subsequently, I was

very careful as to how together with participants the project was handled. This empirical study was governed by the following ethical rules which started by entering into a dialogue asking for permission from the participants and signing assent and consent forms; maintaining confidentiality and anonymity; being careful of deception, privacy, and empowerment; considering harm, and lastly caring and fairness.

Furthermore, ethical principles guided me not to have responses that may be biased or having participants to give me what I wanted to hear (Fontana & Frey, 2012). Gaining trust was very important for the success of the interviews and still acknowledging that this trust was indeed very fragile (ibid). The coherence between research questions aims of the study, conceptual framework, and the data collection methodology, knitted towards obtaining the findings which would be valid, trustworthy, and credible. The following ethical issues were followed:

1.9.1 Informed consent

Learners' participation involved handling them with caution since their consent to participate was expected to be communicated with them and their parents/ guardians as stipulated in the Children's Act No. 38 of 2005. All participants were respected and given the right to refuse to take part in the research (Suter, 2006) and they were allowed to withdraw freely at any time. Participants were allowed to choose the time, place, and conveniently suitable platform for the meeting. Participants were given consent forms to sign and assurance of no infringement on teaching and learning processes. Clarity was made to abstain from being judgmental and interfering in any event.

1.9.2 Confidentiality, participant's identity, and anonymity

There is no fool-proof method that could be used for the verification of identity, age, or gender (Fox, 2017, p. 283). However, participants, WhatsApp numbers, and consent form details were kept secure. Also, they were assured of anonymity and confidentiality throughout the research process. The names of the participating schools and participants involved in the study were coded using symbols and numbers. In the letters to the principals and teachers, the addresses were deleted to protect the identities of participants. Also, the screenshots which carried the evidence of owners of WhatsApp group members were erased so that readers could not associate the extracts with the participants. It was also maintained that the information was for the study only (Giles, 2017, p. 189).

1.9.3 Deception, privacy, and empowerment together with participants' distress

The participants were highly encouraged to openly discuss any problem they encountered during the research period. The benefits of participating were structured such that benefits outweigh risks. There were no deceptions and participants were sharing in the benefit of the study (Suter, 2006). Visual cues could be used as a vigilant approach for detecting distress (Fox, 2017). This included posting comments not related to mathematics, vulgar language, comments with a strong emotional tone. The interim policies regarding the behavior and depletion of focus group rights were drafted which included the School Management Teams. (SMT) It was ensured that the research topic proposed was viable and that adequate research design was established together with adequate data collection techniques. The researcher was ethically obliged to ensure that competency and adequate skills to undertake the research are displayed. The "spirit of trust" with the participants was shared amongst all participants (Fox, 2017 p. 275).

1.9.4 Harm, caring and fairness, the online safety

Conducting this research followed principles that did not have harmful consequences. Participants were encouraged to focus on meaningful contributions of how teaching and learning mathematics can be improved through using social networks. Participants were informed that their participation and data would be used for research purposes only (McQuarrie, Marshall & Rossman, 1990). They were granted full knowledge of all research procedures (Braun, Clarke & Gray, 2017c). The intention was neither to expose nor to humiliate any participant. Written consent to different participants was signed and revisited throughout the research journey to ensure adherence to correct ethical principles. I could not take for granted that since I had the letter from the department of KwaZulu-Natal Department of Education (see Appendix 2), I could have just commanded any participant to take part in the research. Copies of letters requesting permission to different stakeholders were attached explaining the aim of the research and stipulated in detail how caring of every participant was done. At the end of the research, project responses were given to the participants with extensive room for them to disagree with what happened (Yin, 2012). This was indicating to the participants that they share an extensive role in the study findings.

Participants were informed about the Protection from Harassment Act 17 of 2011, which was signed into law on the 27th of April 2013, that the Act protects children from bullying in schools, individual harassment by cyberstalkers, and what happens if someone is being

harassed by cyberbullies. As the means of tracking the offenders who bully behind the cyber walls, the Act stipulates that the electronic service providers can be forced to hand over the details of the (Internet Protocol) IP address, email, or cellphone number to whom the electronic device belongs. They were advised also to treat one another with respect and understand that communicating in social networks was done in the closet but with one click one whole life image could be destroyed. They were reminded that these WhatsApp groups were solely made to communicate mathematics-related matters for this research project and nothing more (see Appendix 5; 8 and 9).

1.9.5 Distractions

Fox (2017) emphasized the conditions on how participants should respond since communicating is done in the public space. Emphasis was made especially for those who were sharing their gadgets to take full ownership of postings that tally with their particulars. For interviews, distractions were minimal because both pre- and post-interviews were less than 60 minutes and done in the face-to-face mode.

1.10 DEFINITION OF TERMS

1.10.1 Emerging technologies

Lai and Bower (2019) described emerging technologies as "different motivations for integrating technology into learning, for instance, to improve student learning outcomes, improve access to learning, and enhance learner motivation".

1.10.2 Social Networking

Social networking is an action for visiting sites that aid "as tools for supporting student learning for different educational purpose" (Almu & Buhari, 2014, p. 6333). In this study, social networking referred to individuals and groups to construct profiles, display, and share their interests through posting and exchanging information (Ellison & Boyd, 2013). What made me choose the term 'social network' was that the study used networks as its central construct. Badshah, Jalal, Rehman, Zubair and Umar (2021) argued about the adoption of this concept since it has no direct relationship with learners' engagement. Here a network was a set of nodes interrelated by dyadic ties (Eun, 2019). Shah (2017) and Reene (2020) used the concept 'social networks' and 'social media' interchangeably.

1.10.3 Facebook

Facebook is an "online social networking website where users can post comments, share photographs and post links to news or other interesting content on the web, chat live and watch short-form video" (Nations, 2019). In this study, it was noted as the most preferred social network that uses wireless connection (Bicen & Cavus, 2010; Cavus, Bicen & Akcil, 2008) and has been popularly used in higher institutions (Rambe & Bere, 2013).

1.10.4 WhatsApp

This is a mobile instant messaging application that offers real-time texting, communication, including the ease of sharing information or media content (audio, video files, images, and location data) (Bere & Rambe, 2019; Ahad & Lim, 2014; Church & De Oliveira, 2013). It is a smartphone application that functions on nearly all current kinds of devices and working systems which has been on the market since 2010 (Bouhnik & Deshen, 2014). It is also a cross-platform smartphone messenger that employs users' existing internet data plan to connect with a specific community (Amry, 2014, p. 119). It is, therefore, "a proprietary, cross-platform instant messaging subscription service for smartphones and selected feature phones that use the internet for communication (Mefolere, 2016, p. 616). In this study, it is an easily accessible platform either in the smartphone or a computer, more affordable to be used as an extension for formal discussion.

1.10.5 Digital Literacy

Digital literacy refers to the principle of belief (Shah, 2017, p. 117). To be precise, as with general literacy, provides an individual with the capability to achieve other valued outputs in life, especially in the modern digital economy" (Chetty et al., 2017, p. 1). In this study, digital literacy refers to new digital knowledge where participants could manipulate technology to suit their needs. Digital literacy enables awareness of ICT and admires education as opposed to indoctrination (Downes, 2017).

1.10.6 Digital natives

Digital natives are "students who are 'native speakers of the digital language of computers, video games, and internet" (Prensky, 2001, p. 1). In this study, digital natives referred to

learners because they are born into technological skills, unlike their teachers who need orientation on how to use their phones.

1.10.7 Rural

This is described as the place "where family comes first and sharing is prominent, even sharing of phones" (Dalvit, 2014, p. 82). The Department of Education was determined not to recognise "rural education as a separate category, however, these schools are governed by the same curriculum, the same conditions of service, the same national legislation and the same policies as all other public schools in the country" (Gardiner, 2008, p. 7). It is only at provincial and district levels that realities on the ground, such as conditions in rural schools can be addressed specifically. It is worth noting that the Department of Basic Education (DBE) has reviewed rural education policy on educational reform, so that rural schools will not be the follower of urban agendas and priorities (Government Gazette, 2018, p. 16). This policy intended to be adhered to by uplifting sense of pride among learners; improve belongingness; harnessing resources by developing individual and community needs (ibid, p. 16). However, rural learners still face unprecedented challenges "in adjusting to a new mode of life and learning, the latter being characterised by the predominant use of online, learning management systems and low-tech applications" (Dube, 2020, p. 1). This indicates that the term 'rural' in South Africa is describing deficiency, especially poverty as not only apartheid legacy but knowledge as well. Rural comes with the liability to strongly harness economic and social impacts using internet for development (Gillwald et al., 2018b) In South Africa, there is no single definition of 'rural' as rurality is characterised by diverse contexts (Government Gazette, 2018). In this study, 'rural' referred to shortage of basic infrastructure for teaching and learning which enhances extensive communication between teachers and learners even after school hours. Trends in International Mathematics and Science Study (TIMSS, 2015) and the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ, 2013) showed lack of mathematics proficiency among SA grade 9 quintile 1 (which is composed of rural schools) (Spaull, 2019; 2015) . Botha and Herselman (2018) used the concept 'resource-constrained context' where people are unfamiliar with, or afraid of, technology or environments where power and network connectivity are scarce and expensive. Seemingly in SA, the call for the need to understand and harness technological scholarship is long overdue. Hence this study explored the rural user's perceptions of mathematics pedagogy on social networking platforms.

1.11 EXPOSITION OF STUDY

This section explains what each chapter entails. Figure 1.2 diagrammatically represents the outline and flow of chapters in the study.

Figure 1.2 Programme of the study

Chapter one provided the introductory note of the study together with the background of the exploration, which served as the orientation of the study. This covered also the problem statement, aims and objectives of the study, the research questions, research methodology, and preliminary literature review. It indicated the ethical issues that I have considered and the means to ensure the trustworthiness of the study. In conclusion, the draft of the plan of the study was presented.

Chapter two presented the literature review, which was reviewed and incorporated the usage of social networks in facilitating effective learning in rural areas. In conducting this study, the lenses that were used as the theoretical framework were indicated.

Chapter three comprised the research design and the data collection methodology. This gave a meticulous explanation of applying qualitative measures in collecting data using interviews,

focus groups, documents analysis, and observation of both teachers and learners (as the non-participant observer and online discussions).

Chapter four offered data analysis and findings of data and information obtained from the research process.

Chapter five entailed the discussion, limitations, and the conclusion of the study. This was the final chapter which ended by suggesting and recommending possible avenues of future research.

1.12 CONCLUSION

This chapter outlined the background, rationale and motivation of exploring the integration of social networks in the teaching and learning of mathematics in rural secondary schools. This introductory part of the dissertation unfolded the main objectives of the study, the research questions, and the research design on how data were collected and analysed.

The next chapter focuses on a literature review that explained more about the integration of social networks in the teaching and learning of mathematics in rural secondary schools.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter was to review literature related to the usage of social networks in teaching and learning mathematics in the rural context. This was achieved by exploring literature about how social networks enhanced the teaching and learning of mathematics. The presentation of this chapter included three sections: first, is the review of literature on the types of social networks and emerging technologies that teachers used to disseminate information to learners. Second, is the review of literature about learners learning through using social networks. Third, the theoretical perspectives that reflect the changing view of education in the context of the rapid technological advances. The chapter concluded with the research gaps identified in the literature review.

2.2 STRATEGIES USED BY TEACHERS TO CIRCULATE INFORMATION TO LEARNERS

Teachers are the key role players and role models in education (Shaikh & Khoja, 2012); hence, Bayles has long attested that teachers should adjust themselves to attain strategies that are contemporary and contextually relevant (Bayles, 1969). Knowledge age presents a paradigm shift (Harasim, 2012) which is presented in the following section that explores the types and use of social networks in developed countries; developing countries, and South Africa. In this discussion, developed countries will refer to all countries outside the African continent, whereas developing countries will refer to African countries.

2.2.1 Types and the use of social networks in developed countries

Statistics have identified popular social networks worldwide (Statista, 2019). These include popular social networks such as Facebook, YouTube, We Chat, Instagram, WhatsApp, and others (see Figure 2.1) below.

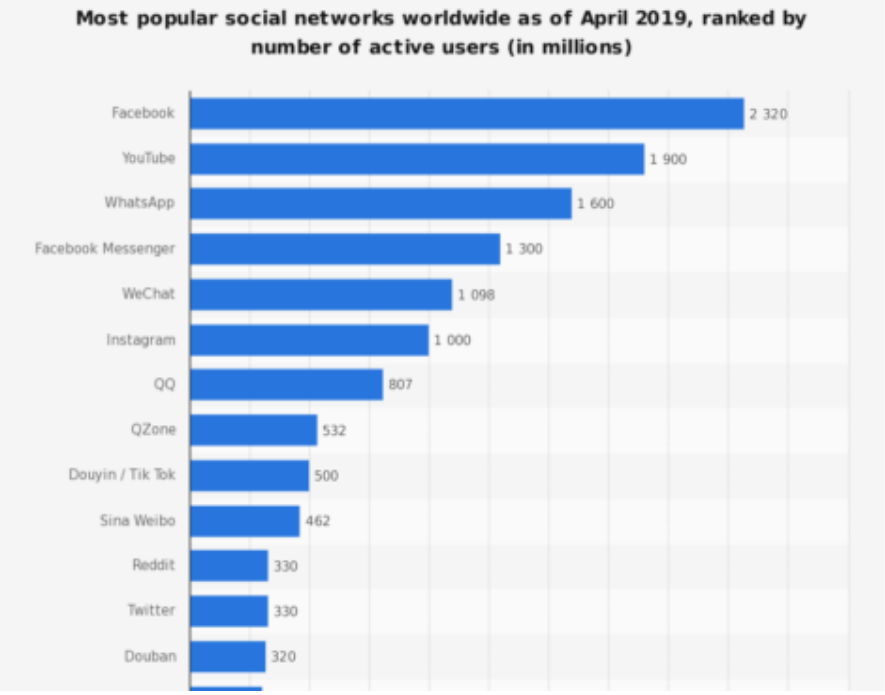


Figure 2.1 Most popular social networks worldwide as of April 2019, Adapted from Statista (2019)

The current popular used social network in Figure 2.1, is Facebook with 2 230 million users followed by YouTube with 1900 million users, and in the third position is WhatsApp with 1600 million users. Similarly, teachers in the developed countries use Facebook, YouTube, WhatsApp, and Twitter to communicate with their educational groups (Abu-Shanab & Al-Tarawneh, 2015; Bouhnik & Deshen, 2014; Church & De Oliveira, 2013; Fewkes & McCabe, 2012). In countries like the United States, Netherlands, Australia, France and Japan, ICT penetration among household members has been common (OECD, 2001). Strategies to improve mathematics by motivating learners to incorporate the digital skills invested in social networking sites over the years were explored in the United Arab Emirates.. Findings have shown fruitful intervention of social networks among university students (Abu-Shanab & Al-Tarawneh, 2013). They were used as social networking tools (like Skype and Facebook), as social publishing or sharing tools (like blogs, YouTube, wikis, or Twitter), as social/content management tools (Moodle, Edmodo, surveys), and lastly, as virtual worlds and gaming environments (PlayStation Network) (Gerber et al., 2014; Prensky, 2005). In Bicen and Cavus's (2010) study in Cyprus, the aim was to find out social networks preferred by students and their usage habits. Similarly, in the Middle East, students use WhatsApp as their daily communication tool (Baytiyeh, 2018). Facebook and WhatsApp were amongst the preferred ones and offered a much more natural learning environment than that provided by schools

(Grosseck et al., 2011; Bicen & Cavus, 2010) because of their offline sharing abilities (Nida, Usodo & Sari Saputro, 2020). Previously, the introduction of new instructional designs was not common in European public schools (Ertmer, Quinn & Glazewski, 2019); hence, an initiative was done by teachers through reflecting and analysing their context and effects on teaching and learning (Pederson, 2019). Trends in mobile devices, as opposed to personal computers, appeared to reach the highest peak in 2017. The growth of mobile subscribers projected for 2017 seemed to be double the number it was in 2008 (Allen, 2017). Statistics indicated that social networks are becoming more popular worldwide, including WhatsApp. In the developed countries, the economy is a multiplying factor that communicates new ways of working and living in many interconnected places (Schwoebel, 2018), hence using WhatsApp was more of a social influence in Germany (Church & De Oliveira, 2013). However, being at the developed level involved designing and using network tools that are more adaptive and which aimed to achieve automated exchange of information without the need for humans to exert direct control (Schwab, 2021). Developing countries are revealing a gap between entrepreneurs and scholars which is heightened by the fact that the benefits of higher education are non-monetary and external, meaning that those who enjoy the benefits of education are not graduates. There has been an unbundling of the knowledge economy at universities, especially among United States universities. So, they uphold the linked idea of marketization of vacancies and learning informally using YouTube videos. However, this Facebook posting of every lesson and posting videos is a challenge to knowledge that extends beyond the boundaries of the textbook and classroom, thus ending up being a distraction. The study in Hong Kong collected from SITES M2 revealed that pedagogical practice was not determined by the aggregation of characteristics of the practice per se, but on whether empowerment permeates the curriculum goal and process (Plomp, Pelgrum & Law, 2007). Ubiquity and ease of access enabled numerous learners in secondary schools to employ emerging technologies in schools (Bano, Zowghi, Kearney, Schuck & Aubusson, 2018).

Since the era, generally dubbed Industrial Revolution, has no specific determined period, these developed countries have widened connectivity even among secondary learners where Facebook as a social platform is used to build good relationships outside of school and enhance knowledge beyond the classroom and textbook boundaries. Usage of social networks in an interactive nature increased learners' engagement, quality of assignments, and a sense of responsibility for their learning (Mao, 2014; Mills, 2011). In the Netherlands, teachers used social media for information sharing with students outside the class which promoted self-

regulated learning (SRL) among learners and did not affect student-teacher relationships. Technological innovation directly contributed towards active participation of humans in educational, economic, and political life (Clark, 1994; Kozma, 1992). Social networking sites were expected to have four features shared by many social media technologies which were a digital profile, relational ties, search and privacy and network transparency (Ellison & Boyd, 2013). The teacher has a role as an agent of change, leveraging technology resources as meaningful pedagogical tools; hence, there is a proposal of changing teachers' mindset that involved effective teaching (Ertmer, Ottenbreit-Leftwich & York, 2007). This could be through incorporating technology-based support together with social networking which is common in a particular area (Ertmer et al., 2019).

In the developed countries, laptops, tablets, interactive whiteboards, data projectors, and notebooks are pervasively used in European countries; thus, teachers' use different gadgets (European Commission, 2013). Although the gadgets could be pervasively common, teachers' attitudes about the behaviour (Would I do this sort of thing normally?) and subjective norms (Would other people in the group do this?) drive the process (Fishbein, 1967). Fishbein started by narrowing the scope of the concept 'attitude' by separating it from 'belief'. Thus, attitudes which were predispositions to respond to an object or class of the favourable consisted of three components which are affective, cognitive, and conative (action) (Fishbein, 1967). This brought a conceptual confusion since Fishbein limited the term 'attitude' to the affective component and designated the cognitive as belief about objects and the conative as belief about what should be done concerning the object (Fishbein, 1967; Shepherd, 1986). On the other hand, mathematics education viewed learners as active participants who construct knowledge by reorganising their current ways of knowing and how they extract coherence and meaning from their experiences (Moyer, 2001). Experiences with formal pedagogical knowledge amongst teachers are seen as the least powerful factor that affects education.

To fight digital inequalities in the United Kingdom (UK), gradations in the frequency of internet usage aimed at the continuum of digital inclusion (Livingstone & Helsper, 2007). This type of education has potentially lightened the load for the teacher by supplementing primary instruction with additional learners' driven learning experiences. Teachers were guiders and facilitators of mobile learning. Innovative ways to use technology out of the classroom aims towards personalised learning (Attard & Holmes, 2020; Ingram et al., 2019; McLoughlin & Lee, 2010). In Australia, Finland, Singapore, and the UK, teachers adopted policies for school-based tasks that use technology to access information and solve authentic problems in line with

twenty-first-century skills (Ottenbreit-Leftwich et al., 2018; Voogt, Knezek, Christensen & Lai, 2018; Darling-Hammond, 2012). Developed countries can be used as the reference to countries that have national policies identifying the high priority for their use of ICT in education. Education provided is mostly individualised learning with multiple representations for teaching concepts with curriculum approaches to individual user's preferences and interests. The current reporting occurs that enables the teacher to adjust classroom instruction and quickly address learners' learning gap before it is too late. In schools there has been a collaborative approach to personalised learning activities, a good quality ICT training, and support package for practitioners (Merchant, 2012). These have been live 'spaces' (Bicen & Cavus, 2010), 'situated learning' developing the ability to think (Lave & Wenger, 1991), and making a difference in the individual's learning through fully participating in the learning environment (Cross et al., 2002). That laid a solid foundation for implementing the teaching of thinking (Plana, Gimeno & Appel, 2013; Sfard, 2008a), which was more applicable to learners from disadvantaged backgrounds, different cultural backgrounds (European Commission, 2013). There must be an understanding of the conception of what it means to teach mathematics as being related more specifically to how the teacher thinks about the mathematics domain for learners (Borko & Putnam, 1996). Users of the social network expressed their identity online through profiles and interaction (Ellison & Boyd, 2013). The notion of having teaching and learning as a conversation (Sharples, 2005) laid the proposal that learning event does not halt, but is possible to continue within various networks used by people in their day-to-day lives (Sharples et al., 2017, 2014). Technology provided a framework for describing the outcomes for technology-enhanced teaching which included: (1) an overarching conception of what it means to teach by integrating technology in the learning; (2) knowledge of instructional strategies and representations for teaching particular topics with technology; (3) knowledge of students' understanding, thinking, and learning with technology, especially for mathematics; (4) knowledge of curriculum and curriculum materials that integrate technology with learning in mathematics area (Borko & Putnam, 1996, p. 690).

Countries in Asia and Pacific regions have employed mobile learning to reach underserved communities and therefore leapfrog the populations' overall level of education. In various cases, teachers have become the biggest blockers of ICT because they revealed themselves as unenthusiastic, overwhelmed, and underprepared (Pegrum, Oakley & Faulkner, 2013). The use of mobile handheld technologies and social networks as informal tools for teaching is still at an experimental stage (Almu & Buhari, 2014). Users' goals included sharing knowledge;

promoting partnership and coordination to improve research and evaluation, thus reducing the duplicative efforts. It has been attested that usage of social networks in rural societies is rising and students are spending time on social networks (Abu-Shanab & Al-Tarawneh, 2013). For instance, a study in Sokoto metropolis aimed at assessing the trend of mobile social networks usage among secondary school learners indicated that social networks affected learners' performance because of their addiction to SNS (Almu & Buhari, 2014). Further, they had a venue for friends, relations, and even learners to interact to share common interests and ideas (ibid). Also, a quantitative study done at Sultan Qaboos University investigated the extent to which social networking tools had an impact on academic patterns of informal scholarly communication in studies (Al-Aufi & Fulton, 2014). Findings indicated that there is perceived usefulness of the impact of social networking tools on patterns of informal scholarly communication.

Interestingly, the 21st century pedagogy considers teaching and learning with social networks, wherein there is shifting of the role of teachers and more attainment of engagement (Murawski & Scott, 2020). It has been grasped that teachers in developed countries were oriented to new standards of mathematics teaching as the best method of teaching informally (Mun & Hertzog, 2018; Luna, Balase & Aclan, 2015). It is based on this information that this section discusses the types of social networks applicable to teaching and learning, how these networks were used, and what influenced teachers to adopt the use of the social networks to share information with learners in developed and developing countries. In some cases, teachers could not allow learners to use the emerging technologies because they could not use them (Clark, 1994; Prensky, 2005). This debate challenges the status quo which denied incorporation of ICT to enhance learning in the developed countries (Greenhow, Galvin & Staudt Willet, 2019; Marginson & Dang, 2017; Bouhnik & Deshen, 2014). Moreover, blurring the distinction between public and private life has motivated researchers to study deeply possibilities for ethical education policy (Greenhow et al., 2019; Mfaume, 2019). It was the ontological turn that pushed my zeal in collecting qualitative synthetic data pursuing this research project to explore rural teachers and learners' 'petites perceptions' (Serres in Freitas & Walshaw, 2016); 'esoteric' and 'realistic' (Cooper & Dunne, 2000) boundaries and issues of problem-solving among learners from rural secondary schools (Gates, 2002).

It has been identified that even among the developed Arabic countries, usage of social networks among high schools is still exploratory and findings demand proper training among teachers

and learners to keep motivated and focused on their learning (Abu-Shanab & Al-Tarawneh, 2013, 2015).

2.2.2 Types and the use of social networks in developing countries

The very usage of technology could be used to categorise countries as developing countries (Ndume, Songoro & Kisanga, 2020; Bagui & Mwapwele, 2019; Botha & Herselman, 2018; Dahlman, Mealy & Wermelinger, 2016). Teachers incorporated technology as their teaching aid in and outside the classrooms and outside at an increasing pace which is called the need for technology that will be available for every learner to learn and develop.

Opportunities available in Nigeria which were provided by ICT in education were to engage teaching and learning but in the classroom environment. Findings presented factors influencing or hindering the adoption and integration of ICT in teaching and learning (Lawrence & Tar, 2018). In support of this, the Nigerian Department of education summarised six priorities that the government believed would make the difference in skills acquisition. It cannot be underestimated that there has been a problem with digital infrastructure to support the transformation of education (Eze, Sefotho, Onyishi & Eseadi, 2021). There has been an outcry for the pedagogies appropriate for a 21st-century education system since traditional methods have not achieved enough due to shortages of technological skills (Ereyi et al., 2016). Factors that limited teachers' adoption of technology have been based on teacher-level factors (their attitudes and beliefs); technological factors (lack of capabilities) and leadership support (lack of resource and management support (Lawrence & Tar, 2018). Nigeria's improvements of the economy have been substantial, yet education performance still lagged. This was seen in the inadequate infrastructure of schools; inadequate curricula, insufficient quality, and poor learning outcomes (Njideka, Isiaka, Bashiru & Omotayo, 2016). Nigeria was among the lowest sub-Saharan countries in terms of household ownership of mobile phones (Gillwald et al., 2012). This has been surprising because Nigeria has been "the continental leader in the area of ICT, the sector is currently at a low ebb" (Gillwald et al., 2018a, p. 8) To increase access to educational technologies, what was noted was that they allowed more people to have more devices by cutting the price of the ICT devices, but ICT services have been relatively low (ibid). Interestingly, the social networking internet services has been relatively high with 45, 97 percent, against 52, 78 percent social networking for their personal use while 20, 24 percent used social network for education.

In Zimbabwe, schools' adoption of digital platforms has been lagging (Muzurura et al., 2021). Unlike Tanzania, there has been a development of informal learning, MIMs, wherein learners were introduced to communicating with their teachers in a multidimensional way (Bagui & Mwapwele, 2019). It was interesting to learn that teachers have long adopted using their phones to share with learners and that had no adverse culture (Ndume et al., 2020). It is worth noting that at school level, the influx of using social networks is still behind. In Tanzania, there has been a lack of knowledge on how learners can utilise informal learning platforms to ascertain learning (Bagui & Mwapwele, 2019). Findings have shown the need for using MIMs and to offer support on using digital learning platforms which will afford opportunities for innovation (ibid).

In Botswana, Boitshwarelo (2005) confirmed that connectivity problems in schools limited teachers' interest in using their digital technologies. Others ended up using their connectivity due to their zeal and interest in using technology. Further, the lack of ICT policy escalated the challenge. In a similar disposition, these challenges are recorded in Ghana, where teachers lack confidence in using digital technologies in their teaching (Buabeng-Andoh, 2012).

Universities in Uganda have long been using various Learning Management Systems (LMS) and have recently used WhatsApp Enabled Learning (WAEL) to develop Higher Order Thinking Skills (HOTS) which included creativity, critical reflection, and dialogue (Baguma, Bagarukayo, Namubiru, Brown & Mayisela et al., 2019).

Africa experienced drastic changes in internet penetration at different levels, creating tension from what is common with social networks promoting weaker ties (Wasserman, 2011). The African Declaration to use the internet as a vehicle for the exercise and enjoyment of human rights and participation in social and cultural life has been signed by developing countries that aimed at having the internet as a vehicle for the free, open, equal, and non-discriminatory exchange of information communication and cultures (AfricaninternetRights.org, 2019).

The following discussion views types and uses of social networks in South Africa.

2.2.3 Types and the uses of social networks in South Africa

The South African government has recently recognised the need faced by rural schools by introducing the rural education policy (Government Gazzette, 2018). Currently, rural schools experience poor education as compared to other places in urban areas in South Africa (Gardiner, 2008; Weber, 2008). Thus, there has been a need for a special curriculum among

rural schools (Writer, 2018). Interestingly, the issue of cyber-crimes and Cyber Security Policy (CSRT) in the South African parliament was one of the prioritised agendas since the bill was gazetted in 2017. However, even long before that, teachers who were having a technological mentality initiated change, since they were aware that technology was all around humans and inhabits every personal and professional space (Ankiewicz et al., 2015). On the other hand young people's accessibility to social networks has dramatically increased in South Africa (SA) especially those learners in rural areas, see Figure 2.2. (Gillwald et al., 2012). They used the internet to socialise and for other personal reasons (O'Hagan, 2013). In this case, the social network was a 'substantial indicator' of data used as compared to the usage of computers (Dalvit et al., 2014). Halse and Mallinson (2011) applaud social networks for instilling Ubuntu principles. The influx of digital technologies has been identified in SA where tablets (Haßler, Major & Hennessy, 2016) and computers (Matthee & Liebenberg, 2007; McCarthy & Oliphant, 2013; Saal, 2017) have been used although WhatsApp (Bere & Rambe, 2019; Khoza, 2020; Jere et al., 2019) has been minimally used for education. According to a report from the South African Mobile Report (2017) (see Figure 2.2 below), WhatsAppers and Facebookers use their services with over 50 percent than their counterparts in their day-to-day social networking. Interestingly, some teachers have initiated teaching mathematics as songs using WhatsApp (Sibiya, 2019). On top of that, Daily News confirmed that the following figures reflect on social networking sites that are commonly used in South Africa (see Figure 2.2):

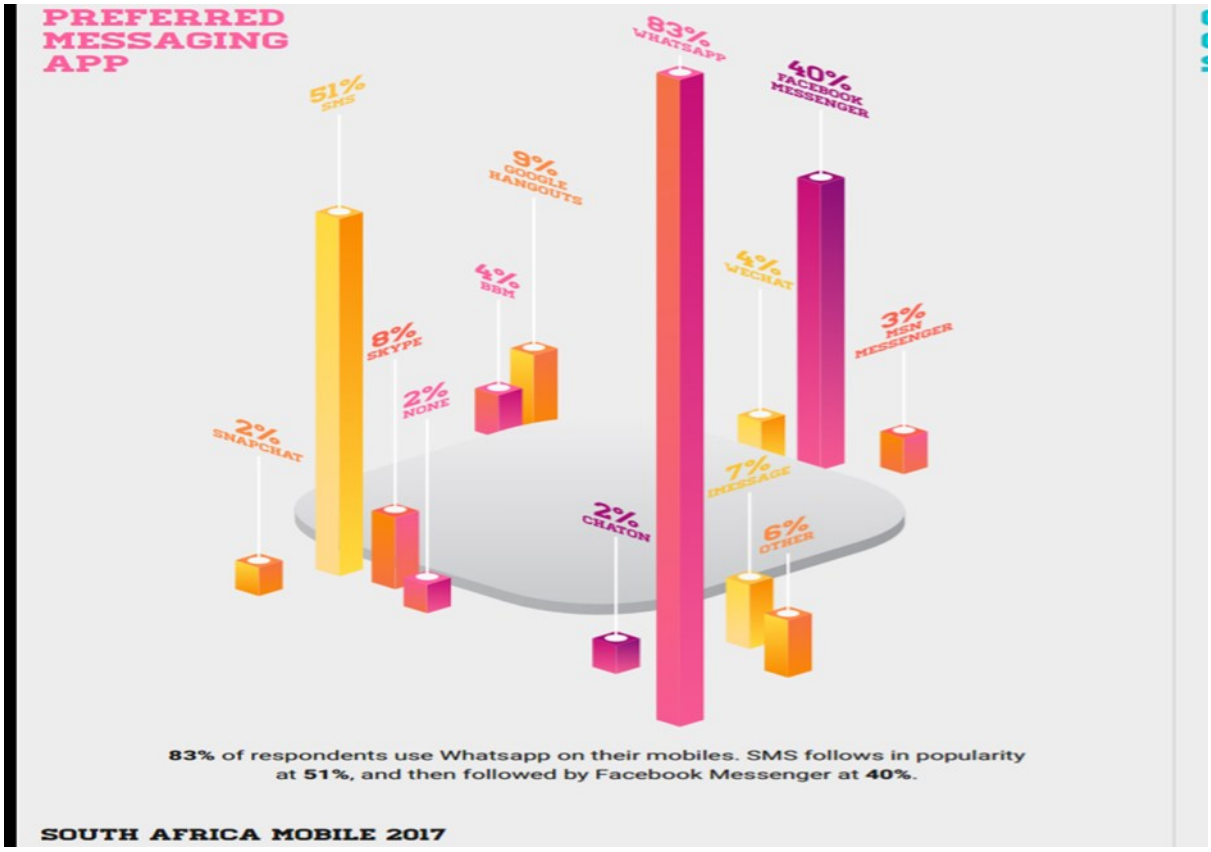


Figure 2.2 South Africa Mobile Report (2017.)

The illustration on the graph shows the most popular social networks used in South Africa and it was discovered that WhatsApp was the most popular, used by 83 percent of respondents. The mobile ownership and use in South African rural areas have been identified as problematic because mobile ownership in the rural area was 80, 8 percent while urban areas were 86, 3 percent versus 1, 2 percent of urban learners with cell phones compared to 0, 7 percent of learners with mobile phones in rural areas (Gillwald et al., 2012, p. 60). This source expatiated on the fact that people in rural areas were having their phones charged in shops and sharing phones was common whereas in urban areas they charged in their homes and schools (ibid). This contradicted the assumption that if there is a shortage of electricity, there must be a shortage of social networks adoption. O'Hagan speculated the new users which would be young, black, and poor (O'Hagan, 2013), of which the study at uMkhanyakude District focused on such participants. To date, data have confirmed that the "digital divide between urban and rural in the use of the internet is narrowing in South Africa" (Gillwald et al., 2018b, p. 90). The following table has been drawn to give the narration of what informed the need for the study back then.

Table 1.2 Internet as used daily

	National	Urban	Rural	BoP
Education or learning activities (formal)	9.8%	9.6%	10.6%	8.5%
Getting information for school, research topic	8.8%	8.9%	8.3%	4.6%
Looking for free education content, such as free courses	5.4%	4.9%	7.3%	5.7%
Collaborating online on documents	8.2%	7.0%	12.4%	2.0%
Social networking or video-sharing websites, Facebook	51.7%	51.5%	52.4%	35.9%
Finding or checking a fact	12.0%	10.1%	18.5%	8.9%

Statistics in Table 1.2, specified that usage of social networking in rural areas was 52.4 percent higher than in urban areas which were 51.5 percent. These statistics indicated the vast potential of using social networks for learning. It was therefore imperative to explore the strategies used for teaching and learning at uMkhanyakude District based on social networks after school hours. It was still heartening to learn that still in 2018, the majority of users were young users aged 15-24 years but "less than half of Internet users use the platform to acquire educational content" (Gillwald et al., 2018b, p. 96).

The presented statistics validate the importance of this study. In support of teachers looking for free education content (Gillwald et al., 2012), teachers in rural schools in South Africa have been identified with the problem of poor mathematics content knowledge (Spaull, 2015; Brijlall & Maharaj, 2014). Literature mentioned the following social networks that have been used in SA: Facebook; MXIT; Nokia Mobile mathematics; M-Thuto and WhatsApp. MXIT has been a leading platform with instant messaging services available using low-cost feature phones in SA which used Dr. Maths as an online tutoring system across the country (O'Hagan, 2013). These networks have been distributed through technology, have restructured how human beings live, communicate, and learn (Dalvit et al., 2014). In the study conducted by Chigona and Chigona (2008), it was asserted that the theory of communicative action had three world concepts which were the objective world, individual subjective world, and social world. Understanding communication distortion and communicative action were important for transforming and improving practice since its sustainability was hindered by poor research (Chigona & Chigona, 2008). On the other side, M-Thuto was used by learners to interact while

learning (Bozalek Ng'ambi & Gachago, 2013). Mathematics was benefiting the participants with its multilingual structure and aimed at supporting learners from under-resourced schools. It was game-based and not directly related to learners' current studies. There was a need to domesticate other digital platforms to enhance learning among universities (Chigona & Dagada, 2011). In support of enhancing learning using the domestication of digital platforms, a study has been conducted in one of the previously disadvantaged South African universities, using MIMs which was fruitful (Rambe & Bere, 2013). Although the MIM was good, its adoption remained disappointing in different South African universities (Rambe & Bere, 2013) in 2019 they presented the need to overcome proximity and differential knowledge which was attained by using WhatsApp in higher institutions (Bere & Rambe, 2019).

Exposure to ICT and other emerging technologies from an early stage is said to have changed how learners approach learning (Atweh, Graven, Secada & Valero, 2011). Previously, learners relied on the traditional methods alone, and for this reason, they struggled to interact and engage with fellow students during their learning in higher education institutions (Brown & Czerniewicz, 2010). There is a reclaiming of 'digitizen' wherein both teachers and learners would think digitally beyond the computers (ibid, p. 366). In the universities, the focus for coupling teaching and learning with educational technology has been the priority. This has been in line with the South African government's strategy of helping disadvantaged learners with diverse educational backgrounds (Tarling & Ng'ambi, 2016). Amongst the South African communities, numerous social networks have been used. This research indicated that cell phones ownership pave the good platform for cell phone usage among the resource-constrained communities in South Africa (Gitau et al., 2010). In this regard, the social network enabled efficient skills of ease of use, facilitates cognitive skills, and was cost-effective and efficient to participants in rural areas (Spaull, 2015). Further, other teachers have allowed learners to relate to what they were taught using social lives and what was happening around them (Sibiya, 2019). Interestingly, South Africans' access to the internet to others is limited by rurality and to others by their being economically disadvantaged. Interestingly to others, the internet was available but they needed the 'push' to use it (Gitau et al., 2010).

The main barrier was on integrating mobile devices and using them effectively to enhance teaching, learning, and learner support (Traxler & Kukulska-Hume, 2005). This would be done by equipping sufficient digital skills to embrace the 21st century teaching/learning opportunities (Sharples et al., 2016). Teacher support in ICT training has been identified as the priority need in South Africa (Gudmundsdottir, 2010) which enabled teachers to allow learners to become

co-creators of their learning (Botha & Herselman, 2018). The usage of technology was needed to encourage teachers to use devices for their capacity with anticipation that it will assist them to reach curriculum objectives (Botha & Herselman, 2018). The shortage of technology equipment's and policies was a challenge in the low income South African context (Ramorola, 2018; Masilo & Ramorola, 2013).

South African universities have started incorporating social networks in their teaching and learning (Rambe & Bere, 2013). Using cell phones as common mobile devices has been seen to be the form of low-cost technology that enabled economically disadvantaged schools to break the cycle of repairing and fixing computers before accessing the internet (Gillwald et al., 2012). Similar anticipation in South African secondary education and higher institutions expected growth by 2020 and attainment of its growth by the year 2025 (DBE, 2011; NPC, 2011) has been speculated. Schools were left with a need to establish themselves and stipulate the policies that channel the usage of cell phones and emerging technologies (Kreutzer, 2009a, 2009b). The quality of education for all was still an issue in South Africa since gaps in socioeconomic status were highly manifested in educational resources (Botha & Herselman, 2018). Thus, this study aimed at education that focused on redressing inequalities and proposed the continued research exploring issues of disempowerment and agency, constraints and possibilities considering emerging technologies. The findings are articulated to shift the focus from a discourse of deficit and helplessness towards a discourse of possibilities in the struggle for equity and quality education for all. Projects like Dr. Math, on the MXIT social networking platform, were discouraged because of the tutoring happening between old and young ones. MXIT has been used as a one-for-one replacement for text messaging, with avenues of 'self-expression' and connection that have drawn detractors, media stories of illicit chats and photo-doctoring have fueled moral panics (Chigona et al., 2009).

Learners from a rural school in uMgungundlovu District (KwaZulu-Natal) declared poor mental construction of mathematical knowledge during engagement with the identification of the problem (Brijlall & Ndlovu, 2013). It was verified that these learners lacked conceptual understanding which could be improved by modelling problems and using specific rules and formulas (ibid). On a similar note, a study in the Eastern Cape Province identified the problem of conceptual understanding where the language was identified as the barrier for learners not associating the root of an equation (Jojo, 2019). Learners were struggling with conceptual understanding; hence, they were having limited mental assimilations (Jojo, 2019; Brijlall & Ndlovu, 2013).

SA learners' opportunities for problem-solving are minimal and learners could not engage in adaptive reasoning (Ramdhany, 2010). This would mean that teachers improvised pedagogy where there were shortages in developed countries. Further to this, to support underachieving mathematics classes in KwaZulu-Natal, findings recommended the inclusion of knowledge that would make particular topics easy for learners to understand (Brijlall & Maharaj, 2014). There is a call for a new net growing generation 'digital natives' to substitute an older analogue 'digital divide' generation to unravel digital opportunities and not bounded by 'digital apartheid' (Brown & Czerniewicz, 2010).

2.3 LEARNERS' SOCIAL LEARNING USING SOCIAL NETWORKS

The study reviewed learning as it occurred during the digital age where social learning was integrated with social networks usage. The focus was on literature that portrayed learning as influenced by new technologies (Badshah et al., 2021; Reene, 2020; Shah, 2017; Almu & Buhari, 2014; Boyd & Ellison, 2007). Personal distributed learning (Downes, 2017) that promoted actionable knowledge which was intended to know where to get knowledge became more important than answering how and what that knowledge encompasses (Duke, Harper & Johnston, 2010). Besides soliciting assertion of knowledge not kept in individual's head and changing roles between teacher and learner (Kop & Hill, 2008), "There is a need for reinventing classrooms without walls in which we are all co-learners" (Mbembe, 2015, p. 6). Visuals in mathematics are documented as important new communication tools that could promote engagement, understanding, expression, and self-assessment (Boaler, Chen, Williams & Cordero, 2016). Considering what is mentioned, the discussion followed reviewed the viewpoints of learner-educator discussion that took place in the literature, the ubiquitous methods of learner information discovery, and lastly identification and indication of learning demonstrated by learners.

2.3.1. The viewpoints of learner-educator discussion that took place in the literature

After the participants chose the social network, it was imperative to find out the extent to which learner discussions took place. Qualitatively, the word 'extent' was understood to mean embracing learner-teacher discussion using WhatsApp. In this study 'extent' referred to the range or scope which meant an area in which teaching and learning operated or had control over. As Siemens specified "[t]he ability to synthesize and recognize connections and patterns

is a valuable skill" (Siemens, 2004, n.p.). In European countries, education has been fused with technology in their traditional classrooms which not only allowed teachers to foster a more collaborative environment but also cultivated learners' engagement, trust, and self-directed learning (Bouhnik & Deshen, 2014). Technology is said to have the ability to tap into multiple minds around the world and collaboration across time and space (Calder, Larkin & Sinclair, 2018; Manathunga & Hernández-Leo, 2015). Teachers may feel the need to demonstrate their accountability to students, parents, and administrators and may often feel disoriented when they encounter conflicts between their own beliefs (Chapman & Heater, 2010; Chen, 2008). This brought an understanding that the issue around ICT was not only oriented to technology but also toward attitude among trained support groups to aid in pedagogy (Badshah et al., 2021; Kamei, 2016). Teachers' innovation, in this case, could be a new idea, such as a new approach of teaching technological innovation using ICT, allowing innovations (Kearney, Burden & Schuck, 2018) or maybe posing challenging tasks (Ingram et al., 2019).

Discussions between learners and teachers involved knowledge creation, which included the monitoring of tacit (knowledge with personal quality, which makes it hard to formalize and communicate) and explicit knowledge (knowledge that can be codified and transmittable in formal and systematic language) (Sternberg, 2012). Engagement (Kearsley & Shneiderman, 1998) is said to encourage human interaction in the context of group activities not individual interaction with an instructional program. Learning designed for the 'Third Space' extension widened the room for extra understanding. The term 'Third Space' is used by some scholars in a geographical sense to refer to the 'out-of-school' learning which occurs in a social context (Burden, Kearney, Schuck & Burke 2019; Looi, 2010). The 'First Space' has been interpreted as a place or institution where formal learning occurs, the 'Second Space' is a site where informal learning takes place, while the 'Third Space' lies somewhere 'in-between' where creativity takes place. 'Third Space' is a "metaphor for imagining learning across these diverse contexts" (Schuck et al., 2017, p. 122), an emergent shared space, socially negotiated for providing an opportunity to develop contemporary learning skills and knowledge. In short, this was a space that extended beyond traditional, often incidental, and sometimes free from teachers and prescribed curricula. In Odeyemi's study, the teacher-learner relationship was identified as the barrier towards learners' mathematics good performance (Odeyemi, 2020).

2.3.2. The ubiquitous methods of learner information discovery

Bereiter and Scardamalia (2014) argued that the relevant educational approach is the one that promotes knowledge building among learners by giving them a chance to be part of this dynamic, living the life of a knowledge society rather than only preparing to live it. Mastering the device was not important but what learners can discover using the tool matters in a long time (Bereiter & Scardamalia, 2014; Hardré, 2011). Learners could make cross-literate connections, move among a variety of texts and experiences (Gerber et al., 2014). These means of getting multi-sourced information and network exchanges supported the development of dynamic knowledge ecologies that embraced modification and discovery of new knowledge (ibid). This diffusion of knowledge according to Looi et al (2010) conveys that

> The learning space is no longer defined by the 'class' but by 'learning' unconstrained by scheduled class hours or specific locations. With the mobile technologies at hand, students can learn seamlessly – both in the classroom and out of the classroom, both in school time and after school time. While learning can be facilitated or scaffolded by teachers or peers, at other times it could be student-initiated, impromptu, and emergent. (Looi et al., 2010, p. 156-157)

Learners felt comfortable and motivated to research, discover, create and fulfill school assignments (Grosseck et al., 2011) while refraining from taking notes (Sanabria, Chavez & Zermeño, 2016). In the US, adoption of technology has been common, hence for them, objectivity rested in the public nature of language, hence concepts and knowledge can change, as social constructions, became publicly negotiated concepts (Bloor, 1983). This was however relative to a particular culture, in a time and a place, to function as objective knowledge, without ascribing to them a transcendental existence (Lerman, 2001). The social divide has long been an issue of concern among developed countries (Dahlman et al., 2016; OECD, 2001). In SA, ubiquity has been delayed since the issue has still been on the usage of emerging technologies whereby poor students were identified using the internet for games or chatting online, while richer teenagers use the internet for learning (Coughlan, 2016). It was then that Brown and Czerniewicz (2010) proposed a concept ‘digitizen’ which acknowledged the full range of digital capabilities (thinking beyond computers) in various structures thus allowing for notions of access as being determined by connectivity and not a location but acknowledging skills based on what learners can achieve. The coursework was given to students and they had to respond by exercises administered through SNSs. The study revealed that the benefit of using WhatsApp far outweigh the risks (Baguma et al., 2019; Callaghan & Bower, 2012).

In the Connectivism theory, “the capacity to know is more critical than what is currently known” (Siemens, 2004, p. 4). Learning in the third space considers learners as self-directed participants with the potential of being members of global communities as initiators (Schuck et al., 2017; Looi et al., 2010) Learners needed to learn to orientate themselves when encountering complex information to take coherent and understandable information. This could be through sense-making and wayfinding, when encountering symbols or environmental cues (Siemens, 2011). Wang et al (2014) developed these cognitive engagements into four levels of interaction by prefixing with operation interaction and suffixing with innovation interaction. Learners ought to learn to follow people in social networks, aggregate information, and filter content (Downes, 2017). These involved understanding of lower-level interaction as the foundation of higher ones while preparing higher-level interaction to be means of engagement in deeper learning with more connections and networking opportunities. This was the revised taxonomy which moved from remembering to understanding, applying, analysing, evaluating, and creating as cognitive processes (Wang et al., 2014).

Interestingly for the US, knowledge was ascribed by looking at meaning and significance, thus assigning our experiential world, hence Lerman’s hypothesis stipulated

> that we are not 'discovering' the way the world works, in the sense that America was there and inhabited and then 'discovered' by Europeans, or whoever., We cannot talk about the way the world, certainly and timelessly, works, simply because we cannot know that what we are describing is just what is (Lerman, 2001, p. 216).

The postulation implied the need to ‘understand’ (Lerman, 2001) learners in proportion to their culture which is achievable through communication. The central core of mathematics research lies in either ‘correct understanding’ or ‘incorrect understanding’ which could be achieved by a particular behaviour of a learner (Lerman, 2001). Further interactions were identified including learner-interface (computerised learning tools; content-content (algorithms and remedial content) and group-content (connective resource sharing’s or working in groups) (Wang et al., 2014).

In SA, when aiming to have quality education, the Department of Education claims from all schools irrespective of the facilities available, the National Planning Commission encouraged technology shifts and innovation that are necessary to solve challenges that are prevailing every day (NPC, 2011). These are intended to be promoted when schools are acknowledged as the building blocks for learning and socialization; therefore, the values that are learned at school

permeate society (NPC, 2011, p. 262). The National Curriculum Statement (NCS) Grade R-12 aims to produce learners that can:

- Identify and solve problems and make decisions using critical and creative thinking;
- Work effectively as individuals and with others as members of a team;
- Communicate effectively using visual, symbolic, and /or language skills in various modes in the environment and the health of others (DBE, 2011, p. 3-4).

The given NCS statements are contested. For instance, Ramorola (2014) indicated that an ICT policy is the one that channels the teacher on integrating ICT usage in the classroom, but this becomes functional when teachers are aware of this policy. She further asserted that this is imperative for effective technology integration to take place to have sufficient numbers of teachers who are expected to be digitally literate to be able to enhance learners' motivation with technology skills. Integrating technology effectively into the curriculum requires planning, time, and dedication (ibid). The South African Department of Education has not emphasized the usage of social networks in public schools due to privacy, safety, and security issues to be considered. Setlalentoa mentioned that it is almost impossible for people residing in rural areas to access and use ICT in education. This was a challenge since people learn well when they are vigorously involved rather than being unreceptive listeners (Setlalentoa, 2012).

2.3.3. Identification and indication of learning demonstrated by learners

In most of the literature reviewed, it was identified that learners were exposed to learning as a process while it was both esoteric and public knowledge which is done collaboratively.

2.3.3.1 Learning as a process

In England and Wales, a sociological analysis of school mathematics was administered where language was used to extract wider practice of school mathematics and its development (Dowling, 1996). Americans on the other side have adopted a model, the National Educational Technology Plan (NETP), of 21st century learning powered by technology which is aimed at five essential areas: learning, assessment, teaching, infrastructure, and productivity (Peters & Araya, 2011). Similarly, in Spain, WhatsApp was used to develop transmedia skills (Costa-Sánchez et al., 2020). The aim was to engage and empower learning experiences using resources. Further to this, the model aimed at asking

> [t]hat we focus on what and how we teach to match what people need to know, how they learn, where and when they will learn, and who needs to learn. It brings state-of-the-art technology into learning to enable, motivate, and inspire all students, regardless of background, languages, or disabilities, to achieve (Atkins et al., 2010, p. vi).

Concerning learning, the developed countries target at using social networks together with wide-scale of mobile adoption and educational applications to transform their classroom into immersive, and personalised learning environment by keeping learners engaged on their tasks (Aerohive-Networks, 2014). This confirms that education as a process relies on a great deal of coordination between learners and resources (Sharples et al., 2017). Learners were more likely to use the internet for learning rather than using it for games (Gerber et al., 2014) and bringing 'internet revolution' (Haßler et al., 2016; Abu-Shanab & Al-Tarawneh, 2013). Gerber et al. (2014) identified the commercial-off-the-shelf (COTS) videogames used out-of-school spaces and tied to learning objectives by creating a connected learning frame that enabled learners to engage in a constellation of connections among digital media, traditional texts, peers, and teachers as guiders. Several teenagers who used online technology at home found using WhatsApp convenient in their everyday lives (Ahad & Lim, 2014). Teenagers in wealthier and well-developed countries are more likely to use social networks for getting information rather than playing or socializing (Bouhnik & Deshen, 2014). In such countries, the report mentions that school plays a much more important role in ensuring that young people have access to information and communication equipment in and out of school (Clark et al., 2020). Most learners who are born as millennials embedded with the latest gadgets are not necessarily better learners with them; hence people who are not digital natives use technology with more of a sense of a purpose (Moje, 2008).

The climax was not about technology and innovation but was about the adoption of that particular technology (Bere & Rambe, 2019). This paved the way for the techno-social development process whereby mobile phones have become more important in everyday experiences and communication practices and where teachers slip, technology is there for 'mediatization' (Couldry & Hepp, 2018; 2013; Knoblauch, 2013). The availability of technology in the didactic encounter expanded the room for this golden 'trilogy' education or triadic encounter (Bandura, 1988). Visual mediators narrating how those symbols could be used performed various repetitive mathematical patterns (Sfard, 2008b, p. 133-134).

Research indicated that there have been ICT programs in place that were designed for teacher development and to capacitate learners like Vodacom digital classes, UNICEF and REACH mobile Apps, Microsoft programs. "ICT access is not necessarily leading to ICT usage" (Kamei, 2016, p. 223). Hence, social networks have become the 'de facto' space for learning, whereby participants initiate the usage of ICT in education (Feshchenko, 2015). One study conducted among 11 high school teenagers from low-income families in the United States brought that social networks enabled learners to understand vital social learning functions (Greenhow et al., 2019). The study showed that change in demands on current and future ICT-related policy has not been much affected by the flexibility of learning, delivery of education, and the pace of learning. ICT has an impact on the way students and teachers construct knowledge. The nature and intensity of ICT usage depended on individuals. General understanding of ICT usage was still limited to communication and presentation tools, not at the level of knowledge building, and sharing tool. Overall, research highlighted the fact that there was a section of learners from rural backgrounds who still needed to be ICT literate. Digital Divide was seen in the rate of diffusion of ICT among peers within institutions. The need was felt for the creation of a conducive learning environment to encourage peer-to-peer influence. The flexibility of institutional policies is required for the integration of ICT use in the curriculum in teaching/learning. Faculties consider that knowledge society in today's context is all the knowledge base that is available at the click of a button. Some feel that the more they have knowledge on social media the more the need for ICT to bring it into the public sphere. Literature indicates that some teachers would like to 'preserve the sanctity of knowledge' by not using ICT. Teachers fear plagiarism, and fear dependency on technology (Kamei, 2016, p. 224).

2.3.3.2 Collaborative learning using as a language

It has been insisted that "without a means of communication, teaching is certainly a wasted and futile effort" (Lerman, 2001, p. 220). This implies that among various geographical scholars there is a need to 'reinvent the wheel'. In the UK. mathematical learning was achieved by attainment from lower levels to higher levels of learners' 'ability' (Dowling, 1996). Learners' logical thinking is attained by a mere understanding of the language (Riccomini et al., 2015). They could use it at a societal level (Chomsky, 1986) wherein their societal language becomes the language of their thinking (Sfard,2020a; Chomsky, 2005). However, also language could determine their higher level of thinking (Sfard, 2008a) and demonstrate their competence

(Mcnally & McNally, 2012; Wittgenstein, 2001; Bloor, 1983) together with 'commognition' (Sfard, 2020b).

In many cases, learners are not given a platform to communicate their thinking (Sfard, 2020b; 2008a) or to express their thinking in the classroom (Sfard, 2019). Kamei argued that teachers are still comfortable with the conventional form, they 'still prefer chalk n board'. This shows that the need for ICT champions is still crucial (Kamei, 2016). Teachers are expected to be resourceful when faced with the under-resourced environment and transform learners' zone of development (Ackermann, 2004). In many cases, time constraints limit digital opportunities (Dahlman et al., 2016). Yet, informal platforms could supplement classroom time (Attard & Holmes, 2020). This implies using any ICT-related tool to construct new teaching aids to conceptualize and concretize content (Ankiewicz, Van Rensburg & Myburgh et al., 2001). This is similar to a shoestring approach where a teacher could explore different ways using 'zero-cost teaching' (ibid). In Australia, these collaboration platforms have been used by learners for revision purposes (Attard & Holmes, 2020) by learners with sophisticated devices (Greenhow & Lewin, 2016). This was also applicable when there are no sophisticated technological devices where any feasible smart gadget could be used (Kearney et al., 2018; Verenikina, 2008). Learners need to be taught at an early age to be knowledge creators and problem solvers by adding value to others (Duval, 2006).

Lim and Chai revealed ICT as a tool in the process of education in the following ways. Firstly, as an informative tool: it provided vast amount of data in various formats such as audio, video, and documents. Secondly, as a situating tool: it created situations that learners experience in real life, simulated and virtual reality. Thirdly, as a constructive toll: to manipulate the data and generic analysis. Lastly, as a communicative tool: it could be used to restore communication barriers such as that of space and time (Lim & Chai, 2004). ICT has the potential to boost the education sector of the country by providing cost-effective, quality education by overcoming human resources time and distance barriers. It enabled sharing of best practices in related fields which could enhance pedagogy. In developing countries like SA, education became an important bridge of social economic and political mobility (UNESCO, 2013). ICT gave access to the latest knowledge and information (Kymäläinen et al., 2014; Plomp et al., 2007).

Information Technology (IT) was originally a technology of storing and retrieving knowledge of data on computers, where communicative technology (CT) was a technology of a process (or transmission) by which A sends a message (data) to B (Kamei, 2016, p. 5). Other scholars

defined ICT as tools, facilities processes, and equipment that provide the required environment with the physical infrastructure and the services for the generation transmission processing storing, and disseminating of information in all forms including voice, text, data, graphics, and video (Cigognini, 2006; Pettenati & Cigognini, 2007).

Schuck et al. (2017) argued that education happens in a third space which accommodated the extension of 21st century learning. This emphasised the need for a shift since education was at risk of becoming irrelevant with traditional modes of teaching and learning (Harasim, 2012). They enforced the potential of mobile learning which could appear in a malleable nature of space and time, in a digitally connected world. They acknowledged that the third space can be both productive and constraining.

Using the Mobile Pedagogy Framework, educators can think about how to design learning across the increasingly blurred, shifting temporal and spatial boundaries. This was education designed in a 'contested space' (Bhabha, 1994) which demands extra leadership qualities to manage tensions.

Moreover, this facilitated effective language to describe new ways of learning. Teachers and learners were enabled with new ways of teaching and learning which were not previously available. To design learning in the Third Space, educators needed to anticipate and facilitate seamless 'boundary-crossing' across learning spaces (Burden et al., 2019; Kearney et al., 2018). This could be one strategy against minimal guidance (Kirschner, Sweller & Clark et al., 2006) and disengagement (Hlalele, 2018).

The classroom was a fixed setting that was highly managed by the teacher. The introduction of mobile devices for learning paved way for informal learning which is controlled by a learner in a seamless setting (Looi et al., 2010). This seamless learning aims at supporting continuity of learning across contexts and devices which involves a variety of personal, institutional, and public technologies (Scardamalia et al., 2012; Pegrum et al., 2013). This understanding was a continuation of what Kukulska-Hulme (2009) proposed, where the proposal was based on four key principles for future research which should be in tune with new thinking about learning, consider the impact of context, consider different types of data and analysis. The research suggested the involvement of learners as co-designers or co-researchers (Kukulska-Hulme, 2009). The factors that influenced the success of mobile learning included the availability of technology, institutional support, connectivity, and integration into everyday lives. The

spreading of learning and interleaved with other activities demanded intense monitoring which involved ethical issues since learning happened outside the classroom (Sharples et al., 2014).

Teachers needed to evaluate most aspects of mobile learning weighing it philosophically and practically. UNESCO submission was made where emphasis on learners was made since they also needed to be present in educational forums where discussions about the sustainability of mobile learning were discussed (Traxler & Kukulska-Hume, 2005). Learners used portable devices which have a record of having qualities as conduits to 'learning on the move' (Sharples et al., 2017; Matthee & Liebenberg, 2007). Understanding the strategies used by teachers and learners in different countries indicated the gaps of the study and indicated the importance of theoretical perspectives to be considered for this study. This review indicated that social network tools can shift the control to the learner, through promoting learner agency, autonomy, and engagement in social networks (McLoughlin & Lee, 2010). On a similar note, learners need to be taught about handling themselves in discussions using social media since reaching out can be easier and daunting yet irrevocable (Oliver, 2017).

2.4 THE THEORETICAL PERSPECTIVES

The theoretical perspective became a substantial base for the generation of the research question in this study and not a single theory (Lesh et al., 2008, p. 137). The function of theory in this study was to inform the rest of the design, enabling the researcher to assess goals as realistic formulating research questions and methods thus identifying potential threats to research conclusion (Maxwell, 2012). Moreover, the basic components of a theory are the concepts, thus a theory is a set of statements that each expresses a relationship between concepts (Creswell, 2013). About these definitions, this study was viewed through the lens of educational theories: connectivism, cognitivism, social constructivism, and constructionism. Among three broad epistemologies, objectivism, pragmatism, and interpretivism (Kop & Hill, 2008). Interpretivism (considers knowledge as an internal construction and is informed through socialisation and cultural cues) is aligned to constructivism. Downes (2020) supported by Siemens (2008) came with the fourth framework which was distributed knowledge (which viewed knowledge as composed of connections and network entities) and is aligned to connectivism theory. Even though most scholars presented the three distinct perspectives of the learning process, this study did not adopt behaviourism as important for this research. Instead, it claims the fourth framework inclusion (guided by mnemonic aspects where learning

is reconstruction rather than as a transmission of knowledge) which is aligned to constructionism. Behaviourism was not appropriate because it focused on the importance of performances and contends that responses in communication are followed by reinforcement and are more likely to recur in the future (AlDahdouh et al., 2015). A learner is characterised as being reactive to conditions in the environment as opposed to taking an active role in discovering the environment. Since the study adopted connectivism, what was learned through WhatsApp brought the shifting of reality and what might be right during that day might be wrong the following day due to various alternations (Siemens, 2004).

2.4.1 Social Constructivism

Vygotsky (1978) came with socio-cultural learning which emphasized the role of social and cultural interactions during the learning process. In his view, knowledge is co-constructed and learners learn from their teacher and one another as they attain maturity (Vygotsky, 1998). In this theory, scientific knowledge has a limited or non-existence role. Socialization is the main strength. Knowledge is constructed by socially-negotiated meanings in a social community, allowing learners to discuss, using safe norms of negotiation (Dowling, 2010; 1996). The sociocultural theory was used due to its life-long learning approach and suggests that "an advantage of informal learning is that activities are generally not mapped to the formal learning process" (Divjak et al., 2004, p. 11). In this regard, informal mathematics situations are crafted by mutually reinforcing societal activities" (Roth & Walshaw, 2015, p. 228). Further to these discussions, decisive thinking, which involved crafting learners' cognitive development (ibid, p. 308). Participants are guided for proper ethical issues (Giles, 2017) using proper 'language of description' (Sfard, 2020a; Fernyhough, 2008; Dowling, 1996; Lerman, 2001). The text comprises of textual strategies which position voices (positioning strategies) and which distribute messages to the respective voices (distributing strategies) (Dowling, 1996, p. 396). In this regard, the text becomes a cultural product which is understood to be producing and reproducing a social structure, as an 'activity' using language as a 'code' as the esoteric domain mathematics reflects the knower (ibid, p. 393). Vygotsky under the influence of Karl Max reflects on the importance of language, social interaction, human's vital role to react to the environment and at times alter it for his/her gain (Ernest, 2006; Tudge & Scrimsher, 2003). Further to this, interpersonal (social), cultural-historical, and individual factors were stressed as the enablers to human development (Tudge & Scrimsher, 2003). Linguistic competence, generative grammar, phrase structure rules, the difference between deep, surface, and universal

grammar characterize the language used in social constructivism (Chomsky, 2005, p. 1986). Teachers' actions, words, and symbols were 'taken up by learners (Walshaw, 2017). The quality of the research relies on the achieved intention of the realistic conversations and conversation analysis of the participants (Planas, 2021; Sfard, 2020a; Toerien, 2014; Greeff, 2011) after selecting a good modality (Bower, 2008).

The literature presented teachers' interactions with learners in the school environments identified as part of a collaboration that could enhance developmental processes together with cognitive growth (Durgungoz & Durgungoz, 2021; Murawski & Scott, 2020). This resonates with what Foucault indicated concerning power dynamics when clarifying 'knowledge' since it could be linked to 'man' as "a revealed space proper to the human sciences" (Foucault, 1966, p. 29). In this regard, there could be locally produced and situated dialogic relations which could lead to reconceptualizing and expropriating concepts due to relaxed and informal spaces of interaction (Barwell, 2016; Moore, 1989; Bakhtin, 1981).

However, there were negotiation potentials (Eun, 2019) between teacher-learner autonomies and boundaries (Muzurura et al., 2021). Also, it was imperative to note that interactions were not useful in a traditional sense wherein learners were just provided with content, but the importance is on learners' transformation of their knowledge, experiences, and ability to re-organise their mental growth (Schunk, 2012). The dyadic element enabled dialectical constructivism and mediation is the key towards development and learning (Cai et al., 2018). Nevertheless, parental involvement plays an important role (Cheng & Chen, 2018) and teachers reframe their beliefs (Chen, 2008).

Tools of learning involved socio-cognitive conflicts and de-legitimization of the mathematical construct (Ernest, 2006). The teacher monitors the Zone of Proximal Development (ZPD) of a learner. ZPD is the "distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Another tool of learning was all human psychological processes (higher mental processes) are mediated by such psychological tools as language, signs, and symbols. Teachers guide learners towards joint (collaborative) activity. Only after learners have internalized these tools do teachers use them as mediators of learners' advanced psychological processes. In this theory, the teacher as an expert, instructed learners, based on what she or he believed in. In this regard, the beliefs become the convictions for explaining their knowledge, intelligence and

experience and were therefore manifested implicitly and explicitly in their attitudes and practices (Klinger, 2009). Good pedagogy empowers learners to take control of their own learning experiences, aiming at liberation, not domination (Freire, 2012). Learners communicate with each other and share their understanding, feelings, knowledge, and experiences to come up with knowledge. Horn, insisted that positive relationships motivate learners to persist even in the face of trouble or uncertainty (Horn, 2012). Further, good teaching sometimes does not focus on what the teacher does, like motivating students and presenting ideas clearly, but on the interactions among tasks, relationships, classroom discourse, learners' activity, and content that constitute on supporting learners' mathematical understanding a learning environment (Horn, 2012). Moral commitment is another epistemic stance, where learning about teaching differs from learning mathematics for instance engagement and hope for the best in it. This is clarified by the Chinese Proverb that "it takes a village to raise a child". To implement social constructivism theory, the following model in Figure 2.3 was used.

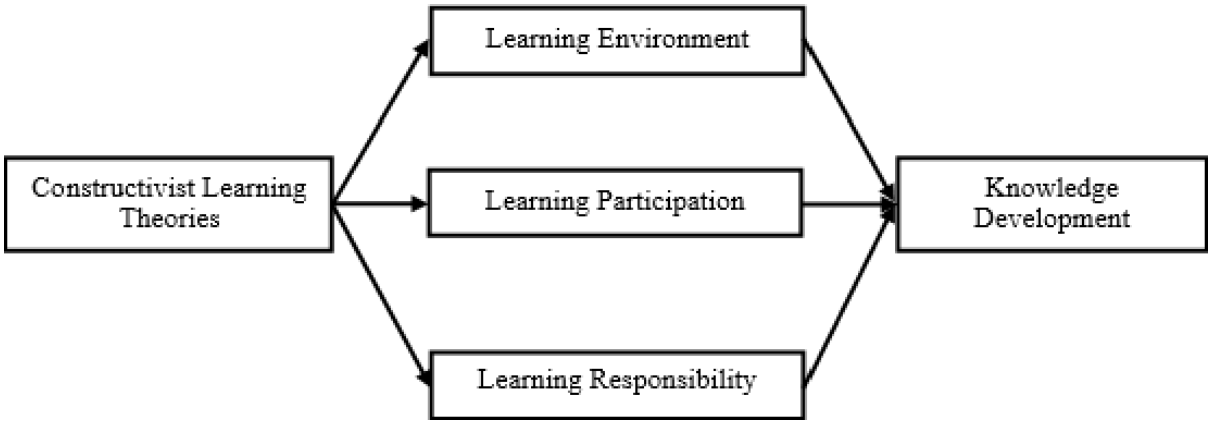


Figure 2.3 Social constructivist theory (Vygotsky, 1978)

The model of social constructivism implied that the knowledgeable person (teacher) uses some skills (constructivist learning theories) to guide and encourage learners using the zone of proximal development where a person is guided from what is known to what is not known, thus knowledge is developed. The social constructivist theory (Figure 2.3) indicated the inclusion of technology as a learning environment, hence the focus in this study extended to a social embeddedness approach that has been applied in higher institutions (Bere & Rambe,

2019). In this case, WhatsApp was deployed for learning, wherein socialization due to its immersion was the focus of the study. Therefore, research question 2 "To what extent have learner-teacher online interactions taken place?" was formulated, which was informed by social constructivism and connectivism theories (see Table 3.3).

In this study, social constructivism was adopted since although it acknowledges the role of logic and reason it also accepts that criteria for acceptance vary and change over time (Ernest, 2018). One main strength was teachers' knowledge of the prior mathematical knowledge of learners (Setlalentoa, 2012). It is therefore unique due to its breath as it is inclusive, wide-ranging fallible philosophy (Ernest, 2018; 2006; 1993). Social constructivists identified the teacher stepping aside to a new role as a leader, pairing learners with peers, learning processes, and learners creating their knowledge plus early learning pathways (Kymäläinen et al., 2014). Human psychological development emerges through the unification of interpersonal connection and actions taken within a given socio-cultural environment (that is language, culture, society, and tool use) by using a 'leading activity' (Keiler, 2018). The teacher must understand the role of emerging technologies in education and their impact (Voogt et al., 2018). Teachers enter into dialogue (Fares & Atef, 2018) using contemporary tools and bringing significant changes. Literature indicated the importance of technology for 'personal response' as the key feature in enhancing learners' mathematical skills and enforcing engagement (Simelane-Mnisi & Mji, 2019). During the dialogue, learners learn to articulate their ideas, negotiate and evaluate their contributions in a socially acceptable manner (Setlalentoa, 2012). Human interaction would be demonstrated by social communication and some of the social constructive elements as the elements of social presence.

This theory has been analysed as a 'defense mechanism' used by psychoanalysts (Keiler, 2018). The meaning of constructivism as a learning theory in mathematics differs from intuitivist researchers in the understanding of the concept and the focus was more on the relativist approach (Lerman, 2001). This radical constructivism (Ernest, 2018; 2006; 1993) has been attacked due to it leading to significant consequences but demands a good selection of other theories. However, its adoption of human language creates the platform of losing mathematical meaning (Ernest, 2006).

For this theory to be implemented, teacher, curricular and societal readiness should be aligned (Elkind, 2004). However, this idea was contested because of the assumption among teachers who would like their learners to acquire more knowledge. It was also disputed because of the

denoted objective philosophy (Carson, 2005). Further, the theory has been criticised by objectivists (Cronje, 2006) as not the best theory of education in the South African scenario since the information used is assumed to be independent of the learner, and knowledge is to be imparted by an experienced teacher. Further refute was on two central themes that guided the theory which were logic and reasoning (Jenkins, 2007). This has allowed the objectivists to argue that knowledge is constructed to any degree by a learner. The reality was that the teacher was the one to decided what was important to be taught. In most, South African schools, teachers instruct learners and transmit information to passive learners who do not even participate during the lesson (Cronje, 2006; Jenkins, 2007).

What was attained in this approach was the sociocultural and historical dimensions from learners' ' practical intellect' (Vygotsky, 1978, p. 27) and learners' meaning-making talks from their speech genres (Bakhtin, 1986). Among teachers, was the problem of readiness (Carson, 2005; Elkind, 2004), poor teachers' confidence (Umugiraneza et al., 2016), and ethical issues among rural secondary learners (Kymäläinen et al., 2014). Social presence is felt with the learning environment, participation, and responsibility (Marginson & Dang, 2017; Vygotsky, 1978).

2.4.2 Cognitivism

Bruner's cognitive approach is relevant because of the purpose of education here which was not to impart knowledge but to facilitate learners' thinking and problem-solving skills which could be transferred to a range of situations (Bruner, 1996). In this regard, 'thinking' drives communication (Sfard, 2019; 2008b). The real focus of cognitivism was on learners' ability to transform, rehearse information, store and retrieve information. In this case, learners' thoughts, beliefs, attitudes, and values were the most influential elements of the cognitive learning process (Ertmer & Newby, 2013). The focus was on the mental structures which developed gradually as learning was constructed through organisation and integration of new information and experiences. Bruner proposed the three modes of representations which are enactive representation (action-based), iconic representation (image-based) and symbolic representation (language-based) (Bruner, 1986; 1960). To attain knowledge, procedural and declarative means could be used (Anderson, 2010) in the situated cognition (Boaler, 2009). Discussions became discourses that were special cases of 'arguments' (Duval, 2006). This is informed by a socio-historically specifically defined setting (Wertsch, 1985) and cultural element (Chaiklin,

2003). These could add to knowledge-making with deep or high or low dimensions (Janes, 2013; Churches, 2010; 2007; Mercer & Sams, 2006; Colley et al., 2004; Garrison et al., 2000).

This theory incorporated the shift from a dyadic model of teaching (teacher and learner) to the more triadic method of learning (teacher, learner, and teaching/learning tool). Bruning et al (2004) extended the usefulness of social constructivism by claiming that social interactions facilitate the coordination of the three influences on development. First cognitive change results from using cultural tools in social interactions, second from internalizing and last, mental transformation of these interactions (Bruning et al., 2004). This indicated the link between social constructivism and Bruner's cognitivism. In creating the autonomous learner, Bruner's third mode of representation which is symbolic (a learner from seven years upwards) viewed the kind of memory where information was stored in the form of a code or symbol is an important element of language. These symbols or mathematical symbols need to be prearranged properly by a knowledgeable person and become flexible since they can be manipulated and classified by a learner as an individual.

The language was used as a neutral vehicle for reporting observations and means to report what was in the speaker's mind (Mercer & Sams, 2006). Learning is analysed as a process of input and output. That is why the main purpose of education is not to impart knowledge but to assist learners' thinking with problem-solving skills (Metsämuuronen & Räsänen, 2018). These skills could be transferred to different situations. Specifically, education should also develop symbolic thinking among learners (Gardner, 1983). Gardner, the cognitive psychologist, is noted with the distinct social turn, not originating from Bruner. He introduced the 'theory of multiple intelligence'(Aprayadi & Marfianti, 2013; Gardner, 1983). Multiple intelligence was defined as " the ability to solve problems or to fashion products that are valued in one or more cultural or community settings" (Gardner, 1983, p. 7). This theory was more efficient in this study due to the study's out-of-school nature.

Bruner somehow confirmed this by widening the abilities of the language since it could code stimuli and is free from an individual and able to supply a complex yet flexible cognition (Bruner, 1986; 1973).

WhatsApp was projected to facilitate engagement since literature lifted the ability of technology as the means to enhance engagement since it creates successful collaborative teams (Kearsley & Shneiderman, 1998). It is important to note that for them, engaged learning referred to activities that involve active cognitive processes such as creating, reasoning,

problem-solving and decision making (Kearsley & Shneiderman, 1998, p. 24). Interaction, in this case, can be viewed from learner-content to learner-interface; learner-support, learner-learner, and learner-context (Ally, 2004; Callaghan & Bower, 2012). Research question 4 "To what extent has teaching and learning taken place through social network interaction? was informed by this theory (see Table 3.3).

Bruner came with three views on how to construct learning, which was the role of structure in learning, the spiral curriculum, and discovery learning. The mastering of facts and techniques plays an expedient role in learning. Bruner's second view was the spiral curriculum which pointed to the curriculum as having a direct impact on learning because when it develops its cycling and recycling process revisits the basic ideas repeatedly until the earner grasp that particular knowledge (Bruner, 1960). What was learned earlier and later was presented clearly? In this study, it was foreseen that mathematical equations and symbols could not be written hence this theory was used to explore 'social reality and Bruner's 'sensuous consciousness' (Xu, 2019). Xu viewed 'sensuous consciousness' as the principle of consciousness back to mathematical existence which includes culture, language mind, and society (Xu, 2019, p. 594). In this regard 'spiral curriculum' meant the action when an individual takes steps backward before moving forward (Wang et al., 2014). This refers to acknowledging social life as a historically constructed curriculum that could be used as scientific research due to objects, problems, and methods constructed by human beings (Xu, 2019). This view enabled a learner to look at the picture such that it activates existing schema (old knowledge) as the learner engages in inductive thinking (Sfard, 2008b) and bridging the new knowledge (Perkins, 2013; Bruner, 1996).

All learners enter school with a degree of mathematical intuition, and misconceptions which demand the teacher to discover and correct those intuitions (Bruner, 1960). This could be implemented by allowing the learner to apprehend these misconceptions using his or her discovery journey. In the same vein, teachers must reflect after every step, in short, the insightful approach to their teaching of mathematics, which was "the knowing how" model (Polya, 1966). Polya offered guidelines in the form of four stages: understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 1966). This was discovery learning which was more learner-centered and inquiry-based (Elkind, 2004). This promotes the application of knowledge and fosters critical thinking (Sfard, 2008a, 2008b). In short, this indicated that learning takes place across three domains: the cognitive, social affective, and psychomotor (Li, 2004; Bruner, 1986).

Social cognitive theory complements cognitivism by providing explicit guidelines on how to equip learners and teachers with competencies, self-direction, self-motivation self-regulatory capabilities, and a resilient sense of efficacy that enables them to enhance their psychological well-being and personal accomplishments (Bandura, 2006). This was achieved through mastery modeling, strengthening people's beliefs in their capabilities so they make better use of their talents and enhancing self-motivation through goal systems.

Bruner insisted on the role the language plays in learners' problem solving since it will mark also differences between cognitivism as the theory of learning or theory of instruction (Bruner, 1978; 1963; Lawrence, 1969). In this regard, the theory of instruction is prescriptive and deals with the optimal sequence that is required for learning. It should be constructed around four problems, namely, predispositions (transforming powers), structures (body of knowledge), sequences (what kind of learning is intended), and consequences (output) (Bruner, 1963). Teachers could learn from their practice (Morine-Dershimer, 2006). The 'realistic' element of discourses was refuted by the latest scholars (Duval, 2006). In short, the dispute is on the application of this theory as using traditional classroom techniques (Cowan et al., 1998). Teachers as reflective practitioners are encouraged to develop other skills but classroom numbers usually limit them (Jenkins, 2007). Moreover, the issue of having Bruner's theory prescriptive was a limiting factor to the usage of WhatsApp after hours since learning was going to be informal. In this case, the learning theory, although it was labeled as 'shocking' (Bruner, 1963), would suffice the needs of the study due to its description. Bruner describes learning theory as "a theory that describes what takes place while learning is going on and after learning has taken place" (Bruner, 1963, p. 524). Teacher presence was attained even after hours.

2.4.3 Constructionism

This theory is rooted in practice, and participants obtain meaning from the usage of concepts gained and it is demonstrated through their objectivity in their public nature, while written down it becomes public property (Lerman, 2001). In this case, participants' objectivity does not lie in their being the ultimate truths (Bloor, 1983). Knowledge acquired is subject to dispute, negotiations, and adaptations (Lerman, 2001). This indicated that there has been the cognitive psychology paradigm shift in the United States (US) wherein researchers moved from intuitionist ontologies to the relativist view of mathematical knowledge (Lerman, 2001). The ontology of this theory unfolds the important feature in this study to unpack the origins and historical developments of education (Badshah et al., 2021) and knowing learners' hidden lives

(Nuthall, 2007; 2005). The interest is on the shared social aspect of all psychological matters. Communication skills view relationship versus isolation, and belongingness versus psychological distance were boundaries to evaluate their institutional and transactional presence (Shin, 2002). Social interaction enable participants to demonstrate constructions through language representations (Braun et al, 2017a).

The epistemological understanding of this theory lies on grasping an idiosyncratic meaning of individual as inhabiting, education, culture, and norms (Knoblauch & Wilke, 2016; Peterson, 1966). In this regard boundary objects were viewed as maximizing both autonomies from the social world (classroom) and the communication between them. Literature unpacked that there has been a shift from social constructivism to communicative constructivism which is rooted in the massive empirical research triggered by approaches from Luhmann's systems theory (Luhmann, 1998), Habermas' theory of communicative action (Habermas, 1971), interpersonal conversations (Ernest, 1993) and Cultural-Historical Activity Theory (Kopung, 2016; Amry, 2014). Literature exposed the paradigm shift in education from social constructivism to cognitive psychology then to constructionism. Interestingly, although the developed countries started 'communicative constructions' (Knoblauch & Wilke, 2016), South Africa has started with it in higher education and urban areas (Naidoo & Kopung, 2020; Kopung, 2016; Brijlall & Ndlovu, 2013). Germans claimed to be the originators of communicative theory (Knoblauch, 2013). It is worth noting that in the South African context, learners preferred codeswitching (Adler, 1998; Setati, 1998). To observe learning that became personal with qualities of social interactions (outside the classroom) (Amry, 2014, p. 133), this study used explanatory theory to research teaching effectiveness and to explore teaching and learning (Latour, 1990). This sociological explanatory theory questioned 'how is teaching related to learning?'(ibid). Ausubel (1968) suggested higher levels of abstraction and inclusiveness to identify meaning, verbal, non-verbal, and textual learning. This has the potential of adding aesthetic value to mathematics (Cadler et al, 2018; Downing, 2003). Bishop (1985) acknowledged this as drastic development needed in teaching and learning.

In this regard, the clear difference between Chomsky's and Wittgenstein is narrated in this theory. The problem of thinking and language extends beyond the limits of natural science and becomes the focal problem of historical human psychology (Wittgenstein, 2001; Walkerdine, 1990). In this study, the museum exploration used the RTOP Observational tool as a form of philosophical investigations (Wittgenstein, 2001) which intended to find out whether there has

been trajectory or translation; forms or content; and local or global realities of teaching and learning (Latour, 1990).

In short, mathematics problems should be solved using 'routine learning' (Roth, 2008) which could form the basic skills. 'Routinization' of learners could either be practical (ritual and) or discursive (exploration and product-oriented) (Lavie et al., 2019).

Moreover, transactional communication and presence was the issue of concern. In addition, "how a person learns a particular set of knowledge and skills and the situation in which a person learns, become a fundamental part of what is learned" (Putnam & Borko, 2012, p. 4).

The type of knowledge entailed here includes 'future forming actions' (Slife & Richardson, 2011) using the public as a source of knowledge (Sharples et al., 2016) using technology as any tool (Garcia & Lee, 2020). In this case, research as future forming shifted from forecasting to 'world making' education (Gergen, 2015; Slife & Richardson, 2011).

The teaching and learning according to this theory claim that it is the quality mathematics teachers that hold rich and flexible mathematical knowledge that will offer the quality of mathematics education (Borko & Putnam, 1996). The intention for this involves changing teachers together with learners who ought to have positive belief, creating a conducive environment for teaching, learning, and understanding. In Singapore, much effort has been on developing teachers ' understanding of real issues at the micro-level and macro-level that could have an impact on the situated teacher learning process by presenting contradictions teachers faced and decisions they made (Lee, Seow & Jan, 2020). The central feature of this theory that appeared in Russia was conditional learning, which involved encouraging learners to solve addition and subtraction tasks in a variety of ways especially the ways that would be easier for them (Roth, 2008; 2004). In the US, their belief in creating the right environment in their teaching, learning, and understanding has caused them to re-examine their meaning of knowledge and located objectivity in the social domain, not the transcendental (Lerman, 2001). Mathematical concepts were produced and shared publicly; hence, their meaning, usage and understanding were laid in the public domain (Bloor, 1983).

The way of engaging with the "world focus on the relational practices and the social realities through practice creating, maintaining, and transforming" (Geldenhuys, 2015, p. 6). This could be emphasized by the assertion that 'the ability to solve textbook and test problems does not constitute mathematical knowledge, but to become productive, knowledge must be lived by the learners." (Bereiter & Scardamalia, 2014). Constructionist learning happens as learners

construct mental models to understand the world around them. It is important in the study because of its discourse analysis which had a close relationship with rhetoric and genre analysis (Foucault, 1972). However, it was not the main theory for the study because "social constructions are not solely linguistic, but they are constituted through embodied interactions with the world" (Talja et al., 2005, p. 91). These constructions were supported by Ernest (1993) and the area reflected in the diagram below:

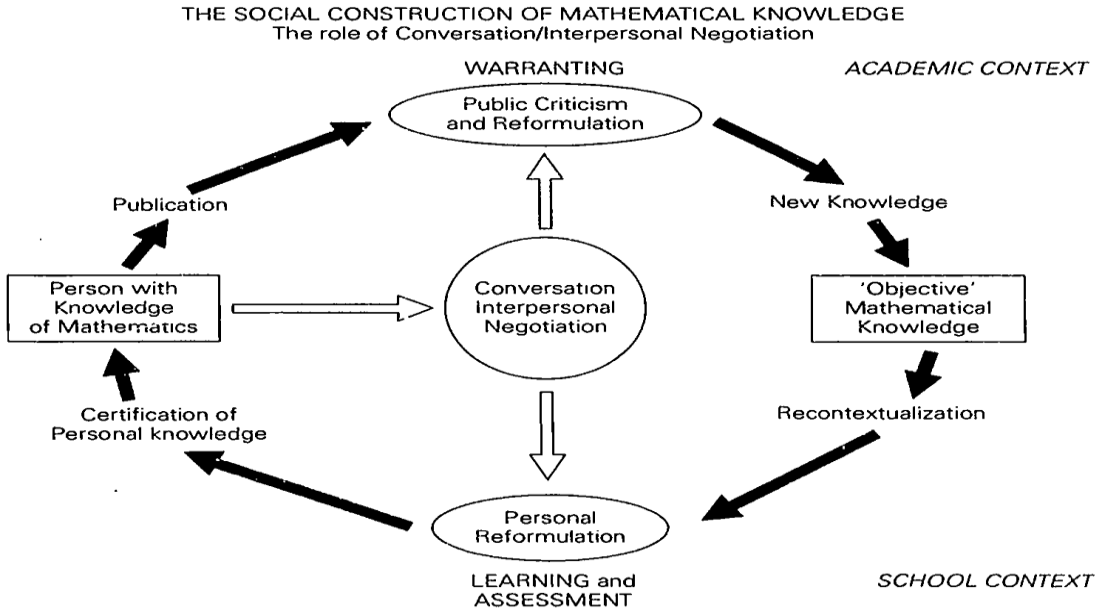


Figure 2.4 The creative/reproductive cycle of mathematics (Ernest, 1993, p. 45)

In the diagram (see Figure 2.4) knowledge is shaped by the use of external support and is essential to expand the human mind. In this case, feelings and ideas become the keys to learning. The subjective construction of mathematics and presentation on how mental constructions over linguistic forms reproduce and re-contextualise new knowledge is portrayed in Figure 2.4. The social construction of mathematics could be interpreted as a text or symbol dialogue with high mathematical features and concepts (Rotman, 1987). This 'warrants' the claims and assessment made for knowledge. 'Publication' involves acknowledging that mathematics is 'human' with the potential to make mistakes and corrections, dialectic mathematical logic, and proofs (Lakatos, 1964). 'Certification' indicated the acceptance of mathematical objectives and personal knowledge. In short, the objective of mathematical knowledge and personal knowledge links academic and school contexts. Learning is happening publicly (Ackermann, 2004). Face-to-face interaction (as a primary zone) together with digital

platforms (as a secondary zone) is used for interactivity of two individual zones (Knoblauch, 2013; Knoblauch & Wilke, 2016; Berger & Luckmann, 1966).

The world could be socially constructed by the social practices of people (Berger & Luckmann, 1966) using a communicative approach which would lead to either knowledge attained as mediation, then mediatization, or finally medialization. Knowledge attained could be from face-to-face (mediation) than primary zones (mediatization) and secondary zone which is characterized by action (medialization) (Knoblauch, 2013). Couldry and Hepp's materialistic constructionism explains how media played a role in learners' lives using socio-technical tools (Couldry & Hepp, 2018; 2013; Bower et al., 2010; Couldry et al., 2009). The two constructionisms were identified as the main pillars of accumulating cultural history.

Scholars have contested that constructionism should not be regarded as a replacement of other theories since it has limited scientific literature with the construction of reality and with power over other paradigms (Geldenhuys, 2015). Further, its usage over social constructivism was opted since an individual mind constructs reality within a systematic relationship to the external world, while social constructivism had a mental process that has been informed by influences received from societal conventions, history, and interaction with significant others (Slife & Richardson, 2011). The supposition of mathematics subjective construction from different people that could lead to the same body of knowledge could be contested. Teachers needed to be creative, with learning built around the individual, engaging and weaving new ideas. This could demand a good socio-cultural background and prior knowledge. Research question 3 "What technological methods prevail in the learner's discovery of mathematics content knowledge?" explored answers from this study (see Table 3.3).

2.4.4 Connectivism

This is classified as a learning theory and a learning paradigm for the digital age in 21st century education. It presented a model of learning that acknowledges the tectonic shifts in society where learning became no longer an internal or individualistic activity (Siemens, 2004) and these methods are the relatively new instructional frameworks that have never been tested in traditional forms (Boitshwarelo, 2011). It is about 'emergent ontology' that implies 'learning to be' (Heick, 2018) reconceptualizing the notion of what is to be learned (Chai & Kong, 2017); the teacher plays a role as a 'network administrator' (Fischer, 1999). AlDahdouh et al. elaborated that

> [i]t does not make sense to consider learning merely as an internal construction of knowledge. Rather, what learners can reach in the external network should be considered as learning. Moreover, the knowledge itself has a structure; it is not something fuzzy or mysterious. It is complex and chaotic, of course, but it has a structure (AlDahdouh et al., 2015, p. 4).

Bell insisted that "connectivism alone is insufficient to inform learning and its support by technology in an internet worked world" (Bell, 2011). Connectivism is informed by "the changing socio-technical context [that] offers a promise of new opportunities, and the sense that somehow things may be different" (Bell, 2010, p. 526). In this regard, minimal or guided learning alone could not suffice due to unsettled communication between teacher and learners (Kirschner et al., 2006). Siemens and Tittenberger's (2009) contestation of the whole environment with participants and tools interacting in a very loose direction is acknowledged.

Connectivism theory has been criticised for lacking sufficient empirical research (Kop & Hill, 2008), lacking rigour, and being unable to be tested (Verhagen, 2006). It is argued that it can be used empirically (Bell, 2009) with a clear understanding of explanation and guidance for proper teaching and learning in the digital age (Foroughi, 2015). In the problematic notion of the 'theory of instruction' or 'learning theory', usage of 'approach' was adopted (Downes, 2020). Limited literature was found about the application of this theory in disadvantaged secondary schools. The challenge was on how the teacher would motivate their learners since gestalt character in this theory (Sánchez Cabrero & Costa Román, 2018) demanded that a learner should have a strong sense of his/her learning and an active role (Rimpiläinen, 2009; Latour, 1999). To keep learners engaged (Kearsley & Shneiderman, 1998), the strength of this approach is that learners know how to use WhatsApp but their learning strategies (cognitive load) and their attitude will be attained prior (Lim, 2004; Clark, 1994; Kozma, 1994). In this study, this theory was addressed by research question 1 "What types of social networks do teachers connect with learners for content sharing" (see Table 3.3).

"The future depends on where WhatsApp takes its product" (Mefolere, 2016, p. 622). In a situated space (Lave & Wenger, 1991), it is indeed alarming to note the quick developments of WhatsApp. It is worth noting that in 2016, WhatsApp did not have live-group talking facilities. This reinstates what Bell stated that "learning is not only a human activity that is escaping from the classroom but also one that is being recognized as happening more in sites such as the workplace and home where it has always taken place" (Bell, 2010, p. 526).

In short, intellectual autonomy demolishes 'the great wall' between science and society (Pels, 2003). Connectivism in this study is viewed as originating from the Actor-Network theory (ANT) (Latour, 1999; 1990) as it considers objects and discourses as actors similar to human beings. Connectedness between humans and non-humans is acknowledged even during social analyses (Rimpiläinen, 2009). For learning space, there is no full debate, but relations matter with the concept ANT used to refer to 'tools'; 'sensibilities' and 'method of analysis' (ibid, p. 4-5).

Teachers have an expedient role in this theory of becoming learners too. All the 'cognitive capabilities' lie with a pattern of the network shifting from processing to recognizing a pattern (AlDahdouh et al., 2015; Kop & Hill, 2008; Siemens, 2008). This would mean a shift in knowledge and pedagogy. In this regard, Siemens (2008) viewed the changing roles for teachers on three domains as follows: 1) Conceptualization – an exploration of theories and ideas whereby there is the questioning of boundaries concerning what currently exists; 2) Experimentation – the research focus and evaluation of different ideas and approaches; and 3) Implementation – understanding gained through experimentation. It is worth noting that Connectivism represented the act of learning as a network formation process at an external, conceptual, and neural level (Siemens, 2008). Connectivism was influenced by emerging technologies and the dynamics of networks, environments, and ecologies that support a continual learning process. Interactions develop to interactivity, with their higher dimensions characterized by co-creation between the sender and receiver as knowledge is verified (Atkinson, 2008).

Connectivism is associated with, and proposes, a perspective similar to Vygotsky's mysterious construct of Zone of proximal development (ZPD). Identification could be traced from the 'leading activity' (Keiler, 2018) with an expression of an inseparable unity of emotional, volitional, and cognitive development (Brown et al., 1989). These theoretical perspectives are viewed from activity (practice), concept (knowledge), and culture (context) for learning.

Communication tools include connectivity, blogging, photo/video-sharing (Boyd & Ellison, 2007), and clustering of similar areas of interest that allowed for interaction, sharing, dialoguing, and thinking together (Siemens, 2004). Networked communication reshaped offline social geography, while online communication reinforces cultural beliefs and activities, personal and popular communication (Boyd & Ellison, 2007).

Siemens (2004) identified the following seven principles of Connectivism:

- Learning and knowledge rest in diversity of opinions.
- Learning is a process of connecting specialised nodes or information sources.
- Learning may reside in non-human appliances.
- Capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is needed to facilitate continual learning
- Ability to see connections between fields, ideas, and concepts is a core skill.
- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of shifting reality. While there is a right answer now, it may be wrong tomorrow due to alternations climate affecting the decision.

The importance of this theory was the fact that these principles address challenges that many individuals face in knowledge management activities that are not addressed by previously mentioned theories. In this case, the knowledge that resides in social networks is connected with the right people in the right context and is called 'learning' (Siemens, 2004). Learning communities nodes started small but end up in larger communities (Goldie, 2016). Networks comprised of two or more nodes that are linked to share resources and vary in terms of size and strength (Downes, 2010). Social networks were seen as a set of actors (nodes) which were connected (Cross, Borgatti & Parke, 2002). This implied that social networks conversation gave birth to participation and interaction between learners, other knowledgeable peers, and the teacher (Goldie, 2016). There are characteristics of successful networks (Downes, 2011) which include diversity, autonomy, openness, and connectivity (Downes, 2020). It was through this network that the 'culture of silence' (Downes, 2012) is broken. Nodes become learning and the grain of everyday practice (Sharples et al., 2014). Interactions occurred in group-contents, group-group, learner-group, and teacher-group (Dron & Anderson, 2007). The 'marginal sense' of commitment to one another and formulated 'altruistic sense' of mathematics contributions formed engagement (Johnston & Taylor, 2018).

Knowledge is gained from experience They use knowledge and have to work with others to manage new or unknown situations, transferred through connecting the nodes (Herlo, 2017; Hung, 2014; Duke et al., 2010; Siemens & Tittenberger, 2009). Social networks are used with the intention of analyzing thus acknowledging one another in everyday life, blending,

perpetuating like-minded and increasing social divisions (Merchant, 2012; Bicen & Cavus, 2010).

For instance, the model begins with its connection, forming, filtering, and selecting; moves with contribution and involvement; participants doing reflection and metacognition; and lastly acquiring basic skills of awareness and receptivity (Pettenati & Cigognini, 2007). Confirmed connectivism as a learning theory has a direct impact on education and teaching as it works as a learning theory matching the standard of the 21st century demands, suitable for "The information age" (Castells, 2000, p. 5). This is due to its 'adaptive learning system' nature (Downes, 2017, p. 48). Connectivism is proper to clarify the description of the ancient 'elephant' story (AlDahdouh et al., 2015). AlDahdouh et al. (2015) just append two summaries to the elephant story: (1) the elephant is not an elephant, it is a jellied creature, which changes its shape much often and (2) the investigators, the teachers, the learners, along with non-human agents are within the knowledge; they are partners, not counterparts (AlDahdouh et al., 2015, p. 15). Therefore, an individual learner is assisted by a dedicated teacher who can 'skillfully woven' 'out-of-school' digital platform (Bourne, 2003, p. 8). Learners become actors (Latour, 1990).

This process of connectivism is clearly articulated in interpreting and understanding the teaching and learning in the current world during technological evolution (Sánchez Cabrero & Costa Román, 2018). Each learners' engagement is determined by individual cognitive, affective, and motivational strategies (Heflin, Shewmaker & Nguyen et al., 2017; Lim, 2004; Kearsley & Shneiderman, 1998) which could be a challenge if prior social constructiveness was not well established.

Criticism to this approach was considered properly; for instance, the issue of a learner who is mobile (on the move), or technology (Sharples et al., 2017); limited literature on ANT in schools (Sánchez Cabrero & Costa Román, 2018); understanding learning patterns and collaboration (Wright & Parchoma, 2011).

2.4.5 Summary of basic assumptions about theories as learning theories

Table 2.1 Summary of basic assumptions about theories

Theory	The basic assumption about theories
1. Social constructivist	Knowledge is not abstract but is linked to the context under study and the experiences that the participants bring to the context. Learning cannot be identified independently of content and context also knowledge domains cannot be separated.
2. Cognitivism	Focuses on the conceptualization of learners' learning processes and address the issues of how information is received, prepared, stored, and retrieved by the mind. Learning is a mental process. Learning is not concerned so much with what learners do but with what they know and how they come to acquire it.
3. Constructionism	Learners construct mental models to understand the world around them. Learning cannot happen without language since it enables us to study how social realities are formed, sustained and transformed through dialogue.
4. Connectivism	Knowledge is to be stored in human heads but through networking, with people using technology it can be stored, accessed, and retrieved to motivate others. Knowledge does not reside in a person's head, but rather could be distributed throughout networks.

2.5 RESEARCH GAPS IDENTIFIED IN THE LITERATURE

The issue of cost behind the internet was interesting when comparing developed and developing countries. It was interesting to find out whether participants would afford to use WhatsApp in this study.

The novelty of this study was achieved in that most of the studies used to integrate behaviourism, cognitivism, and social constructivism (Boitshwarelo, 2011; Klinger, 2010; Klinger, 2009). The previous theories could not imbibe technology (Shrivasta, 2018). This framed the potential strength of integrating an already established theoretical construct,

constructionism. The genuineness of adding constructionism was the distinction and transition of what is happening in most rural schools which were using 'instructionism', the banking method (Freire, 2012). The need for 21st century teaching and learning approaches was expedient. This thesis established the extent to which the use of WhatsApp can be perceived as a potential by both teachers and learners to promote meaningful teaching and learning knowledge and participation while narrowing the gap of resources and high failure rate in mathematics in rural secondary schools.

A literature review has been used to explore how the connectivism framework can be applied in the South African context of education. The literature reviewed indicated an urgent call for a collaborative engagement among citizens, business, government, and academic institutions to facilitate mathematics practice after school hours (Johnston & Taylor, 2018). What is identified is that the continuum of social arrangements and teachers' influence on the pedagogical problem space has some significance in scholarly results. Some teachers view fundamental elements of their work as teaching, monitoring students, and facilitating content yet others do not. Literature signposted that there has been a vast need to close the gap between theoretical and practical knowledge of teaching amongst teachers, overcome rurality and teachers as agents in the field of mathematics teaching, by completing and overhaul the education system under apartheid and embark on radical educational transformation. This could be narrated by looking at the theories that have been attempted in the construction of the connectivism theoretical framework about other learning theories.

First, sociocultural theory

It was comprehended that there must be a guide on how learners learn (Nuthall, 1999) and have interpersonal conversations (Ernest, 1993). There is a framework for selecting teaching and learning affordances (Bower, 2008). This could rely on the basic intervention of the teacher (Foulger et al., 2017) by incorporating technology in teaching and learning (Slykhuis, Foulger, Graziano & Schmidt-Crawford, 2019). Social constructivism has been used with connectivism (Sánchez Cabrero & Costa Román, 2018; Heick, 2018; Herlo, 2017; Goldie, 2016; Duke et al., 2010; Klinger, 2010; 2009). The shortfall for the incorporation of social constructivism alone was based on its instructivism nature.

Second, cognitivism theory

Sfard's theoretical argument of having new technology affording unprecedented insight in human cognition was the main stance of this argument (Sfard, 2020b; 2008a). However, "the extent to which outcomes are achieved in SNSs ultimately depends on the way the SNS learning activities are implemented by the teacher" (Callaghan & Bower, 2012, p. 16). Hence, some scholars have incorporated cognitivism with connectivism (Hung, 2014; Klinger, 2011; 2010; 2009). The shortfall of this framework relates to its attraction on the maths-adverse and maths-anxious learners (Klinger, 2009).

Third, Constructionism theory

Bower et al. (2010) proposed a framework of Web2.0 learning designs wherein for a tool used, it aligns to learning outcomes, knowledge and cognitive process, type of pedagogy, and synchronicity is considered. In South Africa, the internalization of new knowledge and skills has been dimly perceived instant messaging (WIM), was proposed to be more valuable (Kopung, 2016; Amry, 2014). This could not directly articulate the rural secondary school's problems. The presentation of sociological exploratory tools (Latour, 1990). They all indicated the gap, Latour, not initially intended for a classroom setting, even examples made relate more to work situation (Latour, 1999). Nuthall only focused on the learners, forgetting the role of the teacher (Nuthall, 2007). Ernest was more logical and theoretical and perhaps could be more suitable for the more sophisticated environments where 'act ants' are used for social construction experience (Ernest, 2006). The gap of having the tool that speaks to novice and poor-resourced 'act ants' could not be closed. It became expedient to have teachers craft learning design, considering types of learners and content to be applied.

Connectivism and other learning theories

Origins of connectivism with its neutral networks (Hung, 2014; Siemens, 2008) has a limited and meaningless understanding of the under-resourced environment. That is why it will work effectively with solid-based social constructivism, with teachers who know what they are called for and intended to make their legacy in these paradigmatic revolutions and pedagogic shifts. ANT was initially considered by Latour, Callon, and Law between 1978 and 1982 (Latour, 1999; Law, 2007), which was fused with connectivism (Bell, 2010). This calls for a wider

understanding of socio-technical relationships. was used to clarify the learning process. The interesting question of what is special about ANT? (Hanseth & Berg, 2004) was important. In support of Hanseth and Berg (2004) the novelty of this study is on using this approach as a social theory of technology to elaborate on its uniqueness in the context of secondary rural schools. Technology will be available to people who know how to use it. In the South African context, this will bore good fruit since the country is in the transition of accommodating long overdue 'dual-medium' policies in schools (Department of Basic Education & Republic of South Africa, 1997, p. 2). ANT is anticipated to bear more concepts that will be contextually understood (AlDahdouh, 2018; 2015; Bell, 2010; 2009; Rimpiläinen, 2009; Law, 2007; Latour, 1999).

In a South African context, limited studies on using WhatsApp in schools have been confirmed (Mefolere, 2016); hence, this review encountered studies on WhatsApp used on Community of Practice (CoP) (Basitere, Mogashana & Ndeto, 2019; Armellini & De Stefani, 2016) all in higher institutions. In this study, the gap was to bridge the understanding of this theory/approach and explain how learning occurred. This could be even challenging based on the 'agnosticism' view where no point of view is privileged or any interpretations, and connections are becoming a diversity of opinions (Figueiredo, 2008). The question would be, how would networks not be a space for infrastructure, but the space for transformation?

2.6 CONCLUSION

The chapter provided pertinent issues on (1) literature review which indicated that very little was known about the conditions and consequences of using social network in learning at school level in rural areas of South Africa; (2) integrating social networks to learning involved the readiness of both learners and teachers on how to construct their knowledge through connectivism; (3) connectivism was very diverse; thus, all its conceptual meaning was important to understand the learning process. The discussion was laid to determine the truth and logically explain the researcher's thoughts. Chapter 3 covers the research methodology employed in this study.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the study philosophy, the research methods and design employed to explore how social networks could be integrated into the teaching and learning of mathematics in rural secondary schools. It begins by indicating how the research paradigm was chosen and the utilization of the qualitative research approach. It then moves to the research design which paints the picture of how data were collected following the applicable ethical considerations.

Studying the new technology provided the platform for new theory, which could shape teachers' and learners' worlds of understanding. The function of theory in this study was to inform the rest of the design, enabling the researcher to assess goals as realistic formulating research questions and methods thus identifying potential validity threats to research conclusion. The procedure of how data were analysed was stipulated with measures to ensure the trustworthiness of the study. The study was underpinned by a professional code of ethics formulated to check the limits of freedom in research and to define the rights of participants. The main research question of this study was: "What are the users' perceptions of mathematics pedagogy on social networking platforms?" The study was driven by the following sub-questions:

1. What types of social networks do teachers connect with learners to share mathematical content?
2. To what extent have learner-teacher interactions taken place?
3. What technological methods prevail in the learners' discovery of mathematics content knowledge?
4. To what extent has teaching and learning taken place through social network interaction?

3.1.1 Study philosophy

The philosophy of this study was informed by Lakato's proofs and refutations (Lakatos, 1964), Bishop's streamlined intuitionism 'constructivism' (Bishop, 1985), and knowing the researcher's role as a teacher in a 'networked world' (Siemens, 2004). Philosophy refers to a

system of beliefs and assumptions about the development of knowledge that is "contextual" (Braun et al., 2017c, p. 243).

The study philosophy intended to understand the experiences of the participants while consciously being aware of the researcher's competencies, attitudes and values brought into a research project (Bell, 2010). Equally important was the researcher's presence and position in the lives of participants, which were fundamental to the methodology of the study (Ernest, 2018; Marshall & Rossman, 2016; Walshaw, 2017; Harasim, 2012). This results from the notion that successful educational reforms need to be built upon human philosophy that clarifies aims and objectives of research (Elkind, 2004). Given these, the researcher's subjectivity and reflexivity were valued, and the language was often treated as a productive force, rather than a neutral medium for communication (Braun et al., 2017c). Furthermore, the reflexivity sharpen the researcher's subsequent research practices together with an appropriate instrumental approach when harvesting knowledge and to follow the correct research protocol (May & Perry, 2014).

The researcher's passion for teaching and learning through social networks is worth to noting. Firstly, the researcher had the growing desire for mathematics after studying Statistics, a modular course-based Associate in Management (AIM); the Advanced Certificate in Education (ACE) (Mathematical Literacy) and Euclidean Geometry by attending summer school at Oxford University. It was through the use of social networking sites that the researcher performed well in studies.

My twenty-nine years career as a teacher, teaching mathematics for ten years at primary school enabled me to identify language as the persistent problem in mathematics. My understanding of connectivism theoretical framework is embedded on Euclidean two points in the plane with a unique line passing through distinct points. When two planes meet; an intersection line appears. Interestingly, in the same coordinate points in a graph on the Cartesian plane the intersection line continues in both x and y directions. Therefore, out of logic, the axiom of infinity prevails which is not logic. It becomes possible to extend points either with a straight line or circle but maintaining a radius. Interestingly there is congruency at a right angle.

However, my current position at Higher Education equipped me to identify the constructivism paradigm value of the connectivist approach and its implication on emphasizing the value of the connectivist statements. I comprehended that connectivism is applicable to interpret processes related to learning and knowledge in the current world, particularly regarding the

technological evolution of social networks and e-learning as a whole. I recognized that principles of connectivism cannot explain every kind of learning and knowledge as some gaps could be found in its principles. However, when it is used with other theories, a solution is found. These gaps are covered by previous theories "supplemented" by connectivism to adapt them to the digital technological world. In terms of what has been alluded to, my assumptions are based on identifying connectivism theoretical framework to be employed in finding the solution to the stated research problem. It is, therefore, crucial to understand the various philosophical worldviews that researchers employ to conduct and shape their research studies. In this regard, this study reviewed the theoretical basis based on the birth of connectivism as a new paradigm among secondary learners in rural schools.

The next section deals with the research methodology employed in this study.

3.2 RESEARCH METHODOLOGY

Hesse-Biber (2017:7) referred to research methodology as "a strategy or plan for how a study will be executed". This was the crossing bridge for the study's philosophical standpoint (ontology and epistemology) and method (perspective tool). Accordingly, the paradigmatic view on the social world, plan, and rationale determined the qualitative approach of the study (Maxwell, 2012; Mertens, 2014; Schurink, Fouché & De Vos, 2011).

The paradigmatic perspective

In qualitative research, quality is enhanced by using various strategies when dealing with social life practicality and effectiveness, whereas in quantitative research validity could be reached due to causal conclusions and statistical procedures (Maree, 2016; Nieuwenhuis, 2016). The research paradigm was informed by epistemology and ontology which fed my rationale and aim of the study, the process of the inquiry, data collection tools, analysis, and presentation of findings (Braun & Clarke, 2019; Braun et al., 2017a). The thesis discussion included what I did when embarking on research and developing knowledge of integrating social networks in the teaching and learning of mathematics in rural secondary schools (Ernest, 2018). My study's set of beliefs or metaphysics formed a paradigm that unfolds as the main background theories of connectivism and the identified learning theories. The objective is to explore whether this new educational paradigm is an evolution from identified rural secondary schools or a

revolutionary theory in the educational field. The metaphysical approaches (refer 2.4) undergirding the conventional paradigm is interrogated using suitable data collection tools.

Ontology adopted in this study

The social reality was constructed through participants as social actors in meaning-making activities and keeping abreast with the current situation (Hesse-Biber, 2017). This was a method of discovery, interpretation with intention of making what has been learned becoming visible (Denzin & Lincoln, 2013). Philosophy underpinning of this qualitative research was connectivism theoretical framework wherein interpretivist approach drove the study as knowledge about reality was gained through language, consciousness, and shared meaning (McQuarrie et al., 1990). Researchers' creativity, understanding of the nature of a problem, and accommodating flexibility because the philosophy of interpretation pursued in search for truth created a deeper understanding of 'innovation' (Braun et al., 2017b, p. 243). History of participants' human; cultural and practical experiences had value (Lerman, 2001). However, the field was multi-disciplinary involving mathematics and science, and technology.

Firstly, the objectives of the research questions (see Chapter 1 paragraph 3), indicated that 'this study intended to explore the integration of social networks as an attempt to facilitate teaching and learning of mathematics in rural secondary schools. I explored the relationship between the underachievement of learners in mathematics and the usage of social networks (ontology). Reality did not come from one source. Considering that many factors were considered when addressing the usage of social networks in rural areas like poverty, poor network connections, shortage, unavailability of computers, poor internet reception, and lack of training in as far as how to integrate social networks in education. My stance was built from the existing gaps identified in the literature (refer to section 2.5) and the objective of this study was to illuminate research on social, cultural, and educational issues about the usage of social networks in uMkhanyakude rural secondary schools. The truth was told by participants. Mobile phones subscriptions among the rural communities surprisingly, do not match the prevalence of poverty levels of South Africans (Aker & Mbiti, 2010).

Secondly, I looked at participants from their biographical point of being in the rural area and interpreted the findings from their context (epistemology). Participants were considered with their historical traditions by adopting the distinct point of view guided by politics and research ethics (Denzin & Lincoln, 2005). The social reality was known but subjective, thus the main

goal was to understand the intersubjective nature of reality (Braun, Clarke & Hayfield, 2019; Hesse-Biber, 2017; Clarke et al., 2017).

Thirdly, the qualitative research method was to observe the sample and draw conclusions from the empirical reflection using inductive reasoning (methodology). The nature and scope of knowledge and justified belief were analyzed considering skepticism derived from the knowledge claimed. The researcher's attributes for coding were extensively used which included being organised, persevering, dealing with ambiguity, flexibility, creativity, rigorous ethical character, and ability to use extensive vocabulary when searching for themes (Braun & Clarke, 2019; Marshall & Rossman, 2016).

Fourthly, tools that were used to collect data from participants' lived reality captured "how they construct their worlds, and what meaning they attribute to their experiences" (Merriam & Tisdell, 2016, p. 6). Subjective meanings were interviews; focus group discussions, documents, and observation as non-participant and online discussions. Data were collected to answer the research questions. Understanding the nature of rural teaching and learning is not similar all over the world which demands extensive support intended to prepare teachers to serve rural populations (Barley, 2009). Lastly, was the identification of data and analytic methods suitable for harvesting findings. Data interpretation was governed by research paradigm (Lesh et al., 2008), collaborative teaching and learning (Dillenbourg, 1999), engagement out-of-school context (Mupezeni & Kriek, 2018), and conversations (Toerien, 2014) to understand the phenomenon. The study's novelty was on the gaps identified and the new theoretical framework approach. The study transcended existing notions about using social networks for just personal use and communication, by exploring their perceptions as they were communicating in their relaxed mode out-of-school.

Epistemological assumptions of this study

The linkages between the philosophical assumption and research collected were viewed about a paradigm as an approach to the theoretical framework, research problem selected (philosophical level) and identifying specific methods used, data analysis and guidelines interpretation of research findings (research design level) (Hesse-Biber, 2017; Marshall & Rossman, 2016). The purpose of science became the process of transforming things believed or hearsay into things known, that was "doxa" to "episteme" (Worley, 2017, p. 111). I maintained the research objectives by bracketing values or attitudes towards a given topic and

could not intervene in empirical processes (Sánchez Cabrero & Costa Román, 2018; Hesse-Biber, 2017). The social reality was understood from interactions, actions, and objects. The critical approach focuses on the ongoing construction (Hesse-Biber, 2017), conversations (Toerien, 2014) and the language used (Lavie et al., 2019; Chomsky, 2005; Lerman, 2001; Bloor, 1983). Given the description of my paradigmatic assumption, my assessment of the study verified knowledge, assumptions, and paradigm best fitted to the methodological preference. Thus, this study was situated in the interpretivist research paradigm based on outcomes. Issues of conducting good research and basing research on literature gap were adhered to (Braun & Clarke, 2019; Fox, 2017; Giles, 2017; Clarke et al., 2017; Merriam & Tisdell, 2016; Toerien, 2014 Maxwell, 2012; Merriam, 2009).

3.2.1. Qualitative Research Methodology

The Qualitative Research Methodology referred to "research that elicits participant accounts of meaning, experience or perception" (Fouche & Delport, 2011, p. 65). I acknowledged the challenges and contestations, thus appropriateness from the start to the end was a demand (Fox, 2017; Giles, 2017; Marshall & Rossman, 2016; Mertens, 2014). Thus, this methodology was selected based on its affordance to gather data by using questions (refer chapter 1,1.4) to probe for a deeper understanding of the phenomenon, with no predictions or expected results (McMillan & Schumacher, 2014). Qualitative research was identified for the situated activity that located me in the practical world of participants, with a set of interpretive, material practices that made the world visible (Denzin & Lincoln, 2013). Interestingly, qualitative research was a 'do-it-yourself' process unlike the 'off-the-shelf' process from quantitative research (Kumar, 2014, p. 132). Flexibility, idiographic, unstructured approach, and holistic in all aspects of the research process made the journey exciting since data were collected at the site where the phenomenon (WhatsApp as a teaching and learning, teachers, learners, and policy) prevailed (Lesh et al., 2008). The qualitative research approach was my artistic endeavor (Schunk, 2012) wherein I used various interpretative techniques to understand my research phenomenon, past (secondary data), present (observed object), and future (revolution and findings) (Bishop, 2013; Jablonka, Wagner & Walshaw, 2013). The methodology was selected based on its affordance to gather data by using questions (see Appendix 6, Semi-structured interviews) wherein I probed my interviewees (T1, T2, and T3) for a deeper understanding of the phenomenon, with no predictions or expected results (Fox, 2017; Giles, 2017; Mertens, 2014; Greeff, 2011).

The overhead discussion informed the generic activities that define the qualitative research process as presented in Table 3.1 for this thesis. According to a presentation from Table 3.1, it was evident the characteristics of the qualitative research and the researcher were both considered, focusing on the context, iterative and systematic inquiry. The researcher and participants were multi-cultural subjects; hence, a method of inquiry started by realising the problem in the context. The interpretivist paradigm became the umbrella of the research journey. The fundamental question related to methodology was how do learners acquire knowledge? Case study was used as the research strategy with appropriate data collection tools and interpretation process (Fox, 2017; Giles, 2017; Toerien, 2014). The program of research was constructed as tabulated below (Table 3.1).

Table 3.1 Qualitative Research Process

Phases	Activities	Research process
1	The researcher and the researched as multicultural subjects	The conception of self and participants
2	Connectivism paradigms	Interpretivist
3	Research strategies	Case study
4	Methods of collecting and analysing empirical materials	Interviews, observations, focus groups, and document analysis
5	The art, practices, and politics of interpretation	Inductive practices, writing as interpretation and abduction process for emergent concepts

Phases, activities, and research processes (see Table 3.1) listed the researcher's interconnected interpretive practices (Denzin & Lincoln, 2013; Merriam & Tisdell, 2016; Merriam, 2009; Stake, 2005). Exploratory research questions (Bernard et al., 2016; Nieuwenhuis, 2016; Toerien, 2014) were open-ended in nature with qualitative features guiding the entire study which was either ontological (capturing participant's realities) or Epistemological (designed to understand a phenomenon). Data were collected from the field at the site where participants' experiences occurred; to see, hear and understand what they experienced (Creswell, 2013). The

research approach elicited participants' accounts of meaning, experience, and perceptions rather than predicting human behaviours (De Vos et al., 2011). The next section discusses the qualitative research design used in the study.

3.3 RESEARCH DESIGN

In the research methods, there is an intervention research model, which consists of design, an architectural plan of the research (De Vos et al., 2011). The research design of qualitative research may consist of the case study, phenomenology, ethnography, grounded theory, and critical studies (ibid, p. 23). This can vary depending on the theoretical framework, philosophy, and assumption about the nature of knowledge and the field of study (ibid, p. 320).

A research design refers to "the entire process of research from conceptualizing a problem to writing research questions, and on to data collection, analysis, interpretation, and report writing" (Creswell, 2007, p. 5). This research strategy moves the whole project underlying my philosophical assumption (Creswell & Poth, 2018) as a journey (Braun & Clarke, 2019). The qualitative research design was informed by my ontology and epistemological perspective. The intention was on seeking answers to the specific questions as stipulated on top (Hesse-Biber, 2017, p. 225).

A Case study design

A case study design has been frequently utilized in qualitative research but has a very 'contested terrain' (2015, p. 134). Merriam (2009, p. x) refers to case study design as "an intensive, holistic description and analysis of a bounded phenomenon." I opted for a case study research design to explore the full issue of the user's perceptions of mathematics pedagogy on social networking platforms. To limit trespassing, both qualitative and quantitative literature concerning interpretivist research design were reviewed to construct proper esteemed qualitative case study design. It is worth noting that as non-participant observer, the case study design allowed me to have real-life experience of participants in their real-life situations in their WhatsApp groups. This was my phenomenon within a 'bounded setting' of Umkhanyakude District (Creswell, 2007) bounded by time (in compliance with UNISA ethical clearance) and agreed time frames with my participants (8th of February to 25th of March 2016). Stake (1995) argued that 'case study research is not a methodology but a choice of what

is to be studied within a bounded system. Yin clarified that "the process has been given careful attention; the potential result is the production of a high-quality case study" (p. 199). Therefore, I had a research strategy (Denzin & Lincoln, 2013) or a program. To be precise, a case study design is a methodology or an approach within qualitative research that serves as an object of study, as it is unfolded at the end of the research as a product of the inquiry.

The case study was chosen due to its important features, namely research centeredness with boundaries surrounding a case (Creswell, 2007, p. 74), an event (Bernard et al., 2016, p. 43), guiding principle (Yin, 2012, p. 28), exploratory and interpretative qualities (Guba & Lincoln, 1981, p. 94). Its empirical features is relevant to the "contemporary phenomenon in depth or a case which is set within its real world context, especially when the boundaries between the phenomenon and context are not clearly evident" (Yin, 2009, p. 18). Collective case studies whereby at times they are compared and contrasted (Hesse-Biber, 2017). Lesh et al. (2008) further added that the boundedness of the case illustrates the issue. That is why a case study "that starts with some theoretical propositions or theory will be easier to implement than with no propositions" (Yin, 2012, p. 9). Given this description of the case study, the research process was a 'journey, not a map' (Braun et al., 2019, p. 8). To be precise, the intention of using a case study was not for discovery, outcomes, or even theory testing (Yazan, 2015; Yin, 2014, 2012, 1998). Choosing the single intrinsic case study was proper for this study. It was used as a 'process' towards exploring the participants' perceptions (Bernard et al., 2016, p. 43). Hence, this case study could have lacked rigor while performing research, due to its massive data but the intervention of theoretical proposition (connectivism theory) became the main pillar of crafting this thesis.

I had a logical plan of getting the initial set of questions to be answered to come to a valid conclusion (Merriam & Tisdell, 2016; Yin, 2014). My strengths included the multidisciplinary background that channeled me not to be biased with my expectations from the data collected; my participants who agreed to become part of the project and a simple logical program that I followed. On the other hand, unavailability of gadgets and good reception was the weakness, thus the discussion chain was breached. Nevertheless, the key strength of this case study was the availability of multiple sources and techniques for the data collection process which included semi-structured interviews, focus groups, online discussions, non-participant observation, and document analysis. Precedence was captured for the good construction of questions; accurate capturing of responses from feedback and gaining trust (see section 1.9).

This research design drove the whole process of site selection, including population, data sampling, and data analysis (Braun et al., 2017a).

3.3.1. Population and Sampling

Qualitative research is excellent regarding the selecting of a population since it is an approach for exploring and understanding the individuals or groups about social or human problems (Creswell, 2013). The class or families living in a place where the sample was selected was called the 'study site population' (Creswell, 2007, p. 49). The criterion for the selection of participants was a matter of convenience, access, and willingness to participate in the research study. It was imperative to conduct a pilot study to similar teacher participants to eliminate the contradiction of research questions.

3.3.1.1. Population

To perform the accuracy of the study, I selected a site that I considered to have a rich source of documentary evidence (Yin, 2008, p. 254). In this regard, my target population (Denzin & Lincoln, 2018, p. 60) was schools at uMkhanyakude District with poor pass performance for three consecutive years as a research site. The setting, size, population, and sampling were properly chosen to match the study design and research objectives. The setting of the study was unique for this particular study including the physical, social and cultural site where the research was conducted (Dahlman et al., 2016). In this regard, the setting was social networks used for teaching and learning as the new space of learning. The aim was to explore the role of social networks in enhancing learning after hours in rural schools. A research site is a place where research was conducted focusing on the setting of the rural schools and research questions were site-specifically constructed (Marshall & Rossman, 2016). The study site in this study was unique since it involved the extension of mathematics communication after hours of three secondary schools using WhatsApp as a platform for extensive communication between teachers and learners.

However, the accessible population in this study was grade 9 mathematics teachers and learners who were able to use social networks after school hours. Grade 9's performance in KwaZulu-Natal was viewed and noted to be consistently performing poorly at uMkhanyakude District which was predominantly a rural area. uMkhanyakude District was mainly made up of five municipalities (see Figure 1.1) and the circuits were also classified according to municipalities, thus the study focused on one circuit within the district which had 22 secondary schools. Research revealed the persisting problem between poverty, inequality, and mathematics

performance. Gender was not an issue in this study as it was mentioned in previous studies (Giles, 2017; Ankiewicz et al., 2015).

3.3.1.2. Sampling

Due to the logic of qualitative research which is mainly concerned with in-depth understanding, small samples are proper to look at the meanings of participants' attributes to their given social situation (Braun et al., 2017b; Marshall & Rossman, 2016). This case study explores the means of extensive mathematics communication even after normal school hours. The 'lived experiences' (Marshall & Rossman, 2016, p. 54) of the participants were conveniently sampled from particular knowledge of the setting and identifying participants who were willing to serve in this study. Expectations of the study were presented to all participants verbally and in writing. Meetings with these teachers for both the pre-research and post-research interviews took place in the teachers' school environment. Considering the site selected, caution was on how and why the research questions were formulated. However, the intention was on having as little control as possible over the participants and use virtual observation to maintain the real-life context. This was an empirical study that investigated a contemporary usage of the social networks within a real life context (Yazan, 2015; Yin, 2014). However, different from Yin's approach of finding truth by using the 'why' and 'how' questions, my approach was using 'what' as means of exploring (Yazan, 2015, p. 138). The scheduled times were drafted for conducting the case study which involved the preparation period; the arrangement of the site visit, planning meetings, and follow-ups with the participants involved on the site.

Initially, two schools were purposively sampled (Merriam, 2009), where mathematics teachers taught learners based on affordability to access WhatsApp after school hours. The intention was to get 15 learners from each school. Due to returning six consent forms from school B, the researcher consulted the supervisor and was advised to approach another school with the same poor performance for three consecutive years and from the same circuit within the same district to maintain rich descriptive data. Thus, three schools were selected from one circuit because of their poor performance in three consecutive years, that is 2013, 2014, and 2015. The pass rate of grade 9s in mathematics from one circuit within the uMkhanyakude District, national policies, and practices on emerging technologies in the teaching and learning of mathematics, as they were applied in these schools were explored. The sample (see section 3.3.2, 1.) chosen was considered important to be explored as a special case study. The next section discusses the demographics of the study participants.

Demographic characteristics of participating teachers

Initially, I did not include a demographic question in the study but was collected as it was engaging first with the teachers and later learners. My journal assisted me to know more about the participants. In retrospect, this should have been structured in-depth to find out the important facts about who are these participants and their backgrounds. Table 3.4 characterizes the participating teachers in the study.

Table 3.2 Demographic characteristics of the participating teachers

Gender		**Age**	**Ethnicity**	**Mathematical experience**	**Highest mathematics qualification**
Male	female	26 – 40yrs	Zulu speaking	How many were temporary, and how many were full-time (permanent)?	Not qualified/ Qualified
	1	32 years	Zulu	Permanent-Biology teacher	Qualified
1		26 years	Zulu	Temporary	Not qualified
1		40 years	Zulu	Permanent – Mathematical literacy teacher	Qualified

The participants as indicated in Table 3.2 were two males and one female teacher teaching grade 9 mathematics from the three selected secondary schools. Their age ranged between 26-40 years. They belonged to one ethnic group (Zulu native speakers) and resided at the uMkhanyakude District. All teachers were not qualified to teach mathematics. One of them was a mathematical literacy teacher and the other one was a biology teacher. The third teacher was not qualified as a teacher at all. It was because of his best results in matric that he was requested to come and work while studying with a distance learning institution. Two teachers used WhatsApp daily and the other one was still a novice, such that the particular teacher had no smartphone. It was only after the request to participate in the study that she agreed to buy the cheap smartphone which came with promotional data and readily available WhatsApp.

Teachers could manage to add learners as WhatsApp group members easily as other scholars mentioned. Table 3.3 summarises the demographic characteristics of the participating learners.

Table3.3 Demographic characteristics of the participating learners

Focus Group	**Gender Male / Female**		**Age**	**Ethnicity**	**WhatsApp group usual communication times**	**Usual times for making conversations**
FC01	4		14–16 years	Zulu speaking	2 hours	4 pm – 6 pm
		1	14–16 years	Zulu speaking	1h30min	4 pm – 5:30 pm
FC02	5		15–16 years	Zulu speaking	2 hours	6 pm – 8 pm
		4	1–16 years	Zulu speaking	1 hour	6 pm – 7 pm
FC03	6		15–16 years	Zulu speaking	2 hours	5 pm – 7 pm
		10	14–15 years	Zulu speaking	2 hours	5 pm – 7 pm

Table 3.3 shows that 30 learners were drawn from three selected schools based on their accessibility to WhatsApp and signing of consent forms. Initially, I intended to use two schools, with fifteen learners per school, those who would be having access to cell phones with social networks after school. The third school was selected after the response from the three schools was not good for the learners who manage to participate in the research. This was the full school service also in the same district and located in almost the similar geographical boundaries with the two sampled schools but assigned to another ward. Learners ended up being fifteen girls and fifteen boys from three different schools, all isiZulu native speakers. Their communication times vary but all used 8 pm as the cut-off time for communication.

3.3.2 Data collection

Data gathering techniques were of multi-perspective to have all participants' interactions observed and their voices heard (Daymon & Holloway, 2021; Gehl, 2018; Bernard et al., 2016; Creswell, 2013). This was done with the understanding that accommodated various skills of different types of evidence used to triangulate the stated research questions (Bernard et al., 2016; Yin, 2009). There was a need for having useful techniques linking research questions, methods, and research design, where questions were listed to identify how data were harvested to answer research questions (Maxwell, 2012). Ramorola (2010, p. 98) proposed using a data matrix that lays the logic of decision-making, formulation of the research questions, and data collection tools. Furthermore, this matrix has the most needed one for data collection and displays how data were captured on how and when to use various tools and techniques (Sedio, 2020, p. 11). Buoyed was suitable for theoretical orientation, research question, participant group, data collection instruments, sources, and analytic approach. The study used the following techniques: semi-structured interviews, focus groups, online discussions, non-participant observation, and analysed documents. Based on the mentioned authors' ideas, Table 3.4 presents the data planning matrix, which shows how techniques were used to gather data in this study (Sedio, 2020).

Table 3.4 Data Planning Matrix

Theory	**Research Question**	**Purpose of study**	**Data collection instruments**	**Sources**
Social Constructivism	1. What types of social networks do teachers connect with learners to share mathematical content?	To explore the different social networks used by teachers to connect with learners to share mathematical content.	Semi-structured interviews (1-12)	Teachers
Social Constructivism	2. To what extent have learner-teacher interactions taken place?	To find out the extent of learner-teacher interactions that have taken place.	Semi-structured interviews (13-24)	Teachers
Connectivism			Online discussions	Teachers & Learners
Constructionism	3. What technological methods prevail in the learners' discovery of mathematics content knowledge	To ascertain technological methods that prevailed in the learners' discovery of mathematics content knowledge	Non-participant observations	RTOP observation tool

Cognitivism	4. To what extent has teaching and learning taken place through social network interaction?	To identify the methods prevalent to teaching and learning through social network interaction	Focus groups	Teachers & learners
			Documents analysis	*2013-2015 mathematics performance records *Staff minutes *1st term CASS 2016

Referring to Table 3.4, data gathering techniques used in this study were (1) the individual semi-structured interviews; (2) focus group discussions; (3) observations (virtual using WhatsApp and once-off classroom observation, and (4) documents analysis. The first research question (RQ 1) "What types of social networks do teachers use to disseminate mathematics content to learners?" It was administered to teachers to explore which social network could they comfortably use? Teachers recruited learners based on the social network that they could afford and understand. The individual semi-structured interviews were used to harvest data from three teacher participants individually, twice; that was before and after the research process (see Section 3.3.2.1). Grade 9 learners doing mathematics, were grouped into three focus groups and were interviewed after the research process. RQ 2 was "To what extent have learner-teacher discussions through social networks taken place?" The objective was to find out the extent to which the learner-teacher discussions took place on WhatsApp after school hours during the research period. This question was answered by a section presented from online-learning discussions that happened between teachers, learners, and among learners themselves. Presentations here describe the interaction that occurred as a means of exploring teachers' and learners' perceptions, activities, and conditions during the research period from the 8th of February to the 25th of March 2016. However, their identities were kept anonymous according to ethical regulations. Secondly, online discussions between teachers and learners were analysed. RQ 3 was "What technological methods prevail in the learners' discovery of mathematics content knowledge?" This was formulated to identify technology methods prevalent in mathematics information discovery by the learners. Non-participating observations in three classrooms were used to explore these methods. RQ 4 was "What evidence of mastering mathematics is demonstrated by learners in the use of social network technology?" This question was conducted to investigate the type of learning that took place

in social networking technologies. Evidence was collected using focus groups interviews (from learners), and document analysis. All these techniques were used in such a way that they complemented one another.

- SEMI-STRUCTURED INTERVIEWS

Interviewing has been a social practice that was responsible for crafting social production of knowledge (Kvale & Brinkmann, 2009, p. 14-18). This was one-on-one meeting (Greeff, 2011). Bernard et al. (2016) insisted on the need to learn probing efficiently and to get participants talking. The research interviews were based on the conversations of daily lives and were professional conversations. There were some rules and principles on how knowledge was constructed in an interaction between the interviewer and the interviewee (Kvale & Brinkmann, 2009). Understanding life was done using a worldview from the participants' perspectives using some specific approaches and techniques (Merriam, 2009). The emphasis was on 'phased-assertion and baiting probes' (Bernard et al., 2016, p. 80). Since there were three teachers interviewed with similar questions, the phased-out assertion was used when the piece of the puzzle was harvested from teachers separately. Bernard et al. indicated that "the more the researcher seems to know the more comfortable could be the participant" (ibid, p. 80). On the other hand, the baiting probe was used to act as if I do not know so that the participant could jump in and correct me. In this study, semi-structured interviews were relevant because social networks have been observed to influence people of all ages.

The intensive interviews were conducted before participants' training on social media professionalism, cyberbullying, and revisiting the school ICT policy. They were used for two purposes (see Appendix 6). Firstly, questions 1-12 were conducted before the study began. This was done to understand the context prior research period. The second purpose was administered by the researcher from 13-24 questions after the research had been concluded. Data were collected on the first set of semi-structured questions on my first encounter with teachers where I introduced myself and asked them to form social network groups with their learners. The second set of semi-structured questions intended to explore the empirical interpretations of the teacher participants after the research project. Interviewing session lasted for 45 minutes.

In this study, one-on-one semi-structured interviews were conducted with three (two males T1; T3 and one female T2) grade 9 mathematics teachers. The first stage was to seek permission

from the participating schools (see Appendix 3,4 and 5). I met with each educator and asked for permission to conduct research at the selected schools (see Appendix 4). To monitor the interviewing session, basic rules were laid to be observed during the process, e.g., asking that cell phones be switched off. This was done not to disturb participants or influence them in their responses while answering. It was also ensured that the venue was quiet to minimize all possible distractions. Participants agreed to the use of audio tape recorder during the interviews. Participants were ensured that set time frames of between thirty to forty-five minutes wer going to be observed using the Pomodoro timer. The participants were relaxed knowing that they would not spend much time answering the interview questions.

All participants were asked similar questions using a similar format. I asked the questions without giving any clarifications, except for probing when the participant's answer was incomplete. Probing was done to elicit more information (Creswell, 2013). It was important for me to establish rapport with participants, to respect their viewpoints and avoid superimposing my preconceptions (Fontana & Frey, 2012). The audio recording was used to capture all their spoken words, sounds, hesitations, laughter, and long pauses (Braun et al., 2017b; Bernard et al., 2016). Creswell recommended brief note taking during the interview (Creswell, 2013). It happened that the tape recorder malfunctioned, participants shared information "off the record" and data verification with the participants was done later (Creswell, 2013, p. 231). This research tool exposed the usage of structured questions towards negotiation, hence teachers agreed to conduct the research without any monetary benefits (Fontana & Frey, 2012).

- FOCUS GROUP INTERVIEWS

Focus groups were group interviews used for a better understanding of how learner participants felt about using social networks to enhance their learning after school hours (Fox, 2017, p. 283). Bernard et al. (2016, p. 40) indicated that focus groups "are not good tools for understanding the distribution of responses… the whole idea is to get a group dynamic". I met face to face with three focus groups that were part of their three WhatsApp groups in their school. Group interviews were conducted after they were done with their communication using the WhatsApp platform. The specific questions about the topic were asked to a group of learners' participants. These group interviews were also important to get empirical evidence from learners on how they felt about using WhatsApp as a learning tool after school hours. For

this study, the intention was to have two focus groups with twenty learners from each of the participating schools.

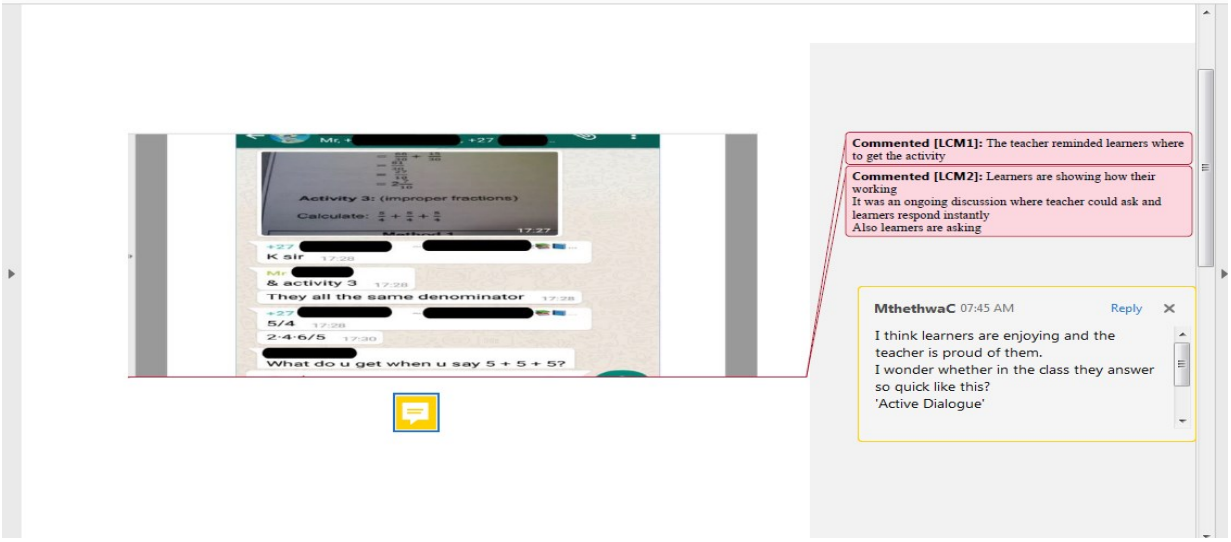
Teachers from three schools recruited learners with access to smartphones. The research project ended up with 5 learners from one school (school A) and 9 from another school (school 2). I felt that the participants' number was so far not viable for ensuring the trustworthiness of the study, hence after consulting my supervisor the advice was to look for another group. Challenges were encountered with the first 2 groups; their participants could not meet the anticipated number. Another school with similar poor performance for 3 consecutive years was approached with the anticipation that since the school was located in the area where Cell C as the freely available network for communicating data would be more convenient. Still at uMkhanyakude but not in the same ward but same circuit, the school that was a full-service school (school with plenty resource and able to assist other schools in the area) with anticipation that they were using technologies. 16 learners from the third school signed the consent forms. It was from this exercise that the study employed 3 focus groups to collect data. Focus groups were from 3 schools, 5 from school A; 9 from school B, and 16 from school C. Learners in each focus group, were given name tags based on the school letter and after counting learners available per focus group. Each learner firstly introduced he/him by tag name (FGA1 for learner 1 in school A; FGB1 for learner 1 in school B and FGC 1 for learner 1 in school C). Similar research protocols and recording using my smartphone were done in all three schools (Bernard et al., 2016; Creswell, 2007) (see Appendix 11).

- OBSERVATIONS

Yin (2012, p. 11) described observation "as a tool that aimed at focusing on human actions, physical environment or real-world events". It was therefore a systematic process of recording the behavioural patterns of participants, objects, and occurrences without necessarily questioning or communicating with them (Nieuwenhuis, 2016). There were repercussions concerning the matter of covert and overt observer's roles, but I was guided by ethical principles not to become biased (see Section 3.3.2.2). The concern here was that when the observed is aware that his or her conduct is being recorded and for analysis, that might influence their conduct (Fox, 2017; Giles, 2017). However, it was due to ethical reasons that the researcher informed the participants that she was observing them in their conversation as the non-participant observer in the "online discussion" social network group they have formed. Observing participants in their groups started on the 8th of February 2016 up to the 25th of

March 2016 (see Appendix 6 for teachers' interviews and Appendix 11 for learners' focus groups' interviews).

Because empirical evidence is used to advance knowledge (Bernard et al., 2016), observation in this study was done differently. Two different observations were used, namely, indirect observation, which was more of structure since it had no impact. Participants were communicating virtually in their WhatsApp space and I was following them virtually in their 'online discussions' (Giles, 2017, p. 191). The focus group was discussing mathematics (ibid) (see Appendix 7). There was virtual observation (see Appendix 7) where I followed participants' online discussions (Amry, 2014), The study aimed at exploring participants' perceptions of 'digital communications' (Marshall & Rossman, 2016, p. 158). Three WhatsApp groups took place between 4 pm to 8 pm during weekdays during the research project period. Saving WhatsApp communications per school assisted the researcher to add sticky notes for comments as part of my memos. A journal was kept and daily conversations were recorded together with saved WhatsApp conversations per group. There was a difference between my reflection notes (personal notes according to researcher' understanding) and observation (empirical data written as it was observed). Researchers' reflections became memoirs which were later used when discussing the findings (see Appendix 7 and Table 3.4). Below was an example of WhatsApp snapshots that were saved together with my observations and memoirs (see WhatsApp group VGN 1)



WhatsApp group VGN 1 School A 07/03/2016

An example of online discussion in the WhatsApp group, VGN 1 offers my memoirs after participants' interaction online.

The second observation in this study involved the 'once-off' visit to each classroom where one mathematics lesson in grade 9 was observed (see an attached tool for observation Appendix 8). I was a non-participant observer, witnessing one mathematics lesson in all three groups. During the 'once-off observation', participants' behaviour, attitude, and perception were observed concerning the usage of social networks and mathematics as they were in their mathematics classrooms. I explored whether using WhatsApp as a communication tool added value in classroom discussion to enhance motivation and clarification of concepts. Indirect observation, as a 'non-participant observer' in the three classrooms using RTOP observation tool for one 60 minutes period after online discussions were done (see Appendix 7). Participants were observed once in their classroom (school A, school B, and school C). My research actions concur with Kumar's perceptions of a non-participant observer. Kumar viewed a non-participant observer as a "researcher who does not get involved in the activities of the group but remains a passive observer, watching and listening to its activities and drawing conclusions from this" (Kumar, 2014, p. 174). The priority of using this technique was observing participants engaging in WhatsApp, looking for patterns of behaviour to understand the values and beliefs of participants while acknowledging their human freedom (Capurro & Britz, 2010). The strengths of using observation in the study was that information concerning usage of social networks was covered and real (Bernard et al., 2016). These factors provided very insightful data concerning personal behaviours and motives. The weakness of this method was that it was time-consuming and too expensive since it involved data usage to observe human observation. All the participants were aware that I was observing them in both direct and indirect observations.

- DOCUMENTS ANALYSIS

Schurink et al. (2011, p. 376) designate any written material which contains information about the phenomenon that was being researched, which helps the researcher to uncover meaning. Merriam (1998, p. 118) identified secondary documents used for document analysis. These are referred to all documents "likely to be relevant to every case study topic" (Yin, 2014). Data solicited from document analysis assisted in answering the research questions. The documents analysed in this study included the school policies on the use of social media and networks;

homework policies; School Management Teams (SMT) minutes; staff minutes, learners' classwork; assessment results for 2013, 2014, and 2015 years; assessment results emanating from Continuous Assessment (CASS) for first the first semester 2016 (refer Appendix 12).

After data have been collected, stringent measures were needed to ensure the quality and evidence of the data collected. The next section indicated the maintenance assurance of trustworthiness in this study.

3.3.3 Measures to ensure trustworthiness

Guba and Lincoln (1982) offered a set of standards for trustworthiness which are pursued by using confirmability, transferability, dependability, and credibility. Literature clarified that the traditional terms reliability, validity, objectivity, and generalisability have been modernised to confirmability, transferability, dependability, and credibility (Marshall & Rossman, 2016, p. 45-7). This implied the need of handling trustworthiness elements accurately due to overlapping tendencies with the truthfulness of the study (Hesse-Biber, 2017).

According to Guba and Lincoln, the trustworthiness of a study can be endorsed if "the researcher ensures the perspectives of participants are represented as clearly as possible (credibility); readers can follow the decision trail of the researcher throughout the study (reliability) and the researcher corroborates their interpretations by returning to participants during the research process (confirmability)" (Guba and Lincoln, 1989, p. 236-243). In this study, I intended to help the reader understand and gain the subjective world of the participants (Delport & Fouche, 2011). Findings were informed by attention to praxis and reflexivity, understanding how the researcher's experiences and background have been constructed. Their understanding affected how they acted in the world including how things were done during the inquiry. This according to Saldanã (2009) is referred to reality check whereby the researcher reflected on the code and explained the reasons thereof. The findings of the study were shaped by the participants and not by the researcher's biases (Kumar, 2014), nor motivation or interest (Nieuwenhuis, 2016). Gadamer argues that this process of setting out the researcher's horizons can never be complete or fully understood by others; hence, there must be a fusion of horizons (Gadamer, 1975). This meant that the researcher must ensure that participants and readers are kept updated all the time. Transferability was used for checking that "salient conditions overlap and match" (Guba and Lincoln, 1989, p. 241). Thus, truth was defined as "the agreement between the participants regarding a particular belief or interpretation" (Cole and Avison, 2007,

p. 831). Objectivity viewed as accuracy in hermeneutic research cannot be solely achieved by faithfully representing interviews and associated texts as readers will interpret the research finding from their horizons. It was at this point that the trustworthiness of the research process and truthfulness of the analysis come together judgments concerning the findings are part of the reader's interpretive process (Saldanã, 2009). Measures to ensure trustworthiness are discussed in depth in the following section.

Reliability was referred to focus on the quality and appropriateness of the instrument, ensuring a high degree of agreement between the codes and what participants are saying (Hesse-Biber, 2017, p. 327). The validity on the other hand referred to a "range of ways to conceptualise soundness" (Marshall & Rossman, 2016, p. 44). An important validity strategy was to do member checking, whereby participants weigh the researcher's thoughts concerning the meaning that was captured (Hesse-Biber, 2017). Using thematic analysis was advantageous in discovering what underlined the surface when the reliability and validity of instruments were strengthened.

3.3.2.2 Confirmability, transferability, dependability, and credibility

Confirmability

Confirmability is described as an objective task whereby there is the removal of inherent characteristics of the researcher and the findings of the study (Lincoln & Guba, 1985, p. 299-300). This measure of trustworthiness ensures that the findings were not influenced by my biases, motivation, and interests. During data interpretation, confirmability may be rooted in context, collection of information other than my imaginations (Mishra & Mehta, 2017). I maintained quality, appropriateness, assigned 21st century relevant themes, and aligned my ontology in delimiting study using the connectivism theoretical framework (Yin, 2012, p. 28). Indeed "qualitative research has to be read, not scanned; its meaning is in the reading" (Richardson, 1994, p. 51). Evidence was frequently checked in terms of reinforcing the findings and interpretations using auditing (Bernard et al., 2016; De Vos, et al. 2011; Guba & Lincoln, 1982). However, this was done almost in all stages and ultimately after the draft of the complete thesis. The aim was not only to review the findings (Creswell, 2007) but to identify the loopholes in the study at a peer level. It was important to have the report read with relevant subject matter expertise to have an opportunity to corroborate key facts (Yin, 2009, p. 179). The techniques for establishing confirmability included confirmability, audit trail,

triangulation, and reflexivity (Lincoln & Guba, 1985). The study presented how trustworthiness unfolds (Lincoln & Guba, 1985), even though different ways popped up in the study which could be attractive (Richardson, 1994, p. 516) but triangulating the methods, resources, and theories I started with what was the best option (Braun & Clarke, 2006).

Transferability

Since transferability in the qualitative research is very limited, purposive and convenience sampling was used to explore information (using WhatsApp) at uMkhanyakude district. This meant that the study was purposely crafted for this particular phenomenon and findings talked to them (De Vos, et al., 2011). In this study, rural secondary schools were the main typical attribute in line with the research questions. Also, the rich descriptions of settings for the data collection process and analysis were explained so that it would be easy for other researchers or other people interested in education to use the findings as they apply to other rural settings where ICT resources are still lagging.

Dependability

Dependability is applied using 'internal consistency' (Hesse-Biber, 2017, p. 326). I checked the logical and well-documented intentions of the study (Schurink et al., 2011, p. 421). Audit inquiries were maintained to identify analytic steps used towards findings. Employing a pilot sample equipped me with correct research questions and ensure consistency of the research questions.

A PILOT SAMPLE OF THE STUDY

It was for ethical and policies compliance that I uphold research status, university image, and human dignity. More than abiding by the ethical principles (see Section 1.9), the whole thesis was guided by admiring and respecting participants. Overwhelming ideas the researcher held were controlled in order not to supersede the thorough preparation of the research project. However, using new tools to enhance learning has become a norm and indeed long overdue in rural schools at uMkhanyakude District (see Section 2.4). But rushing into a research process without being sure that all the preparations were done properly in advance would have tempered with the study objectives. Starting with conducting a pilot sample became imperative; since some skills to prepare for the unpredictable encounter were needed (Jablonka et al, 2013;

Castells, 2000) in this educational journey. It was due to the implications of this study that the researcher kept on referring to the ethical principles of this study (Townsend & Wallace, 2016) to ensure that every research step went smoothly.

Two of the researcher's colleagues, rural mathematics educators at the primary schools, were asked semi-structured questions as a means to test the 'preliminary exploratory study' (Richardson, 2000) and the study's feasibility (Kumar, 2014). The purpose was to find out the suitability of time scheduled for each interviewing session and comprehensive understanding level of the research questions (Creswell & Poth, 2018; Creswell, 2007). Participants have explained the importance of the study together with assuring their confidentiality and anonymity, by signing the consent forms. Adjustment of times set, clarification of questions by correcting their structures, formulation and proper tense for sentence construction ensured my process and attainment of research stance (Marshall & Rossman, 2016). Teachers were given consent forms as a means of simulating what was going to happen during actual research. They were contacted separately using face-to-face encounters and asked to record conversations for 45 minutes. I transcribed all our conversations, with a few references below:

> *"Oh! No, I cannot imagine using my internet for school. I only use what I have been given and that is.*
>
> *My cellphone is mine and has nothing to do with the school matters*
>
> *We were promised computers a long time ago, and the policies are usually drafted on yearly basis but I don't remember the ICT one? Why should we have it since there are no computers?*
>
> *If the schools will buy for us data I will perhaps think of using my cell phone for the school.*
>
> *I mark what I can and the rest will be sorted the following day. At home, I must relax.*
>
> *These learners become so excited when they know that they know your name I think with the cell phone the same issue can happen they will be excited to follow me either on Facebook or to have conversations using WhatsApp.*
>
> *I have never thought of using social networks to communicate with them after. To speak the truth that will be a nice thing to happen because the border between the teacher and learner will be broken. Also, there is a lot one can learn from these learners.*

Should we were not in the rural area I think this will be the best idea, but here our learners are not disciplined they will screw their access to my private life? Oh! No, I do not trust them at all.

WhatsApp is the most popular and cheap one. It is easy to use it. I think more stakeholders should be involved to ensure security and discipline in the groups."

The transcriptions became the mirror of what to expect and increase probing where the answers were not self-explanatory. In this pilot work, I gauged qualitatively the opinions, experiences, attitudes, beliefs, and values in the interpretation of integration of social networks as a teaching and learning tool. I noted the issue of remaining sensitive and receptive to unplanned questions or additional questions during the interview session.

The findings of the pilot study widened my anticipated problems like the issue of data and skepticism in giving the cell phone number to students since they regarded cell phones as more private. These questions were extracted from the first set of interviews which were extracted from the first section of the prior scheduled questions (see Appendix 6). The researcher's concern about the reliability of the tools was sorted then the credibility or the validity is discussed in the following section:

Credibility

Credibility in this study was used as the criterion that focuses on the degree of correspondence (isomorphism) between findings, the raw data collected from subjects, and objective reality (Denzin, 2009; Creswell, 2007; Guba & Lincoln, 1982). This was used to check internal validity. The tractable and documentable process throughout the research process was established. Two 12 sets of questions for interviewing teachers during the pre-research stage and post-research stage (to explore teachers' perceptions prior and after research concerning the incorporation of WhatsApp in enhancing mathematics pedagogy after school hours) and 8 questions for focus groups were formulated. Data were qualitatively collected from observations, focus groups, documentary analysis, semi-structured questions, and reflex journals, analysed thematically following the six-phase approach of data analysis (Braun et al., 2017a; Braun & Clarke, 2006).

The researcher stipulated the expected findings at the outset of the case study by identifying 'potential codes' (see Table 3.5 and Appendix 6). The whole study used the bracketing process of reflection and ongoing memoiring after every data collection session (Creswell, 2013;

Siemens, 2012). Memoiring was what the researcher experienced when engaging in direct research studies and was reflected throughout the entire process of qualitative data analysis. It was through memoiring that a journal was made up full of reflective notes pinpointing key points that were learned from the data, new ideas, and concise insight collected throughout the research process. The well-experienced researcher was asked to read memos and the potential codes to verify coherence (see chapter 3.3.3. Phase 4). The confidence in the 'truth' of the findings was ensured authenticity using Lincoln and Guba's methods: peer debriefing; member checks; triangulation of different methods and prolonged engagements or persistent observation in the field (Lincoln & Guba, 1985, p . 219).

PEER DEBRIEFING

I arranged knowledgeable and available colleagues to get feedback on coding, memos and next-to-final drafts if they were coherent, and making sense to the reader (Marshall & Rossman, 2016). This ensured that analysis was grounded in data using peers and the supervisor. I asked my family members especially my mother, to read my thesis, to check the flow of language and the simplicity thereof. It was from this process that the logic and clarity of the researcher's presentation were polished since it was a continuous process started during phase 1 (see chapter 3.3.3) of data analysis up until the project report was finalised. Pre-warned with adequate debriefing and reflections, the editing of the thesis, although very challenging, was doable due to the support collected through this process.

MEMBER CHECKS

Marshall and Rossman described 'member checking' as when the researcher devises a way to ask participants whether they 'got it right (2016, p. 230). In this study, member checking was done by using the study participants of the three rural secondary schools at the end of the research project. Some principals were gatekeepers. Nevertheless, they were appreciated for allowing the research project, teachers and learners were given full details of the transcripts from the semi-structured interviews, focus group discussions, and observations. There were copies from the documents that were discussed to request participants to indicate statements they were against or the ones that were misinterpreted. The ethics of the research was emphasised and the participants were reminded that the data per school would be collated together and their names, as well as the names of the schools, will not be disclosed, but pseudonyms would be used. They were also informed that they would know when the study is

available online or at the university library for them to read. This was also to formally inform participants that the WhatsApp group's interaction and the study had come to an end.

TRIANGULATION OF DIFFERENT METHODS

This was a strategy that involved using more than one method to study the same research question (Hesse-Biber, 2017, p. 278). This was used to reduce inherent bias associated with a single source, technique, method, or researcher. There are three forms of triangulation; firstly, triangulation in the study was used to validate data using truth from literature, thus called this 'data triangulation'. Secondly, 'theoretical triangulation' which was abductive in this study, used different theoretical perspectives. Lastly triangulation of different methods, which meant using different instruments called 'methods triangulation'.

Data triangulation was maintained since the study used multiple data tools brought together to form the complete picture of data findings and converging lines of inquiry (Creswell, 2007). Every measure was used to maintain a chain of evidence and to construct validity; for instance, information gathered from teacher participants corroborated with learner participants. The intentions of using Lincoln and Guba's (1985) strategies were to have the findings that indicated the type of social relationship between the participants' interpretation. The anomalies were well treated and managed credibly by re-coding protocols and consistency in coding to avoid the dramatic change of the research focus (Downes, 2017; Lakatos, 1964). Checking inconsistent information was done by revisiting the study objectives, research questions, methodology, research design, and analysis together with the findings. Accurate procedures were important for using multiple perceptions to clarify meaning without being redundant of data gathered and verified my observation and interpretation (Stake, 2005). Using the constant comparative method (Creswell, 2013), I recursively compared each incident using manual means through excel. This was meant to identify similarities and differences, determine code and redefine the properties of each code (see chapter 3.3.2.2). In finding the truth from this thesis, data showed that all participants and document analysis were embraced throughout the whole research process. The aim of the research was revisited (see chapter 1.5) and all the contextual elements that influenced the design of the research (see chapter 3.3) and using the prior knowledge as a means to reach validity (Maxwell, 2012). It was through the personal experiences of my participants and thick descriptions of lived experiences (Denzin & Lincoln, 2005) that data were analysed. All the data collection tools were handled as equivalent tools (ibid). As a matter of enhancing the rigor of the study and supporting the trustworthiness and

reliability of the findings, themes that emerged from all the data tools were correlated to validate similarities and differences. My duty was to be the sense-maker and narrator of the situation (Hung, 2014) soliciting the views of the research participants and being immersed in the situation to experience it in their naturalist settings.

Theoretical triangulation was done as a means of abstracting the main findings from potential themes by following 'the rule of essential sufficiency' (Nieuwenhuis, 2016, p. 120), meaning that the simplest way to explain the findings based on the philosophical framework was used. Auditing of the trails to present my knowledge contribution, constructing phrases in describing participants' behaviours and mistakes. This was a practical exercise of searching study focus, relating theories to planned data collection, and developing an approach to data analysis. I noticed the interconnection between social constructivism, cognitivism, constructionism, and connectivism. This action was not attesting the contestation that "for many researchers, triangulation is restricted to the use of multiple data gathering methods to investigate the same phenomenon…. the practice of triangulation often does not move much beyond a single theoretical explanation" (Fielding & Fielding in Nieuwenhuis, 2016, p. 122).

Abduction here was neither a pure reflection of reality nor the reduction of reality to its most important components, but the concepts obtained were mental constructs from data that can be helpful for other studies. They were not easily constructed. Thus, the abductive process here discovered concepts and valid reconstructions. Indeed new orders are always oriented towards future action (Reichertz, 2004, p. 204). Abductive implications were achieved when using this procedure in an inter-subjectively constructed and shared truth with all participants having similar convictions. Events were recounted and clarified by the researcher's interpretations, plausible and conceivable (Delport & Fouche, 2011, p. 428).

Triangulation of methods was applicable through the data collection strategies that were used (semi-structured interviews, non-participant observation, document analysis, and focus groups) bore different perspectives, which developed an all-inclusive understanding concerning the integration of social networks in the teaching and learning of mathematics in rural secondary schools. Denzin introduced the metaphor called "lines of action" (Denzin, 1978, p. 292) supported by "lines of sight" (Berg in Nieuwenhuis, 2016, p. 122) which embodies the use of multiple data-collection methods to achieve corroboration of findings. Corroboration enabled me to be more confident about the study conclusions and got a substantive picture of how social networks can enhance the motivation of teaching and learning (Daniel & Onwuegbuzie, 2002).

The phenomenon prevailed in more crystal and different facets. In this regard, Taylor preferred the term 'crystallization' to convey a holistic, multifaceted, and dynamic perspective better fitting for interpretive research when it comes to understanding and representing the complexity of social realities rather than triangulation (Taylor, 2014). Richardson (2000) also argues that triangulation was based on the assumption of the fixed point. To be precise, 'crystallization' enables the shift from seeing phenomenon as fixed but accommodating infinite variations (Nieuwenhuis, 2016). It is important to note that in this study, I opted to use 'triangulation' since it was driven by trustworthiness while 'crystallization' implied self-critique and self-reflexivity (Marshall & Rossman, 2016). The emphasis was on the regulation of research by standards which included trustworthiness and authenticity criteria that directed the study to construct multiple and provisional interpretations of participants' meaning-perspectives. In conclusion, a solid description of data collection and analysis as methodological triangulation ended up not being a tool or strategy of validation, but an alternative to validation (Denzin & Lincoln, 2005, p. 154).

PROLONGED ENGAGEMENT

Prolonged engagement meant being present in the site where research is being done long enough to build trust with the participants (Marshall & Rossman, 2016, p. 46). Lincoln and Guba (1985) suggested this method of credibility; it enabled me to build trust with participants as some were experiencing various variations. My presence ensured that participants were not going astray. In this study, I was present on the site (WhatsApp space) as a non-participant observer for the whole research period, from the 8th of February 2016 up to the 25th of March 2016. My engagement with participants in the field was important since I got more in-depth information to identify pertinent characteristics among the three rural school participants. The collection of data was not applied in isolation, although different tools were used. Gathering information from one tool was sufficiently done as it was the only technique.

The next section was Data Analysis, where the process I followed is explained that enable me to analyse data from the instruments.

3.3.4 Data analysis

Data analysis referred to the planning of decision rules during focused analysis which involves coding of notes to keep track of dates, names, titles, attendance at events, chronologies, description of settings maps, sociograms, and other valuable practices). Unit of analysis was followed in this study whereby three secondary schools were used for data gathering using both

teachers and learners in grade 9 mathematics classes. The decision to use this format was well defined at the beginning of my journey. The focus of the thematic analysis was interpretive (Braun & Clarke, 2012). However, Marshall and Rossman (2016) did not use the concept 'thematic analysis' like other scholars (Braun & Clarke, 2012) but believed that data collection and analysis typically go hand in hand as I constructed a coherent interpretation and formulating thematic memos (Marshall & Rossman, 2016). Data analysis was within a planned research design, mentioning strategies followed during thematic data analysis. I did not use Marshall and Rossman's (2016) qualitative analysis process because they believed in the technological shifts when collecting data and analysing it. In this study, data was manually analysed although the computer was used, there was no digital tool that was used for analysing data.

The plan for data analysis involved analysing data following Thematic Analysis (TA) because of its popularity, flexibility, and accessibility (Braun & Clarke, 2012). I enjoyed using TA since it afforded me basic skills of engaging with other approaches to qualitative data analysis (Marshall & Rossman, 2016).

The collected data were manually processed and rigorously analysed using all the empirical evidence gathered through semi-structured interviews, focus groups, observations, and my research journal, memoirs, and document analysis. The intention was to gain meaning on the phenomenon as it was observed using the goal to unearth meaning, employing connectivism theoretical perspectives for contextually meaningful processes. It was important to know how participants created their knowledge in the social world using spoken and written words, whether these words were solicited through interviews or naturally occurring in the WhatsApp group. This involved comprehending, synthesising, theorising, re-contextualising (Morse, 1994) according to how connective relations of power operate differently in different social fields. Forms that each of the steps took showed the series of intellectual processes from data being raw examined and reformulated to research product guided by researcher's orientation and philosophical stance. Astute questioning, relentless search for answers, active observation, and accurate recall made the invisible obvious while recognising the significant from the insignificant. Comprehension was done by keeping the literature acknowledged and separated from the data to prevent information from data contamination or categorised with the researcher's perspective. Also, several stories were merged (synthesising) with the description of the typical pattern of participants' behaviour or response, providing referring notes, inter-participant analysis, comparing transcripts from several participants analysing commonalities.

All the analysis was governed by theoretical qualitative results by re-contextualising the data (ibid).

It was important to note that common patterns could not necessarily mean important or have meaning. In short, patterns of meaning used in TA allowed me to speculate items that are important about the topic and research questions (Braun & Clarke, 2012). The analysis itself produced answers to the question. The process fed answers to my specific question.

Adopted was a non-standardized presentation cycle of reflection, wherein different spirals of reflexive interpretations were offered as 'thick descriptions' of meanings that resulted from human experiences (Geertz, 1983). Therefore, data collection was done and prepared and was designed to use a thematic analysis. The single case design was employed using multiple units of analysis for triangulation purposes (Creswell, 2007; 2013). The multi-units of analysis were semi-structured interviews, focus groups, observation, and documentary artifacts.

Braun and Clarke's (2012) TA six-phases were: familiarising myself with the data; generating initial codes; searching for themes; reviewing potential themes; defining and naming themes, and, lastly, producing the report. This was done by reviewing the research questions and objectives (see Chapter 1 page paragraph) to ensure that the data provided suitable answers to the problem. I wanted to ensure that data analysis was based on her interpretative philosophy (see Chapter 3.1.1) which aimed at exploring meaningful and symbolic content of using social networks in teaching and learning environments. The main intention here was to explicitly and systematically present all steps in this research to ensure the reliability of this research (Marshall & Rossman, 2016, p. 3). The following were the data analysis phases used in this study:

- *Phase 1. Familiarising myself with the data*

I was firstly immersed in the data by reading and rereading textual data (Braun & Clarke, 2006). I read and re-read semi-structured interviews transcripts, WhatsApp conversations, focus group interviews, and documents. The main intention was to transform data into findings (Braun, Clarke & Gray et al., 2017c; Clarke et al., 2017) with no inherent meaning (Marshall & Rossman, 2016, p. 217). What was considered as important and basic for qualitative analysis were research questions, purpose, and objectives (see Chapter 1). Digging truth on existing knowledge using literature guided the researcher's accuracy in terms of identifying the gap (see chapter 2.8) and arranging tools to collect data (see Section 3.4) up to the stage where data

were prepared for analysis. Factors that were identified influenced the data analysis process entirely, namely; background of the site selected, the beliefs and biases of the participants, their interests, the philosophical paradigm of the whole study, and being aware of influence as the researcher and considering the strategies of how to bracket influences and biases. Data matrix (see Section 3.4) was used to recap research intentions of using the specific research tool and verified that all the data was collected. Information was stored in a folder with a zipped password and organised material accordingly using the table of sources. The material was grouped according to participants, the data collected, and per research tool. Transcripts were transcribed (Kvale & Brinkmann, 2009) with all the interview data and kept in their original spoken and body language preparing them ready for translation into English and close analysis using coding (ibid, p. 27). However, the identity of participants was highly protected (Strydom & Delport, 2011).

The duplicate copy which was the raw data with no hidden information of participants was kept in an external hard drive with an encrypted password. The working file was prepared to transcribe data from semi-structured and focus groups. Transcription referred to the process of converting audiotape recordings and field notes into text data (Creswell, 2013; Marshall & Rossman, 2016). Original files were kept but other copied files were used which were also password encrypted for ensuring the safety of the information. Real names were edited and replaced with pseudonyms (instead of 1st school teacher surname, T1 was used) and converted slang and vernacular language to English, and corrected spelling and grammar. Demographic information was added to understand the background of the participants (see Table 3.2 and 3.3). A filing system was created with backup information located in a safe with the personalised key to open wherein snapshots for WhatsApp, voice files, observation form, observation journal, and transcripts were kept.

Following ethical principles (Hammersley & Traianou, 2012), when transcribing and translating, preserving participants' identity and maintaining their statements were ensured. Consistency with verbal transcriptions became a priority because debriefing to all participants was done for verification of the intended meaning. The researcher transcribed audio recorded words, sounds, hesitations, laughter, and long pauses (see Appendix 6, 7, and 11). Some symbols were used for hesitation and gurgles (mm- hm) cut-offs in speech (-) laughter (ah-ah) long pauses (!!!) and for strong emphasis (underscore); for continuing intonation (,); reported speech (“”) and for editing done during transcribing (….) (Braun & Clarke, 2012, p. 59). Data were manually analysed by reading the entire data set in a word document using the review

column and adding my comments. This was done to identify the interesting features of the data. The next phase is 'generating initial codes'.

- *Phase 2. Generating Initial codes*

'Codes' are referred to as "the building blocks of the analysis…work as shorthand for something you…understand…" (Braun & Clarke, 2012, p. 61). A code in qualitative inquiry means a short phrase or a word that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data (Saldanã, 2009, p. 3). Both the manifest and latent levels of coding based on the words that have been transcribed were used. (Braun & Clarke, 2019). A code became a word, phrase, or sentence that represented aspect(s) of data or captures the essence or feature(s) of a data, with intention of not losing meaning.

Table 3.5 An example of coded transcript for semi-structured interviews

Transcripts T1	T2	T3	**Codes**
… No there isn't any computer. They were stolen…..also they were useless because there was no internet.	…Oh no ways in this school. There are no computers they were stolen.	.. Yes, I use my internet access to get more practice for my learners. I use it more for grade 11 classes where I take also the projector to the classroom. For grade 9 to speak the truth I have not started, anyway I am still new in the school	ICT refers to computers. Other innovative others not. ICT works with the internet Schools are differently managed

Codes became a mix of descriptive and interpretive analysis where the objective behind was that of answering the research question. This case study was not intrinsic since the design was not developed to what was perceived to be the case's issues, contexts, and interpretations and thus used data's "thick description" (Yazan, 2015, p.139). I supported Geertz (1983) as I re-immersed myself on the data every instance when rereading it attentively. The following example shows how initial codes were formulated in Table 3.5

Mrs. Mthethwa: "Do you use ICT-related forms of technologies as resources for teaching and learning in this school?"

Transcripts in Table 3.5 produced various chunks which were identified as 'potential' codes, summarised, circled, and highlighted responses with one word or short phrase. The codes were marked using different colours per research question and marked the text that was associated with it. Codes that were generated in research semi-structured question 1 were: ICT refers to computer; other teachers were innovative while others not; ICT for these teachers there must be always the internet and lastly data showed that schools were managed differently. In all, the data analysis maintained that 'Inductive conclusions are not logical necessities' (Downes, 2017; 2012; 2011). Conclusions were therefore not true rather they were 'cogent', meaning that, the evidence seems complete, relevant, and generally convincing (Sriraman & Nard, 2013). That was reached through the data immersion process, whereby the researcher got intimate engagement with data (Marshall & Rossman, 2016, p. 221). This was the process of understanding the interaction between general and concrete. Memos were written on daily basis based on what the researcher was observing. They were reflective memos, thoughts, and insights that became "invaluable for generating the unusual insights that move the analysis from the mundane and obvious to creative" (ibid). Memos were divided into observational notes (which were written in my daily journal), methodological, theoretical, and analytical notes, or memos.

Data were coded following three steps. Firstly, I read lines individually using Vivo codes. There was a long list of codes that were brief but related to the text. Codes emerged from the real-life data, participants' experiences, and perceptions called Vivo codes (Marshall & Rossman, 2016, p. 218). Secondly, using focused coding whereby convergence in data was sought. Data were used with an understanding of answering research questions. The third step was employing connectivity theory to answer the research questions using used theoretical coding whereby 'coding families' were developed to highlight the various dimensions of the phenomenon under exploration. The entire data were read guided by these steps and noted that multiple codes for the same segment of codes were formulated. Few data extracts were compared for each code. Affirming Marshall and Rossman (2016), this was indeed the most challenging and exciting stage of the research process. The following phase was searching for themes.

- *Phase 3. Searching for themes*

A theme is a good name referring to "informative, concise, and overlap between themes" (Braun & Clarke, 2012, p. 65). Further, it "captures something important about the data about the research question and represents some level of patterned response or meaning with the data set" (Braun & Clarke, 2006, p. 82). During this phase, data coding was the process whereby data were broken down, examined, compared, conceptualised, and categorised according to families to form themes (Kvale & Brinkmann, 2009). The extended central organising concept that highlighted the analytic interpretation for the data was called the 'theme' (Braun et al., 2019). This was an 'active process' whereby themes were constructed rather than discovering or searching themes (Braun & Clarke, 2012, p. 63). Codes became the building blocks of themes since the code related to a very specific aspect of the data and the theme identifies a general patterning of meaning (Braun et al., 2019). The aim was not to confuse the identification of codes with interpretations and discussions. Related codes were labelled and grouped as categories by describing connections between them. There was a search for new knowledge from the perspectives of participants. The neutral voice as means to avoid interpreting the results was used. This was the peak of research where real situations were studied that meant particular facts. This was the stage where I induced the existing knowledge with the new facts. The chapters were coined with one another to maintain the objectives, research process, literature of the study, and the findings as denoted in Figure 1.2. I employed the method of solving the problems by noticing interesting things, revisiting sources, reflecting, and clustering that into topics or themes (Siedel in Nieuwenhuis, 2016, p. 110). The diagram below indicates what has been alluded to in Figure 1.4

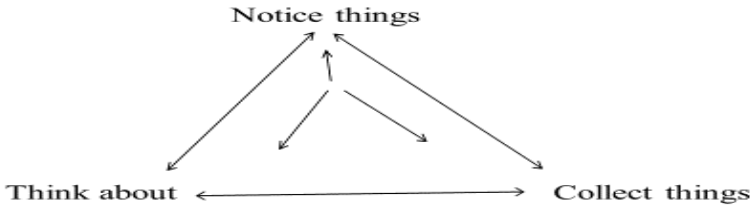


Figure 3.1 Data analysis process adapted from (Seidel 1998 in Nieuwenhuis 2016, p. 110)

This was started with open coding, where ideas bubbled up and were noted. The first round was done informally where the researcher wanted to identify the key concepts relevant for connectivism theory used as a lens. Secondly, it was to look formally for ideas that were cropping up. This was important for the researcher to identify related codes. This categorisation of codes was based on the relationship between codes and the underlying meaning across codes. The themes were formulated such that they provided a unifying framework for telling a coherent story about the overall data collected. This was done by exploring the relationship between themes and considering merging them. In this study, each theme was developed in its own right about the research question about other themes thus working towards concluding the research project by drawing a thematic map.

- *Phase 4. Reviewing potential themes*

The word 'potentially relevant' was used because analysis during this stage was not all categorised as all relevant (Braun & Clarke, 2012, p. 61). The potential themes were reviewed as the means for quality checking answers to the research questions. Themes were checked against the collated extracts of data. The strength of a theme was verified versus the normal code to discard themes with no relevant information in answering the research questions. The senior researcher was asked to verify memos to identify coherence (see chapter 3.3.2.2). The theme's properties were discussed to verify whether data to support that particular theme was thick or thin. Coherence was a priority in this identification of potential themes.

Phase 5. Defining and naming themes

Braun and Clarke (2006) talked about searching for themes whilst Marshall and Rossman (2016) educe meanings and articulates them into concepts and form concept analysis. This was a phase where the uniqueness of themes was clearly stated (Braun & Clarke, 2012). In defining and naming themes, deep analytic work was involved where sub-themes were joined to form one theme that was not overlapping the other one but with a single focus and answers the research question directly (ibid). Eleven themes were developed from this study.

Extracts from the data were extracted with data narratives where data were interpreted and connected to broader research questions and scholarly fields related to the data presented. There was a reflection of two broader thematic analyses namely; 1) descriptive, where data were

illustrative and 2) conceptual together with interpretative, whereby extracts were analysed to identify latent meaning on which they were drawn. After all the truths were presented, the analysis reached its peak by addressing the 'so what' question (Braun & Clarke, 2012, p. 67). The further attestation was on 'a have a go…' where they suggest hands-on activities for trying out and have gaps filled (Clarke et al., 2017, p. 45). The aim was to present data by referring back to the gaps that were identified in the literature (see chapter 2.8) and make sense of what the new information presented. This was the stage where data had to make sense by moving from a level of analysis to an analytic understanding. I identified similarities and differences which altered my understanding (Braun & Clarke, 2019). Abductive reasoning was used here where interpretations of the theory for the data were obtained with assumption to get an explanation from empirical evidence (see Table 3.5). The struggle was to move from the data into new ideas. This was supported by Brennan (2017) on insisting that the abductive processes can be creative, revolutionary, and intuitive. As a doctoral student, abduction enabled me with the most plausible explanation; my themes and recommendations explain "why things are?" (Nieuwenhuis, 2016, p. 120). This phase challenged my interpretations and I moved toward theoretical sufficiency (Hesse-Biber, 2017. Findings were contextualised within the body of existing knowledge on the topic and explored the ability of how it corroborated with what was already known as well as the new insight collected from this research (Nieuwenhuis, 2016). Firstly, interpretation of results from similar or previous studies published in relevant sources. Secondly, considering the theory of connectivism that was used. Theoretical saturation happened when the emergent framework that stems from the literature and new data was adequately developed to fit future works (Gerber et al., 2014).

- *Phase 6. Producing the report*

When producing report writing, scholars warned against focussing on observation and participating while neglecting the importance of having skills for report writing (Daymon & Holloway, 2021; Gehl, 2018, De Vos et al., 2011). Braun and Clarke (2012) insisted on the purpose of producing a report which is clear and convincing while aiming to provide a compelling story about data based on the researcher's analysis. When making a report, the focus was ongoing beyond description to make an argument that answers the research questions. Themes were logically and meaningfully arranged to present a coherent story. Writing the report involved balancing and weaving elements to have a sound presentation. All the choices that the researcher has chosen to follow were adhered to and given the reasons why

things were done. Careful consideration of steps led to the credibility of the study as all the strategies to present were filled with soundness, validity, and articulation of participants' deep truths. This led to the production of this thesis.

3.4 CONCLUSION

This chapter has presented the researcher's study philosophy, research methodology, and research design that was employed in this study. The site selection and the sampling used in collecting in-depth knowledge using the case study were explained. Employing connectivism theoretical perspectives aimed at exploring the participants and development of discussion, discoveries, and new knowledge. In this qualitative research, there has been no set of rigid rules set for identifying data collection tools, but the credibility of the research results relied on the appropriate application of data collection, documentation, and analysis.

Critical discussions of the findings follow in the next chapter guided by the main objectives of the study as well as the research questions. The congruence of the findings together with research questions, aims, objectives, problem statements are discussed in chapters four and five of this study. The next chapter gives the full consideration of data analysis using thematic analysis. The whole qualitative research outline was interpretive with that whole symbolic understanding together with some degree of interpretation which was informed by the researcher's personal and social meaning in the naturalistic connectivity setting.

CHAPTER FOUR

DATA ANALYSIS AND FINDINGS

4.1 INTRODUCTION

This chapter focuses on the analysis and findings of the study. As discussed in chapter 1, section, 1.4, the main aim of this study was to explore the social networks users' perception of mathematics pedagogy. Therefore, the main research question was: "*What are the users' perceptions of mathematics pedagogy on social network platforms*?" The findings will be presented by the research questions (RQs) derived from the five data collection strategies as described in chapter 3, section 3.3. Thematic analysis was followed in the study where data were coded and interpreted (Braun & Clarke, 2006). For ethical reasons (see chapter 1, section 9), special codes represented participants' identities. In the semi-structured interviews, for example, the code 'T1' represented the first teacher; the letter 'A' refers to school 'A' with similar letters representing other schools. The code 'FG' represents the focus groups in the participating schools. For simplicity, code 'FGA' represented a focus group in school A, and lastly, the letter 'L' represented the participating learners.

1. What types of social networks do teachers connect with learners to share mathematical content?
2. To what extent have learner-teacher interactions taken place?
3. What technological methods prevail in the learners' discovery of mathematics content knowledge?
4. To what extent has teaching and learning taken place through social network interaction?

4.2 PRESENTATIONS OF THE SEMI-STRUCTURED INTERVIEWS

Three participants (TI, T2, and T3) took part in the face-to-face semi-structured interviews. The demographic characteristics of participants (Table 3.2) were considered, and it has been noted that all the participants were residing in the uMkhanyakude District and were isiZulu native speakers. A shortfall highlighted from their qualifications was that two of the participating teachers were not qualified to teach mathematics; one of them was still furthering studies towards mathematics education. It has been explained in Chapter 3 (Section 3.3.2) that there were two sets of interviews: pre- and post-research interviews. In this regard, 12 different questions were probed for the pre-and-post research interviews since they were formulated to

explore teachers' perception of incorporating social networks as means of enhancing after-hours mathematics pedagogy. The following section presents the findings from the pre-and-post research interviews.

4.2.1 Pre-research findings

This section presents the findings from the pre-research data. The pre-research aimed to explore the types of social networks used by teachers to connect with learners for content sharing before the intervention. The qualitative analysis harvested two themes discussed in the following sections.

Theme 1: Inadequate use of ICT policies and regulations promote mismanagement and risks to ICT equipment

All the participating schools do not follow the policy, rules, and guidelines to manage and secure the ICT equipment. When asked whether the schools have an ICT policy, all the participants (T1, T2, and T3) responded uniformly that they heard about the policy but have not seen such a policy in their schools. To elaborate on the notion of inadequacy, one of the participants (T1) confirmed, "*I have not visited it* [policy] *recently but since there were computers here at school; no learner was allowed to go to computer room without the supervision of the teacher."* Another participant (T3) expatiated on the same notion and states, "*At times learners just used to go to the computer lab and play games".* This means that schools have some restrictions to guide and regulate access to computer rooms. However, the rules were no longer being operationalised due to theft and vandalism of computers "*Now no one is bothering about this policy because there are no computers"* (T1). Other schools have designed some stringent measures on learners' use of cell phones during school hours. Schools are aware of learners' usage of cell phones and that their use during contact sessions may disrupt teaching and learning. For this reason, one of the participants (T1) responded on cell phone management at school and mentioned that "*No learner is allowed to bring a cell phone to school. Should that learner be found the cell phone will be taken and the parent will be called*" In support, another participant (T3) adds, "*The only thing that is commonly 107mphasized when monitoring learners is that they are not allowed to bring their cell phones to school not to mention using it".* This suggests that schools have only focused on the negative side of cell phone usage at school, and could not view cell phones as a teaching and learning tool.

Theft, vandalism, and lack of internet affected teaching and learning with technology at the participating schools. The participating teachers generally explained their challenges to use technologies for teaching and learning. These result from computer theft and vandalism of schools. One participant (T1) mentioned "*There isn't any computer. They were stolen, it was a very sad thing, also they were useless because there was no internet.*" Another participant (T2) in support of the given challenge stated "*There are no computers they were stolen.*" T3 echoed the sentiment, "*We had the resource room with computers since we are the full-service school, I think they were twenty… Instead, they are vandalised.*" This means that schools had computers that would have advanced teaching and learning activities. This suggests that schools lack technology resources for teaching mathematics. One participant (T2) explained, "*There are none* (technologies)*, except going to the class with the chalk and the textbook.*" This means that teachers have not changed their teaching approaches, they still rely much on chalk and talk. The data suggests that due to theft and vandalism the number 9 millennium goal of ensuring resilience in adapting to ICT needs among rural schools could not be reached by schools. Consequently, approaches to teaching and learning could not be transformed. In this regard, schools could not meet the 21st century skills of using digital media to communicate and share pedagogic content.

In addition to schools being exposed to theft and vandalism, there were challenges about the lack of ICT resources such as the internet. Participating teachers lamented that their attempts to have these resources did not bear any fruit. One of the participants (T3) attested "*Here there are no resources except the books. We have a resource room with computers; the problem is there is no internet. Cell C is available here for communication only but to use it for data the signal coverage is very poor. The government promised a long time ago to install the internet for us, but up to this far nothing has happened*." This suggests a lack of technology resources for teaching and learning. However, schools were not innovative enough hence they have been waiting for the government promises (T1; T2). Despite the lack of ICT resources in schools, some of the participating schools benefited from the help of teachers. In this regard, one of the participants (T3) explained, "*I use my cell phone to access the internet because here at school we are not yet connected. I download information for the class. I use my internet to get more practice for my learners. I use it more for the Grade 11 classes where I take also the projector to the classroom*." Though participants used their internet to access information for teaching and learning, some still lack the relevant knowledge and skills of using the internet as a

resource. One of the participants (T1) mentioned *"We need training in accessing the relevant site where we can download work, photocopy handouts and have them distributed among the learners*." This would suggest professional development programs for teachers.

Theme 2: Social network platforms benefit users

It has been found that the use of social networks enhances communication between users. The data proved that all the participants used platforms such as WhatsApp (T1, T2, and T3); Facebook and Instagram (T2, and T3); and Twitter (T3) for communication. It seems WhatsApp was the most preferred platform due to its user-friendly and cost-effectiveness (T3). Though the participants mentioned the use of the platform for communication purposes, neither of them indicated the use of these platforms for communicating or sharing information with learners. Unlike participants (T2) who used to communicate with class monitors for emergencies, other participants such as T1 do not feel comfortable sharing their cell numbers with learners. The fear was that learners would have an opportunity to be mean to teachers or scold teachers. The participant explained further that he would struggle to separate his professional life and private life if allowing learners to communicate with him on social networks.

The data in this regard suggest that cell phones could enhance extensive communication between teachers and learners. However, to some extent teachers were not comfortable with using social network platforms with learners. This suggested that teachers were skeptical of giving learners their numbers since they demarcated that as contravening their personal spaces. They further showed fear that parents were not supporting the use of social networks by their children. This notion was further elaborated by T2 saying, "*I am sure perhaps the most parents who are traditional, will not allow their children to use this. I have never thought of interacting with them after hours. It will be a hard thing in our community*."

In contrast, the participating teachers (T2 and T3) viewed the use of the social networks as something that may benefit both teachers and learners as it did in other levels of life, though they have not as yet tried it. One of the participants (T2) believed that the use of social networks in teaching and learning would extend meeting learners who have been absent from school such that they are not left behind with their school work.

4.2.2 The post-research findings

Three participating teachers participated in the post-research interviews that sought to find out the extent of learner-teacher interactions through the use of social network platforms. The qualitative analysis harvested two themes that are discussed in the following section.

Theme 3: WhatsApp platform improves collaboration, learning and overcome shortages of resources

The use of WhatsApp enhanced communication and collaboration amongst users. WhatsApp as a social network platform was preferred mostly by participants from different schools. All the participants (T1, T2, and T3) from the semi-structured interviews confirmed that learners were interested in using WhatsApp as a social network platform. The use of WhatsApp in teaching and learning has to some extent improved communication as well as discipline in schools (T2). Learners could collaborate and share knowledge on the WhatsApp platform. This notion was confirmed by participant (T1) who explained that "*Learners can show others how they got the correct answer, could revise and come up with the not yet studied materials in the WhatsApp group*." This means that learners' engagement on social platforms has improved the learning of mathematics, while at the same time they built confidence in sharing their ideas of working out mathematical problems.

Engagement on the social platforms has to some extent involved communication and learners' discipline at schools. One of the participants (T2) alluded to the notion of both communication and discipline and explained, "*Teacher-learner and learner-learner communication improved extensively. It was very interesting to see how disciplined were learners when communicating after hours.*"

Communicating and engaging with learners on social platforms provided teachers opportunities to process learners' work. One of the participants (T3) stated "*Using the group conversation in the afternoon allowed me to mark the classwork informally and in a relaxed environment."* This means that social network platforms in teaching and learning have has to some extent brought up brighter indicators for the learning of mathematics in schools.

WhatsApp as a social network created learning opportunities, engagement, and interaction between teachers and learners as well as between learners themselves. Participation on social network platform WhatsApp specifically, aroused learners' interest and fascinated them towards learning mathematics. All the participants (T1, T2, and T3) confirmed that participation in social network platforms was fun in such a way that learners were not willing

to stop engaging in learning and exchanging their ideas on the social platforms. One of the participants (T3) explained briefly the interest of learning on the social network platforms, "*Learners are coming out of their cocoons, they can now state when they are lost. The one who grasps learning could boldly voice it out with an offer to assist other learners*." This suggests that interaction on social network platforms provided learners with the strength to do more practice of mathematical activities. This notion was confirmed by one of the participants (T1) who explained how she tracked the learners' improvement, "*I compare the classwork before for Learner 3, which was prior and after the group was formed. It shows that he can achieve good results at end of the year.*"

Engagement in social network platforms provided learners the opportunity to become creative (T2) as they could initiate discussions without the presence of their teachers. In this regard, participating learners in social network platforms could explore new information (T3) and come up with new methodologies to solve their learning problems (T1). The participants further saw online communication and engagement as a platform to cater to learners' individual needs. Participating learners communicated individually and as a group, and were easily identifiable in the classroom. One of the participants (T1) confirmed the benefit of learner participation in a social platform, "*Those who were in the group were beginning to shine in the class*". This suggests that learners' performance improved immensely through the use of social network platforms. This notion was supported by T3 who explained that "*their performance improved ...marking and assessing learners understanding became easy as they were interacting in the group*".

Teacher-learner interaction in a social network platform assisted shy learners who could not argue and give answers to questions posed in the normal classroom situation. One of the participants (T3) explained "*The learner-teacher interaction previously was not there at all. There are learners that could not say anything in the class, but who are very active in the group communication*". This means that learners prefer participating in social network platforms than in the classroom situation where there is face-to-face contact with other learners and the teacher. In support, one of the participants (T1) explained "*You know in the classroom you keep on asking them to answer your questions. To my surprise I did not beg for the answers in social network platform. They were more willing to keep on trying*." Another participant (T3) shared the sentiment, "*Learners ask for learning tasks and answers during the class and after the class intervention*." This suggests that learners felt comfortable in social network platforms than in a normal classroom setting. It was amazing that participating learners kept on asking teachers

to continue working with them online, while the same could not happen in a normal classroom situation.

It was not surprising to learn accordingly as one participant, T1, mentioned that the tension that has been experienced between teachers and learners in the normal classroom situation has been phased out. This would suggest that the process of online learning had some bright indications. To elaborate on the performance indicators, TI compared the performance of one of the learners' works prior to the involvement of social networks and after the use of the network. To him (T1) there was an indication of better results at end of the year. One of the participants T3 attests that "*I almost know now the intelligence level of all the learners in my class and where they are lacking."* This would suggest that the teacher managed to know his classroom and where they were lacking since they could interact with him after hours. Knowing the intelligence level of learners is noted as the important yardstick in teaching and learning pedagogy, hence it was achieved during the interaction.

It was clear from the data that through the incorporation of WhatsApp platforms, individual learners could practice and learn mathematical skills. In contrast to the normal classroom situations, participants (T1, T3) explained that learners grew in mathematical literacy and confidence and it was easy to detect the learning difficulties. This suggests that necessary interventions and precautions were taken to monitor learning, and that learning difficulty that prevails before a final assessment could be handled accurately. In this regard, one of the participants attests that "*Knowing learners closely involves knowing them using eye contact and causing them to talk.*" Unfortunately, in these rural schools, overcrowding was prevalent, thus knowing them on face-to-face contact was impossible.

Teacher-learner engagement in WhatsApp increased the discovery of knowledge. All the participants (T2, T2, T3) confirmed learners' discovery of new knowledge in mathematics and their willingness to share knowledge with fellow learners. This was explained as follows:

> "*They could revise and come up with not yet studied materials in the WhatsApp group*" (T1)
>
> "*Learners at times coming with mathematical problems that were challenging ...they surprised me the way they are so keen to answer and trying to assist one another*." (T2)
>
> "*I used to be surprised when learners come to answers using the method that I haven't taught them*." (T3)

These suggest that learners could be proactive in their learning; think critically and formulate new algorithms. The interaction paved the pedagogical shift in the teaching methods from teacher-centered methods to learner-centered methods. This was noted when learners managed to come up with work that had not been handled in their classroom and were willing to attempt getting mathematical solutions and formulating new strategies of learning.

Theme 4: Lack of digital resources, knowledge, and skills challenged teaching and learning

Lack of resources made participation on the platform difficult for users. This would include lack of data to enhance learners' connection to the internet (T2). This affected learners' participation enormously as one of the participants (T1) confirmed, "*Many learners were willing but the response as you could see was very poor during the discussion*." This would suggest that the participation of learners was dragged somehow by some contextual and economic factors. It has been found that teachers lack digital knowledge and skills to design interactive mathematics lessons. One of the participants (T1) confirmed the notion of poor digital skills as follows, "*I was scared to post because I could not write some symbols and I was so surprised when my learners just easily wrote them. It would be better if we posted the ready-made problems to work out, but now writing, cutting, pasting and formulation of clips was very challenging*." Another participant (T2) shared sentiment to the digital literacy skills and stated, "*I would struggle with how to write mathematical signs. It is a hard thing ever. I would end up watching their* (learners) *conversations*."

Lack of digital resources, knowledge, and skills also appeared from the non-participant observation data. The data from the observations revealed that teachers could not design lessons that engaged learners as members of the learning community. The lessons were designed using traditional methods of teacher-centeredness rather than that of involving learners as active participants. This would mean that teachers could not use different alternative modes of mathematical problem solving that include the usage of technologies, let alone encouraging learners to seek different solutions.

In school 'A', the teachers intended to complete the syllabus without generating a room where learners could make their inferences and enjoy the trial-and-error methods.

In school 'B', learners were not encouraged to construct their lesson, they were passive.

In school ‘C’, learners were allowed to demonstrate what they have learned using the chalkboard.

These observations mean that teachers did not encourage learners to seek and value alternative modes of problem-solving. This was evident in school ‘B’ where one learner asked a question that was not yet covered. The teacher told the learner to wait for two weeks until they arrive at the particular topic. This suggests that the teacher was keen to use one teaching method which was lecturing and learners were not encouraged to solve problems on their own.

However, learners’ prior knowledge was given priority. In this regard, teachers reminded learners of their previous lessons. In school A, general knowledge was discussed and in school C, the lesson started with revision from what was learned from the previous lesson. Unfortunately, school ‘B’ did not refer to prior learning. Learners (school A and B) in this regard were presented with challenging questions that pricked their intellectual rigor. This made the lesson interesting as learners were engaged. It thus suggests that learners are always willing to be involved in their learning as long as the teacher is patient with them. The highly noted reference to this was school B whereby the teacher was not patient at all with learners. This brought further attention to learning that although the lessons in schools A and B were interesting, the objectives could not be attained. This could mean that although learners were full in the class, handling individual learners was important to prickle mathematics zeal. The teachers’ patience with individual learners could as well have played a massive role in enhancing learners’ mathematics knowledge. The lesson was not contextualised and could not meet the overall critical outcomes as stated in CAPS. Teachers just aimed at delivering the content. They were not referring learners to what they were familiar with; like giving an example that would be more contextualised.

Despite the challenge of digital literacy, data suggests that teachers were technophobic since they were scared to try new things on a social network platform. In this regard, T3 did not know how to use voice clips and observed how learners used them. Ultimately, the voice clips were useful to clarify concepts verbally rather than by typing. This indicates that learners were ahead of their teachers and comfortable with using the platform, whereas their teachers struggled and became onlookers. To this, teachers had no choice but to learn from their learners. In this light, T2 confirmed that, “*This demanded the teacher who likes texting so that will read their writing and answer them instantly. I decided to try what they were doing, like using voice notes that facilitated effective and quick response*.” The data in this regard suggest that teachers became

the followers as learners were discovering their learning. Interestingly T3 confirmed that he copied what learners were doing since he did not know how to use voice clips. This informs the study that there were teachers who could not text nor formulate some voice clips.

The notion of teachers' poor digital skills, limited the promotion of learner information discovery (T3). This limitation could have to some extent been caused by lack of information literacy skills. One of the participants (T1) explained this challenge and states, "*Teachers and learners need the proper training on how to access the internet to get more knowledge. That shortage of exposure caused the barrier also to promote learner information discovery because I could not direct learners to the proper site for more practice. So they ended up relying upon me and their class book and the resources since the library is also very far*." This means that learners could have performed very well if they had teachers who were experts in incorporating social networks into teaching and learning. These teachers even doubted their computer literacy skills. One of the participants (T3) attested to this notion when stating that "*I think there must be some computer literacy that we as educators* (teachers) *can go through*." This suggests a gap in teachers' preparation for using emerging technologies.

The teachers' limited digital skills further affected learner participation on the platform due to teachers' struggle to source and select relevant content that will steer discussions (T1; T2; T3) on the platform. Teachers believed that if they had a readily resource available to post on the site, it was going to be more interesting to learners. This challenged them as they had to think and struggled with posting suitable and relevant material. Participant T3 explained this further, "*This is because I have noticed that these communications also demand the educator* (teacher) *to have questions, solutions, and practices at hand. With me, I could also have to struggle thinking where to get the exercises which will be clearer but in a very brief structure*." This suggests a gap in the use of emerging technologies to enhance the teaching and learning of mathematics.

The intentions of learning on social network platforms were not well understood by some of the learners. It has been observed from the data that in cases where learners participated maximally, there were some indications of meaningless learning. Some of the learners "*view WhatsApp as a nice platform to chat with their classmates, or even talk all their vulgar languages*" (T2). This would suggest a need for a policy that will alert users against cyberbullying. Although learners could be creative and initiate the discussions, when not properly guided, their interaction would be less fruitful as far as enhancement of learning is

concerned.

Time was also a challenging factor to the participants (T1, T2) as they could not mark the learners' activities and know whether they are ready for the new topic or not. Due to time constraints, participants posted the sum and let learners do it without them (teachers) monitoring who gets it right or wrong. To this, participants would then come up with the correct answer after learners completed the activities. Participants believed that learning could have been interesting if they had more time. This would suggest that the platform demanded teachers to sacrifice more time it occurred after work. T2 complained that "*It was taking my time in the afternoon. Some of the learners were not serious with what was the intention of this communication*." This indicated that teachers need to craft their tasks by designing activities that will keep learners challenged and solve mathematical problems on their own.

4.3 PRESENTATIONS OF THE FOCUS GROUP INTERVIEWS

This section presents the analysis of the two focus group interviews. The purpose of these interviews was to ascertain the periphery of teaching and learning that took place during WhatsApp communication. For ethics, the responses were given the code 'FG' which referred to the focus group, and the letter "A' to the particular school where the focus group was found. Therefore, code FGA would refer to the focus group in school 'A'. Numbers were allocated to locate a particular learner found in three schools. For instance, FGA1 refers to the first learner in a focus group of school 'A'. Two themes were constructed from this section.

Theme 5: Learners' perception towards WhatsApp tool

When asked the question about the networks they preferred to use, 11 participating learners (FGA1; FGA2; FGB1; FGB2; FGB3; FGB7; FGC1; FGC2; FGC3; FGC4 and FGC7) opted for WhatsApp more than the other social network media. Participants gave different reasons for using the medium. Some of these reasons included user-friendliness (FGB3), cost-effectiveness (FGA1; FGB1and FGB3), and being readily available in cell phones without the need to download (FGB3). Participants also mentioned that they could use WhatsApp to share videos, important information, emails, announcements, files; voice notes, and pictures easily (FGB7; FGC1 and FGC7). This means that participants knew the services of social networks, and had solid reasons why they preferred WhatsApp over other social network.

In as much as they would have opted for other social networks, they opted to use WhatsApp because they could not afford other social networks (FGC7, FGB1, and FGA2). Their option was encouraged by the ease to use and affordability (FGA1; FGB1 and FGB2). They could compare social networks and identified the ones that suffice the cost-effective reasons for having it chosen. Moreover, the ability to use R5 and acknowledge its value (FGA1 and FGB2) revealed the major individualistic opinion that is freely communicated. This meant that affording data was a major issue in this rural area. Learners in school B (FGB1 and FGB3) enjoyed the benefits of having Cell C reception which they could access some days. Nevertheless, they managed to get many friends and followers, look at profile pictures and laugh, look at beautiful ladies, because everybody does. This would mean that rural area learners also do not want to be left behind in the usage of emerging technologies and they were striving to pave their way regardless of the lack of exposure caused by their rural context.

WhatsApp created a platform for sharing among the participants, like sharing the learning content. This was confirmed by participating learners (FGA1, FGB3, and FGC4) who stipulated that contrary to their wishes, they never had an opportunity to share information with their teachers on social networks before the intervention. For learners to get their teachers' numbers was against the rule (FGB2) and that learners would be interested in looking at teachers' statuses (FGA1); using the platform to disrupt their teachers and use vulgar language (FGB4). For this reason, teachers' communication was only assigned to parents (FBA3, FGB3). Humanity (Ubuntu) spirit was perpetrated whereby sharing was done and learner relied on any parent with a cell phone for support. Attesting to this FGC5 said, "*I used to carry my sim card along because it has free data. When the time comes I will just ask anyone to borrow me for that hour to use it quickly*". This suggests a sharing spirit amongst learners and society. Data revealed that FGB1 used a sister's phone, while, FGB2 used a mom's cell phone. This was an opportunity whereby learners could explore ICT skills with guidance and support from family members; get the privilege of sharing their siblings' gadgets.

In all three schools, the integration of WhatsApp as an informal teaching and learning platform used after school was a necessary eye-opening event, which was perceived as long overdue.

Firstly, the absence of computers in two schools (A & B), even in the surrounding schools were confirmed. For instance, one participant (FGA4) attested that there was *"No school around that has computers. In all the surrounding schools they were stolen".*

Similarly, a participant (FGB1) verified the absence of computers in their school and even in the neighboring school when stating, "*I wonder what type of schools is the government supplying with the computers and the data projectors.*"

These indicate that learners were aware that some schools were having computers and projectors but not closer to them. These suggest that learners would have preferred to learn using computers but their rural context did not offer them those opportunities. Interestingly a participant (FGC10) mentioned that "*The computer room here was built in 2012 to assist neighboring schools, but still today there are less than forty computers and there is no internet.*" This would suggest that the participant was aware of their lagging behind in using technological means to enhance their learning and that the available computers were not serving the purpose as expected. It was shocking to hear the comment from FGC6 that these computers were "*waiting to be stolen by those boys who write DVDs using computers or DJs.*" Participants thought that these computers should have been used even without the internet. This suggests that participants viewed the presence of computers in their schools as dormant since they were not used, instead they will talk about the computers when they have been stolen.

Surprisingly, being in the rural area was not hindering these learners to know what is happening in other areas. A participant (FGB3) indicated that "*I used to love it when hearing what is happening in Gauteng, learners using tablets and the whole community is supporting them.*" This would mean that this participant perceived that learning did not involve the school setting only but also the whole community. Their learning without computers was perhaps boring since FGB1 mentioned that "*Learning is not boring at all when using computers and projectors.*" Moreover, there was a confession that in the class they became bored and asked permission to the toilets until the period is over (FGA4). This would suggest that participants' perception of incorporating emerging technologies was viewed as a priority for all learners to fight against boredom in the classroom setting.

In support of their perceived emergent technologies, participants preferred using tablets to books because there is no need to carry along exercise books (FGA2, FGA4, FGB1). Their idea of tablets over other resources such as books and desktops would suggest that the participants favored gadgets that will be carried along wherever they go; even after school hours and which will allow them to continue with their classroom conversations any time.

It was evident that the participants expected their learning style via WhatsApp to simulate real classroom context. For instance, the ability to visualize and comprehend was written on WhatsApp by all group members, discussing content without unnecessary repetitions. This idea was illustrated in the following:

Participant FGC2 mentioned that "*It was bad when people have posted something that we cannot see*" In addition to this FGC8, confirmed that "*I hated it when people are repeating answers as if they were delayed by the network where's it was obvious that they wanted to post correct answers after they have observed others.*"

This data suggests that other learners relied more on what other learners posted on the site, and in this case, their understanding could not be assessed. At times, they will post something which they have not comprehended but posting for the sake of posting. In support of this, FGC8 attested that "*Even if I am not sure of the answer no one will stop me to try my luck."* This suggests that learners were enjoying the freedom of participation without any boundaries.

The technological methods that participants reflected on in this study presented them with an ability to think critically and to voice their thoughts openly. There was a variety of learning acquired by learners from different schools. In school C, participants learned to be critical and to speak openly, but in school B, learners learned spelling and manners, while learners from school A could assess what was best for them. There was a change in learners' behavior due to their participation on social media (FGB1, FGB3). As learners interact with one another on the social platform, they became critical participants. For instance, FGC5 mentioned "*The method has pruned me to develop new skills of loving to do homework. Immediately when people have started posting I used to feel the need of checking their answers and comment. It was boring in the group when few people participated*." This would suggest that participants manage to critic conversations. Further noted on the platform was a change in how learners and teachers interact. Participants reflected on how advanced they can use technology. For instance, in his reflection, FGC4 stated "*I enjoyed giving at home the opportunity to download the app and use it."* This implied that learners in rural schools could use the 21st century digital skills and incorporate them into their learning. Surprisingly, they also managed to access worksheets on their own that they used for extensive practice (FGC4). To add on, FGC3 mentioned, "*I used to laugh always when the teacher uses emojis. I could see that xxx is struggling with getting the relevant one.*" This suggests that learners could have input and were drivers of their learning. They could forecast their future based on technological means. This was identified

when FGC5 echoed on the benefits of WhatsApp, "*I studied EMS and I was told that social networks are good for marketing your business, mh…. although I do not have a business now I am looking forward to having it one day. I have used WhatsApp so far but I am looking forward to familiarising myself with all of the other social networks."* This suggested that their learning currently is anticipated at benefiting them in the future.

Interestingly, learners were able to assess and rate their teachers. For instance, in School A, a teacher (T1) was replaced by another teacher. In this regard, learners could establish that the teacher loved his teaching in the afternoon. One participant (FGA1) declared "*I could see, now, the teacher was happy because he knew that there are people that will be following him during the lesson. Oh now since he is gone is boring. We are waiting for Miss to tell us what to learn.*" The extract indicates that learners could easily identify which teacher is excelling and which one is not. This would mean that their exposure to this interaction enabled them to equip themselves with the necessary skills required for a responsible 21st century citizen.

As a sign of respect, learners were scared of their teachers (FGA2, FGB2, FGC4) even when they meet their teacher after school they would run away (FGC3). Widening extensive communication was promising since learners were disciplined as they were interacting (FGB3, FGC2). Confirming to this was the communication channel revolution. Teachers' contact numbers were made accessible to learners not for emergencies only (FGA1, FGA3, and FGB3). One of the participants in FGA3 attested to this notion when stating that "*Yes my class teacher last year gave us her number and advised us to contact her in case we have problems and treat her as our mom*." This suggests that possibilities of having learners communicate with their teachers after hours were before the research used for urgent matters only.

Despite all challenges experienced by participants, the intervention brought some changes for better opportunities. Teachers and learners could exchange numbers and share information on a social network platform. It was interesting to hear that learners' fear was wiped away and interaction drove away skepticism. A participant from school B, FGC2 explained *"Things have changed. Our teacher used to remind us about the submission of the assignment or writing of the classwork when we meet him after school. So I used to run away when I saw a teacher at first."* This would suggest transition in learning through the creation of networked space, and that participants (FGA5) believed that teachers would feel comfortable sharing their contact numbers with learners. This further suggests that learners were longing to discuss informally with their teachers (FGC3) but there were no set structures for extensive communication, and

no teacher came up with the idea (FGA3) before and to have WhatsApp (FGC3) chat with their teacher. In this regard, participants together with their teachers preferred to use WhatsApp as an appropriate space for enhancing pedagogy. Learners were relieved to have the means to communicate with their teachers (FGC4), more especially when doing homework.

Given the opportunity, learners used the platform for revision purposes. One participant, FGA 2 confirmed that WhatsApp "*makes revision easy, why can't all teachers adopt the style?*" Also, a participant from FGB2 highlighted that *"I used to feel very obligated to participate because I will be reminded instantly about what we were learning at school."* It was interesting to observe the sudden shift brought by the use of social networks whereby education became the social issue. Learning shifted from classroom-based to learning anywhere and anytime. Participants (FGB1; FGC4) mentioned that even if they missed a lesson from the classroom they had the platform for catching up later. One of the participants in FGB1 indicated "*Even if they clean the board quickly I was sure that I will ask my teammates to give me those notes.*" Seemingly there was a shift from being reminded by their teachers about submissions (FGC2).

Learning through social network platforms promoted collaborative learning. One of the participants in FGA2 reiterated "*It was very interesting for me to know that when I am trying, the teacher is also there to correct me. I liked and enjoyed the moment very much because it was very unique from what is used to."* Furthermore, other participants (FGC3 and FGC6) mentioned that they could think critically, manage their time, and work with teachers and learners that are available on the net to guide them when going astray. The idea of thought processing was confirmed by a participant from FGC3 who mentioned, "*The formation of the group has helped us a lot to train ourselves in knowing that there is an hour that is set aside strictly for studying. I can now easily ask the teacher or other learners when I am stuck with my homework."* This suggests that learners could manage their schedules and think critically when using the platform. Another participant from FGC6 attested that "*I can now think faster and know that every time I get must be used wisely rather than looking cell phone as the tool for playing games and look at people's pictures."* This implies that participants used WhatsApp as a platform for learning.

Participants were gaining knowledge when using interaction as means of revision and they recommend having this idea extended to other subjects and other schools. In the same vein, FGC6 confirmed that *"We are the only school here that has started this group. I heard other learners who attend Neil High School (pseudo name) saying that they will suggest that they*

form also their group too." This suggests that learners foresee the expansion of WhatsApp as a learning platform.

Learners obtained support at home to do their revisions without disturbances. One learner from school C, FGC9 mentioned "*At home, everybody knew that I would quickly finish my chores and be ready for that hour."* Participants liked learning using cell phones because of having the feeling of a relaxed environment. An excerpt by FGC4 signposted, "*I wish I could just stay at home and learn with it all the day because the environment is very relaxed, no fear, and we are all allowed to try. In the class* (T3) *used to dominate us even if we want to try our thinking in coming up with the solutions.*" This suggests that WhatsApp learning space became their best option.

Other participants (FGA2, FGA4, FGB2, FGB3, FGC2, FGC3, FGC4, and FGC7) mentioned that they prefer Facebook and this would mean that this was the second preference of the social network. They opted for Facebook so that they could have friends all over the world (FGB3), use the platform almost every week (FGC4), to track their favourite people (FGA4), and have followers (FGB2), but were challenged because of the cost involved (FGC7) in accessing all these social networks.

However, besides Facebook other five participants (FGA2, FGA3, FGB7, FGC1, and FGC2) preferred Instagram due to its sharing potential. The participants explained that they can share photos with others, and enjoy being today's youth (FGA2, FGB7, and FGC1). Twitter was the least favoured network used by one participant (FGA3) who loved it because of it being used by descent people. This will suggest that their being in the rural area could not hinder them from what other youths are doing.

Theme 6: Challenges of using WhatsApp during research

It was unfortunate to learn that learners, even though they could afford WhatsApp, technological structures in their communities hindered them because there was poor reception (FGB1, FGC3). This portrayed an image that rural areas are lagging participating concerning technology developments due to poor internet structures and they are just the remote neglected areas. Interestingly also, what was professed as easy usage of WhatsApp was not experienced by others because there were participants who did not have phones (FGB1, 4, FGC1, FGA3). They were relying on assistance from their siblings. Others could not afford data (FGB, 1, 4, 7, FGA1, 2, 3, and FGC5). This would suggest that affording data among rural secondary

learners was a problem. This would have an impact on their integration of WhatsApp as they were using it to enhance their learning in the afternoon. In support of this, FGA3 attested, "*I use to work hard so that my brother would borrow me his cell phone with data. At times he would say I must bring it back early while the communication is still on. At least when my sister is around, it was a very exciting moment because I will use my sister's phone with confidence*." The extract declared that bringing back the phone while communication was still on, would suggest that this participant could end up demotivated to join the group due to disturbances that might occur. Also working hard as mentioned by the participants could lead to having participants focusing on the quantity of work done not on the quality of the communication. Further to this problem of affording data was when participants opted to post using cheap ways as means of avoiding using expensive means that will consume their data quickly. In support of this, another participant from FGC4 mentioned "*Snapshots* (screenshots) *were easy but to download them costs us a lot.*" This would suggest that participants would opt to describe what was on the screenshot to avoid posting what would cost them a lot. In such an instance, the meaning of the content would be distorted.

It was learned that some parents hated social networks. To support this notion, one of the participants in FGB2 indicated, "*Like myself, it was very hard for my mom to allow me to use her cell phone because she hates social networks.*" This elucidated the parental skepticism towards using social networks.

It was heart-breaking also during the non-participant observation to witness that teachers could also not afford learners full participation opportunities and creativity as they were using WhatsApp after hours. It was only in school C where the teacher referred and quoted an example that was handled in the WhatsApp group. Learners from the WhatsApp group were excited to lead. In school A, nothing was said about the group, whereas in school B, the teacher wanted those who were not in the group to feel that they have done something wrong. In school C, the teacher gave learners a chance to reflect on the chalkboard their understanding whereas in schools A and B the learners' understanding of the content was always determined. This would mean that learners' participation in the group could have been used to instill motivation since their conversation would be based on what learners were proud of. In such instances, learners could have been accommodated in the teaching and learning of the content (schools A and B). Learners involved in the social networking group could quote an example. This made them leaders in learning. This implies that learners were not guided to use their critical ideas both in WhatsApp and in the classroom (school A and B). Their passivity indicated that they

have not established full support for linking their learning to social networks. Though not all learners participated in the social network groups, cooperative learning, as well as respect for others' ideas, was still maintained in class. This suggests that the learner-teacher relationship was created. This steered active learner engagement and participation in learning activities. Two schools (school A and B) encouraged equal participation in both face-to-face and also in social networking platforms. Learners (school C) were allowed to demonstrate their alternative strategies towards the solution of the given problems. In all these, the teacher became a resourceful person to enhance learners' investigations. This suggests that learners' participation in online discussions could have paved a more positive mood in communication in the classroom.

In school A, there was respect for both teacher and learners but they were reprimanded for the wrong attempt in school B. This would mean that learners at times could be frightened to think aloud due to negative platforms (school B). Furthermore, it was surprising to learn that learners were not given an opportunity or extensive assistance to unpack their curiosity and unfold the unknown. Learners were attentive listeners and offered no room to come up with ideas that could drive the focus of the lesson. This would suggest that teachers were drivers of any communication towards learning and during such, learners could easily lose attention. Reference could be made from school B where learners were just making noise in front of the teacher. Learners were brought into intellectual rigor, and constructive criticism only in school C. There were minimal thought-provoking activities, yet in school B, evidence indicated that learners were energetic and willing to talk a lot. In short, this would mean that learners were not incorporated as members of the learning community. This was evident since, in schools B and C, learners displayed their eagerness to learn more. In schools B and C, group discussion was permissive, but in school A, learners were reminded to co-operate with the teacher by not making noise. This would suggest that learners were not granted full liberation in their learning such that even their participation was channeled.

4.4 PRESENTATION OF NON-PARTICIPANT OBSERVATIONS

This section presents the findings from non-participant observations. It is worth noting that some of the data were linked to the themes in other instruments to avoid the repetition of ideas. The data were collected from the three participating schools (A, B, C) which were located in the uMkhanyakude District area. The characteristics of the schools revealed that all participants (teachers and learners) were predominantly local people, with a balance of gender. The classes

were well distributed in terms of learner gender and ratio. The biggest class had 36 learners. All three schools had computer labs. Two schools' (A&B) computer labs were without computers due to theft. One of the three schools (School C) had computers without internet connection. The purpose of using observations was to identify the user's perceptions concerning the usage of social networks in enhancing the teaching and learning of mathematics after school hours. As discussed in Chapter 3, section 3.3.1, the RTOP was used to code the data for analysis (see Appendix 7). Two sub-themes developed from these observations; a summary is presented in Table 4.1 below. First, the teachers' lack of knowledge and skills to design interactive lessons is presented in theme 4. The second was the limited learner participation and creativity presented in theme 6.

Table 4.1 Reformed Teaching Observation Protocol (RTOP) Summary Schools A, B, and C

	School A	School B	School C
Background information	Learners 34; time 7:30-8:30	Learners 25; time 9:30-10:30	Learners 36; time 9:30-10:30
Contextual background and activities	Gender-mixed, Ethnicity-Zulu, Availability of computers for learners: computer lab computers stolen; Usual time of their participation: 4 pm-6 pm	Gender-boys many, Ethnicity-Zulu, Availability of computers for Learners: computer lab Computers stolen. The usual time of their participation: 4 pm to 6 pm	Gender-mixed, Ethnicity-Zulu, Availability of computers for learners' computer lab with computers plus overhead projector. The usual time of their participation: 6pm-8 pm
Lesson design and implementation	The teacher did not encourage learners to seek different modes of problem-solving. Learners were attentive listeners having no platform to come up with ideas that could drive the focus of the lesson	Teachers could not allow learners to voice out their opinions yet they were whispering to one another during the mathematics period. Learners asked questions, the response was to wait till they learn about it.	Learners were allowed to do some mathematical solutions on the chalkboard but they were using the similar method that the teacher taught them. Learners did voice out their ideas but were not assisted towards unpacking their questions further
Content	The teacher asked learners to formulate and write exercises on monomials and polynomials	I think learners were focusing on my presence they were not focusing on their teacher	The teacher gave learners a chance to reflect on what they have learned, only one learner demonstrated in the class

Communicative interactions	The teacher was only presenting the lessons. Nothing was said about the WhatsApp group	The teacher was very shy, wanted those who were not in the group to feel that they have done something wrong	The teacher referred to examples they have handled in the WhatsApp group. They even quoted it. Learners in the group were excited to lead.
Learner/teacher relationship	The teacher was respected and learners respect one another	there was no respect at all	There was respect in communication, teachers were respected, learners did not shout one who was attempting to answer but with a wrong answer

Table 4.1 clarifies that teachers were not that much lacking in Pedagogical Content Knowledge (PCK) but the gap was on Technological Pedagogical Content Knowledge (TPCK) because they were all relying upon themselves as the resources with no intervention of technologies. In all three schools, there were no means of enhancing learners to know how to investigate on their own using technologies. In school A, the teacher explained everything without allowing learners to investigate on their own. In school B the teacher was not confident at all to enhance learners. In school C, the teacher tried to guide learners as they were trying solutions on the board. This would suggest that these teachers were not used to incorporating their teaching into technology because they would have referred learners to some relevant sites for extensive reading.

4.5 PRESENTATION OF ONLINE DISCUSSIONS

This section presents online-learning discussions that happened between teachers, learners, and among learners themselves. Presentations here describe the interaction that occurred as a means of exploring teachers' and learners' perceptions, activities, and conditions during the research period from the 8th of February to the 25th of March 2016. However, their identities were kept anonymous according to ethical regulations. Two findings were constructed as the subthemes for theme 3 and theme 6.

Online discussion via WhatsApp was perceived by participants as having numerous possible benefits. For instance, overcoming the barrier of lack of resources. Under theme 3 subtheme was WhatsApp platform used to overcome the shortage of teaching and learning resources. The

shortage of quality photocopying machines and printers to produce numerous worksheets for extra practices was common in all the participating schools. Furthermore, learners mentioned a challenge where two learners would share a textbook. In other situations, they could not copy notes from the chalkboard as the board would be wiped quickly to provide space for other information. These provided no opportunities for learners to share their homework or discuss some strategies that would assist in solving mathematical problems after school. WhatsApp group afforded learners a platform to communicate after school, share content and knowledge.

The incorporation of WhatsApp in schools eradicated sharing of textbooks as a barrier since WhatsApp could be used for cascading information to both learners and teachers. WhatsApp also substituted printing hand-outs. Participants in this regard anticipated good results from social interaction. An illustration in WhatsApp group VGN 1 shows that learners appreciated their teacher. The learner from school 'A' drew the attention of his teacher by telling him that they were thankful for having this platform and making their teacher aware that they are trying "*sybnga, uybna Sir ukuth Syazama*" (LA). These were utterances that suggested that learners were appreciating having the tool and were committed to showing their teacher how thankful they were to be afforded the usage of the WhatsApp platform.

It has been observed that there were no boundaries of learning in WhatsApp and that the platform brought new knowledge and understanding in the classroom. Both learners and teachers acknowledged that there were changes from what was common in the classroom practice concerning information discovery and knowledge construction. In this view, data indicated that learners had a platform to share views and that benefited them in the group. Their daily commitment to attempt solutions to the mathematical problems on their own was noted from the online discussion from the three participating schools. This notion was confirmed by the following extracts:

"*if (x-1) (x+2) = 0 Then x =? The answer will be -1 or 2; 1 or -2*?" (L2 from school C).

This would suggest that learning was a constructive engagement between teachers and learners. However, the teacher in this regard put L2 on hold to attend to the problem the following day. This was possible because the platform served the purpose of continuous extension of discussing mathematics even after hours.

In contrast, learners could respond immediately to their teachers. One participant (T2) from school B posted the problem of converting fractions to decimals. The posting was done at 16:44, amusedly, at about 16:46 answers flew from learners. The flow of answers from

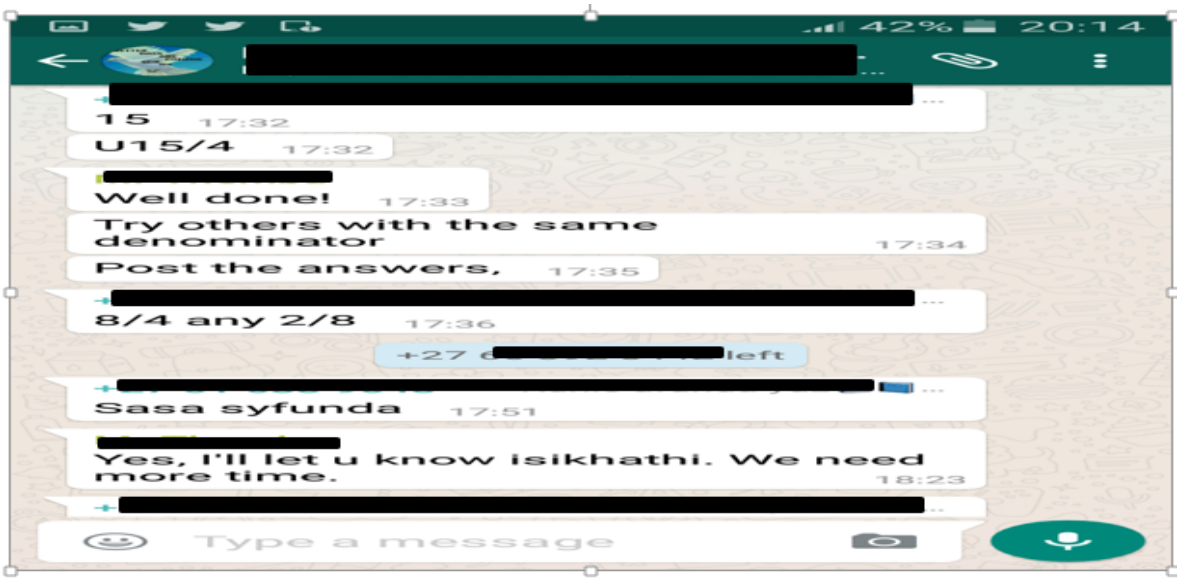
different participants showed that learners were alert and prepared to construct and share their knowledge on the social platform. This notion was evidenced by the following:

Where 1/3 is equal to 0, 3 when converted to a decimal. For the second equation Learner 2 from school B thinks the answer for the question 2/5 will be 0, 2.

This showed that to some learners, the platform could be detrimental such that they are quick to answer before thinking properly. Although it is assumed that learners in the 9th grade should know how to convert fractions to decimals, the answer provided by L2 seems to be guesswork. Interestingly, L3 corrected quickly in the group discussion. This suggests that L2 would learn from his mistakes and will never make guesswork in the future because other learners could come instantly with correct answers.

Nevertheless, communication on the social platform was not a one-man show, but a collaborative practice. This suggests that all participants had equal opportunities to provide answers to the posed questions, provided they were well connected. Evidence revealed that participants connect to the platform due to their common goals and interests. This made it easier for teachers not to beg learners to provide answers.

In all three schools, teachers' willingness to communicate with learners after school hours could not be underestimated. Services of the teachers were viewed within the out-of-school time. Thus, the time spent on WhatsApp during the group discussions varied. All the three groups did not spend less than their stipulated time of an hour; instead, they were observed spending more time discussing mathematics with their learners. There was evidence of learner motivation, problem identification, and learners getting a wider understanding of their mathematics classes after this engagement. WhatsApp group VGN 2 illustrates learners' motivation towards gathering online and discussing mathematics.

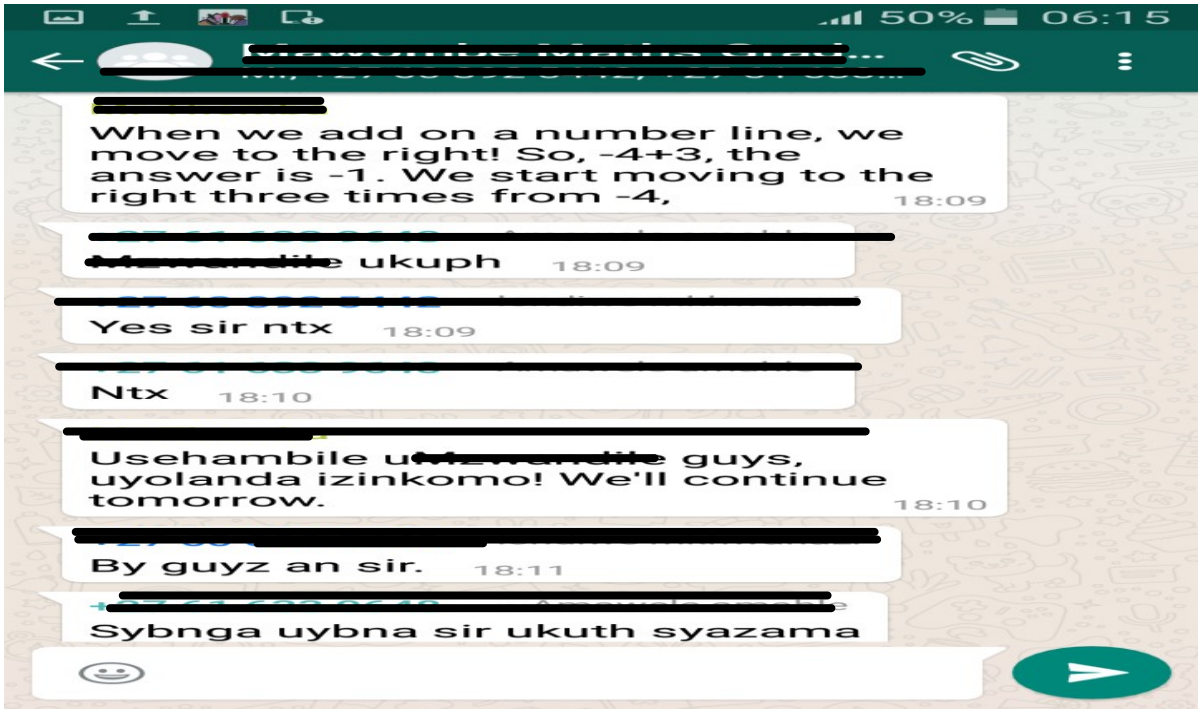


WhatsApp group VGN 2 School A 23/03/2016

It was evident from WhatsApp group VGN 2 that learners and their work were appreciated and they in turn gained confidence. Moreover, learners' sense of responsibility in allocating time for their learning was widened. In the WhatsApp group VGN 2, TA said, "*You will let me know*." The teacher shared responsibility to facilitate teaching and learning with learners.

This was also indicated by the post where learners enquired about the coming class on the following day. It shows that teachers needed to identify a suitable time for these communications as they happened during their spare time, using their cell phones and data, and trying to know their learners demanded a lot of their dedication into their career. In following this devotion, it was observed that it was hard for them to balance their extra time for this extra commitment such that in the vignette (WhatsApp group VGN 2) the teacher was hesitating about their fixed schedule.

Data featured in theme 6 with subtheme 6 about challenges of online discussion. Late responses of participants were witnessed from their participation on the platform. One of the causes of participants' late responses could be some family responsibilities. WhatsApp group VGN 3 indicates an aspect of interruption when participants were doing their homework.



WhatsApp group VGN 3 School A 16/03/2016

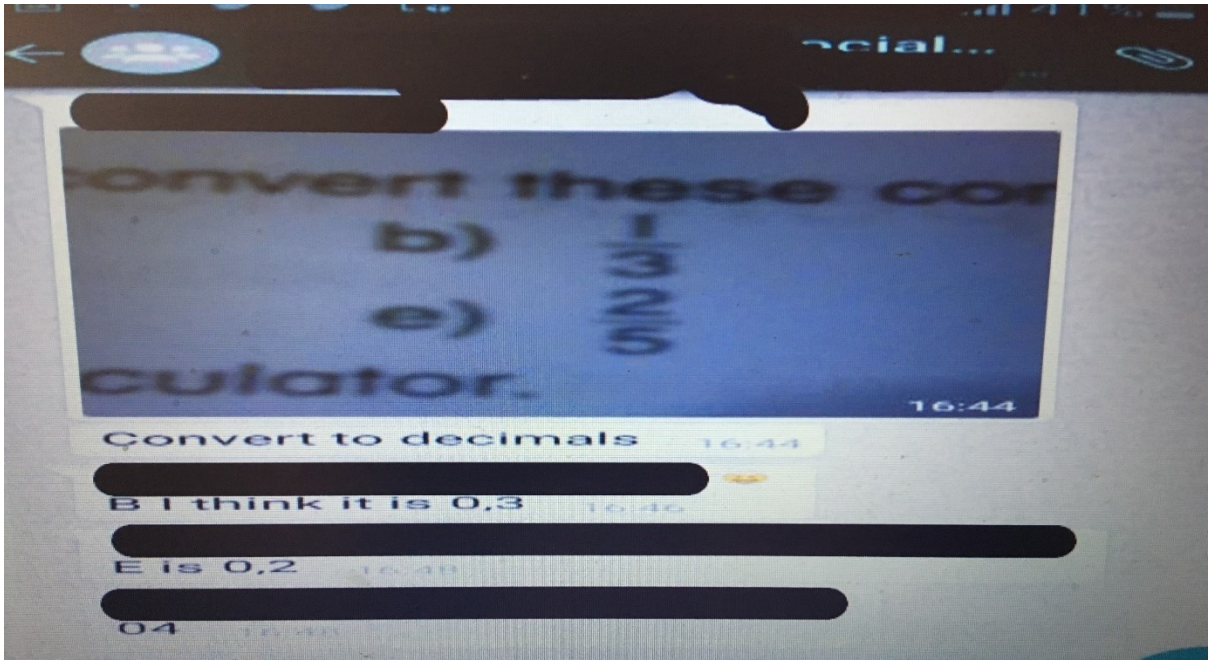
In the WhatsApp group VGN 3, participating learners experienced the challenge of participating in social platforms maximally. Some of the learners in the group were tasked with some family responsibilities of being herd boys. The other delay to their responses emanated from poor internet connectivity, which led to having some learners comment after the discussion has long been exhausted. In some instances, participants joined the conversation late and answered what has already been addressed. This might result from learners who wasted time greeting one another before they start the discussions of the day or unnecessary farewells. In WhatsApp group VGN 3, learners from school A said, "*By guyz an sir*" (meaning goodbye guys and sir).

The whole process would bring confusion to learners who are still struggling with mastering some problems because the message that disrupts the process would just come in randomly. Learners who joined the conversation after the discussion had started would struggle to figure out the meaning of that particular conversation unless they have someone to explain where the conversation started. It was not clear whether delayed responses were really due to lack of network connection or that learners intentionally dragged going online so that they get the opportunity to imitate other learners. Examples attested to this includes learners who repeated answers after the correct answer had already been uttered.

The disruption did not only affect those in the participating groups, it extended to other people such as family members who shared the cell phones with their children. Owners of the cell phones complained about messages that came up before and after the programmed schedule of interaction. In school B the parent was very crossed about messages that came before the programmed schedule which could have even limited the future benefit of having her child chatting with the group next time.

Data revealed an issue where learners were found misbehaving and the teacher kept on asking where they were? Similarly, teachers were challenged by the technology, they could not post relevant material and formulate videos, unlike learners. This suggested that learners were ahead of their teachers in aspects relating to the use of technology. The breach of communication while discussing online, opened a new page of teachers who were not sure of the content they were presenting. WhatsApp group VGN 3 indicates the breach of communication when a learner simply disappeared without reporting. This was noted when teachers would tell learners that they will continue tomorrow with their discussion or just put them on hold intentionally. Lack of technology skills was however prioritized as an inhibiting factor of effective communication. Nevertheless, participants were discussing out of their free will, driven by their self-fulfilling passion and the aim of having the group which was extensive mathematics discussion after school hours. It was also observed in numerous cases when the teacher (T1) from school A, would just apologise for not being available.

Apologies from the teacher could lead to assumptions that there were discussions that took place or maybe interactions were not happening because the teacher was technophobic. However, it became evident in online discussions that teachers' confidence was triggered as their posting what was not good. WhatsApp group VGN 4 confirms poor screenshot.



WhatsApp group VGN 4 School B 16/03/2016

It was evident from WhatsApp group VGN 4 that poor screenshots made participants assume that the posting was incomplete and that the particular teacher (T2) from school B was technophobic as he could not capture the whole picture with the instruction to learners. Instead of sending a single post, there were some messages following the post where the teacher gave another instruction to learners (convert to decimals). This could mean that T2 was still exploring the usage of social networks and was not comfortable posting some extracts from the worksheets. However, the teacher was comfortable with the communication making sense to the learners. This finding suggests that teachers are more sensitive to change since technology skills oblige them to adopt different teaching styles.

Akin to what transpired, another teacher (T3) from school 'C' posted a screenshot on the blue sheet with a blue pen. Learners complained that they could not read or see the diagram. All the three pieces of evidence from these technophobic episodes could mean that the teachers lacked knowledge of capturing clear screenshots and were unable to blend colours well as they were preparing online discussions. Using specific colours is one skill that is needed when incorporating technology in teaching, thus equipping teachers with presentation skills would enhance their technology skills.

Theme 7: Parental involvement motivates and encouraged learners to the learning activities

Learning on the social platform was monitored by the participating learners' parents at home. Parents were involved in their children's school work in such a way that they knew the starting times and ending times at which children would be engaged on the learning platform. Some of the parents would go to an extent of guiding their children when going astray. For instance, one of the parents complained about the platform about some observable learners' misbehavior. As such, the parent reminded the group that the phones belong to the parents. This suggests that parents were allowed to monitor and be aware of their children's learning. This could also mean that parents were available to support their children throughout their learning; guide them concerning cyberbullying, teach them the spirit of sharing, teamwork, and Ubuntu principles. In this milieu, learning became a social activity where families got involved. Additionally, the participating learners developed discipline in terms of time management. WhatsApp group VGN 3 illustrates the thought of time management and discipline.

WhatsApp group VGN 5 School C 23/03/2016

In WhatsApp group VGN 5, the data revealed all participants to be responsible, time conscious and planning for the coming lesson. This suggested that not only feedback was happening in these discussions but also feed forward where teachers would instruct the learners on how to

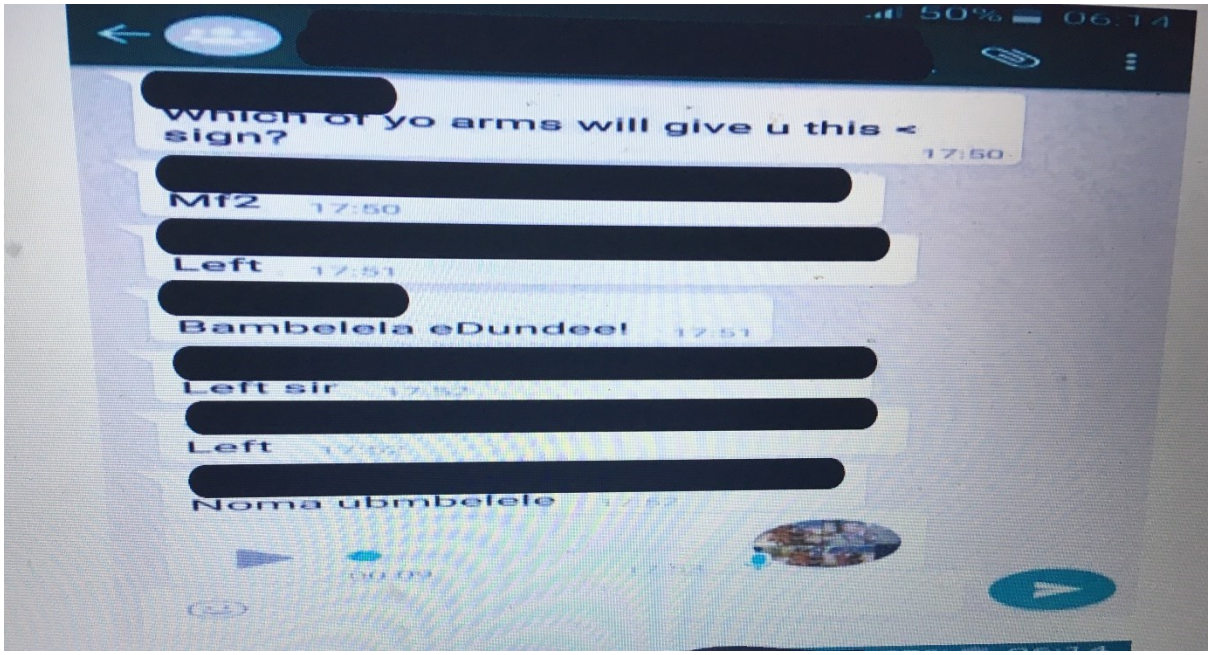
prepare themselves for future discussions. For example, L1 was working consciously thinking about not exceeding the time to take the phone back to her mom.

Theme 8: Participants adherence to netiquette and develop communication skills

Memoirs from virtual observation indicated that participants (both learners and teachers) adhered to issues of netiquette. It was evident that the participants cope very well without experiencing some cyberbullying. In all instances, the use of vulgar language was limited and respect to fellow users was witnessed throughout the research process. Instead, a fundamental feature of effective discussion during WhatsApp group interaction was observable in schools A and C where participants worked as a team. In these interactions, the teacher was not the only one provoking discussions, but learners also initiated conversations. Their communication involved virtual, verbal, and non-verbal communication skills. It was identified that there were some thought-provoking questions, arguments, corrections, and feedback. Others used the platform to recap and get some notes. One participating learner from school A approached the group members politely "*I am so sorry let us get another problem….. I feel bad for disturbing you, can you post for me."*

Technology skills, ability to share content and trust were observable in the data. Data revealed that there were individual benefits like empathy and caring while there were collective benefits too like team working and patience.

Interestingly, participants were free to use their mother tongue (isiZulu), English, and slang (WhatsApp abbreviated language). Learning was observed happening any time and at any place either using virtual (signs), audio, or written text message. In all three groups, no program was followed for the afternoon discussion. Seemingly code-switching enabled learners to learn mathematics easily and enabled them to share resources (scanned or screenshots extracts from books) easily. It was interesting to observe how teachers taught learners using their mother tongue and ethnic (local) language. The following vignette in WhatsApp group VGN 6 showed an instant attempt of learners' response to the questions.

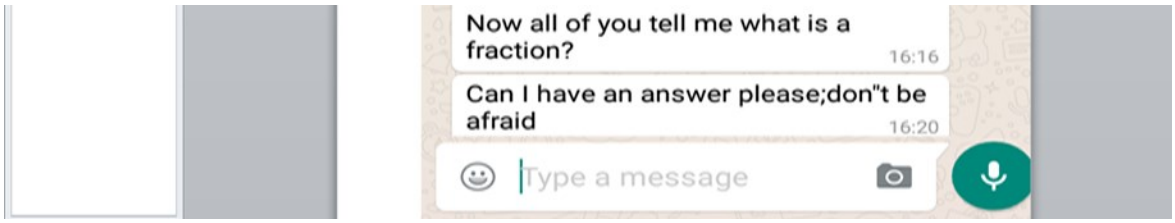


WhatsApp group VGN 6 School A 16/03/2016

Teachers used code-switching to explain mathematical symbols to learners. The teacher (T1) from school A firstly explained greater than (>) and smaller than (<) using mathematical signs, but learners were lost and the teacher ended up using the isiZulu concept "*Bambelela eDundee*" which meant to hold your hand in the hip when standing up straight (forming greater/smaller than using body language). The assumption could be learners were lost because they were not used to contextualise mathematical signs. This was one example showing how participants were during their online discussions using their mother tongue. Learners were also involved in the learning of algorithms where they had to practice and solve problems that involved sharing their views with their teacher. Proximity was not an issue as they were discussing in their platform, since the teacher could instruct learners on what they were expected to do with their arms. In instances where classroom interaction occurred, dyadic interaction happened (communication between learner and teacher). However, the WhatsApp platform supplemented conversation with triadic interaction reviving mental images of their conversation (see WhatsApp group VGN 6). Learners' involvement in WhatsApp activities after school developed meaningful learning. This results from their practice and engagement in extensive communication through WhatsApp. What was observed in the vignette (WhatsApp group VGN 6) was a dialogic process of narrative consciousness that replaced cultural tools, rules, conventions, and language used in WhatsApp conversations. It was a dynamic view of human cognition, a socially responsive discussion that deliberately self-

regulated itself to context and other participants' responses. Learners' development of their content knowledge was at stake from all fragmented sides. The willingness of participants to interact in the group was primarily all the teachers' concern. This would seem to suggest that the quality of the conversation was not highly scrutinized by teachers. However, the evidence from this study indicated the positive attitude from almost all learners in the group to pursue their discussions voluntarily. It was very exciting how they communicated the mathematics signs virtually to explain < / > signs and when others were lost, even the voice clips were used to clarify further. Audio responses were quick and errorless, especially withdrawing the relevant sign. This would have given teachers an indication as to whether learners received any assistance or perhaps copied the answer. Participants shared dialogues which were comprised of activity (practice), concept (knowledge), and culture (context) as it was attested in WhatsApp group VGN 6. The social network within the culture helped participants to develop their language since their belief systems were incorporated for a better understanding of mathematics. Learning as a team, collaboration, and having content that was easily shared added value and enhanced learners' self-esteem.

It was noted as a common thing in their communication to move between English and isiZulu. The whole process was diminishing the language barrier. The use of isiZulu could be used for clarification and breaking the tension of critical thinking. WhatsApp group VGN 7 indicates the anxiety that could be sensed by the teacher among learners being scared to think and speak openly.



WhatsApp group VGN 7 School B 21/03/2016

The vignette displays that learners were not free to communicate since the teacher insisted that they must not be afraid. This portrayed contradiction to what learners were willing to do since in many instances learners were able to communicate with their teachers using English and their vernacular. Displayed here was that learners were more relaxed when communicating in their vernacular.

Learners were observed maintaining new identities and inheriting the new culture; they were initiators of their learning. WhatsApp group VGN 8 captures learners' frustrations.

WhatsApp group VGN 8 School C 16/03/2016

Confirmation from WhatsApp group VGN 8 endorsed that learners could openly indicate when left behind in the lesson. They could duplicate material from other resources and post it for the benefit of their peers on the WhatsApp platform. Learners focused on chatting to get assistance either from peers or from their teachers. They could come up with problems on their own and could not wait for the teacher to start a conversation or to give answers. It was noted in all three schools that on certain dates participation in the group was poor. For instance, from the 8th of February to the 25th of March 2016, communication was poor. Perhaps most of the siblings were getting paid and could not be around with their phones.

In school A, T1 apologised and postponed the meeting. Three learners continued with their conversation without their teacher.

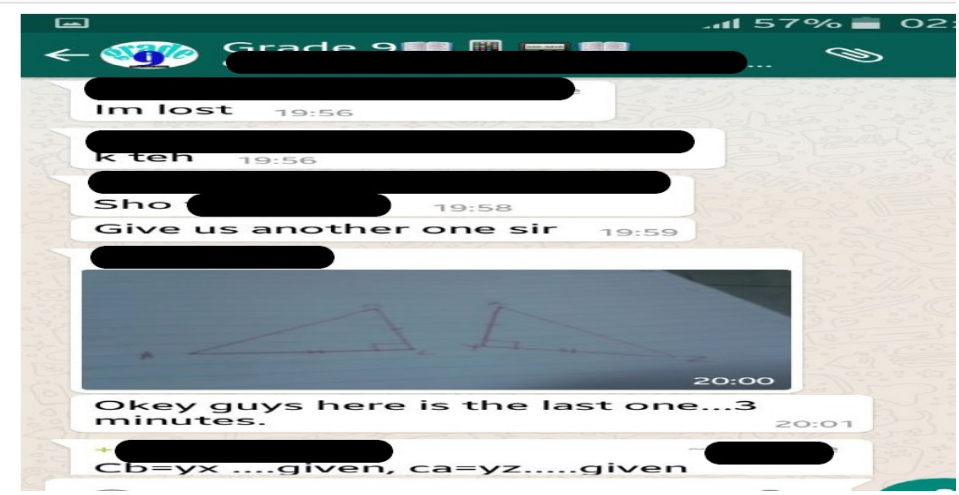
In school B, T2 was furious because only three learners were available.

In school C, T3 did not turn up and there were two learners. These learners reminded one another of the task in their book and called for corrections from their peers. *"We are only two so… let us talk maths.*"

The instances in three schools indicated that learners were not discouraged when their peers or the teacher is not showing up since they intended to benefit and learning on daily basis. This could mean that learners perceived their social interaction as fundamental in their learning which involved their development and ability to work independently.

Furthermore, it was noted that when learners were left alone or promised feedback by their teacher, they could not wait for their teacher but started their conversation with the teacher joining them later. This suggested that teachers create environments that would stimulate inquiry and discussions among learners. The teachers' thoughts were authenticated only by the veracity of the learners' rational thinking. In the same way, teachers could not think for their learners or could they impose their thoughts on them. Thus, learners were observed as not

passive at all since they could dictate their needs and shortfalls openly. WhatsApp group VGN 9 enables the teacher to know when learners are still grasping content or not.



WhatsApp group VGN 9 School C 24/03/2016

In the WhatsApp group VGN 9, learners' rational thinking was acknowledged when the learner openly stated that "I'm lost". This advocated that in this platform learners could shout when mislaid and that implied the potential of reflecting well to the individual style of learning. Interestingly, when participants assessed the support before the project, learners knew that the platform could be used as the ever-present support structure. The identified learners' dictum implied that learners were liberal to signpost when encountering challenges in their conception of knowledge.

Theme 9: Teaching and learning strategies to knowledge sharing

Participants' engagement was focused on special pedagogical benefits. There was evidence that learners could use their preferred ways of learning which involved reading, listening, discussing, watching, and doing. Learning made sense to learners and their teachers. That was noted from the screenshot in WhatsApp group VGN 10.

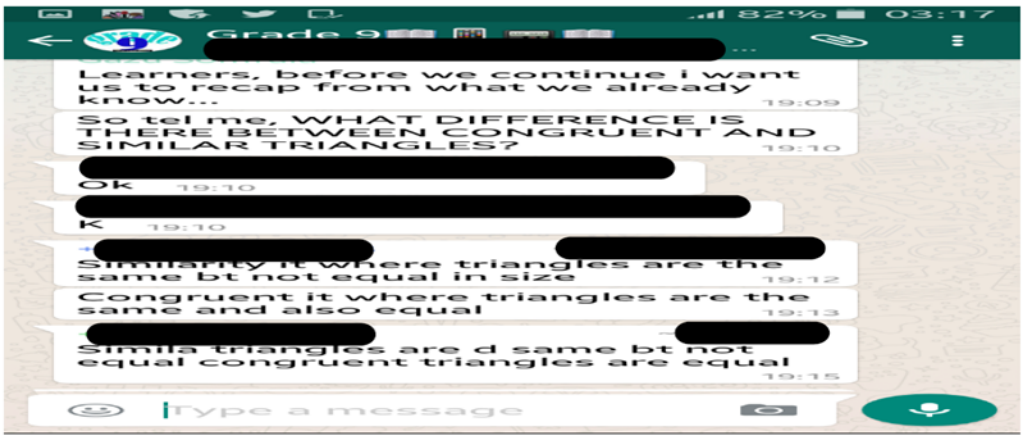
WhatsApp group VGN 10 School B 21/03/2016

There was an indication of willingness amongst learners to answer the question that was posed by their teacher in WhatsApp group VGN 10. The teacher was even calling them by their names, which showed that although they were not physically present, their interaction and cognitive engagement brought them together. During their collaboration as they were engaged, they understood that what they were doing made 'sense' and added value to their learning. This was noted from their preparedness to respond when their teacher shouted at them and learners' response of "*Guyz comn*" meaning 'come on mates' which showed their engagement, sharing, and trust. The teacher was communicating with learners at their level as they were responding to what they get when subtracting negative numbers. The teacher called others to come with their answers. All the participants used the platform as the place to share mathematical information, ideas and messages (see WhatsApp group VGN 10). These online discussions proved to have a social and emotional presence which could have plenty of opportunities to limit dropouts since the teacher will identify the learner with the problem from the onset. Furthermore, this was benefiting the slow learners because even if they missed a solution in the class they could catch up with the group after hours.

Verifying learners' discovery methods was pivotal. What was posted could make sense to learners and this evidence shows that they were prepared to apply their knowledge and further discover new knowledge. Learners preferred to design their own culture and artifact in a natural and social phenomenon. The technology-enhanced constructivist learning has been identified with the ability to translate personal experience into abstract symbols, whereby some

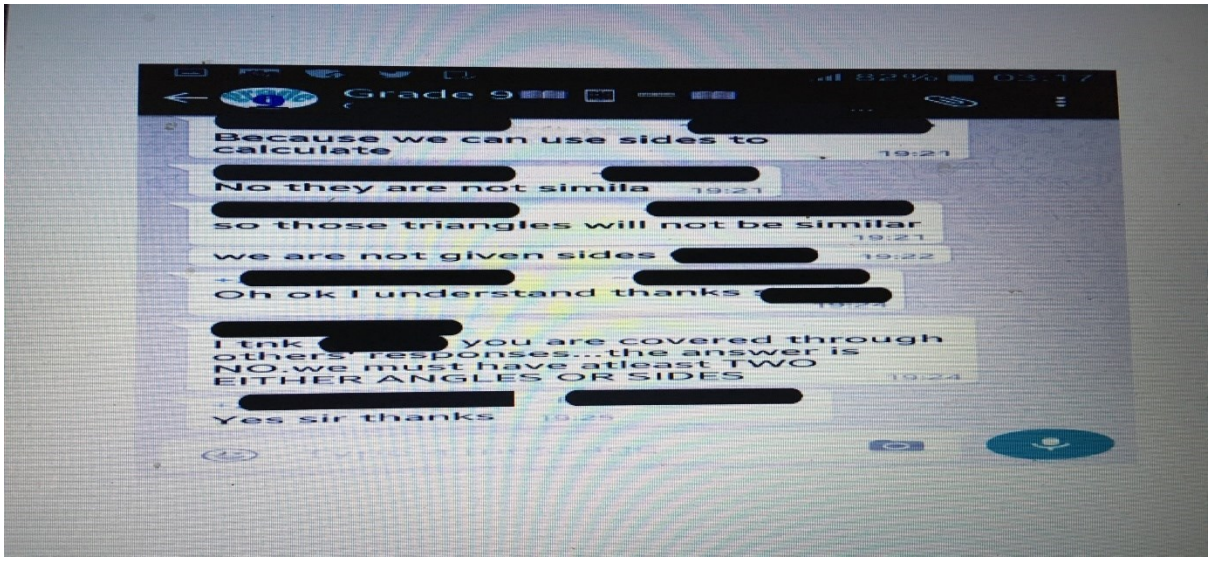
symbols (emojis) were used. WhatsApp platform was used as a tool to convey communication of mathematics but lacked some mathematical symbols. However, this can be contested that participants' focus was not on delivering information but it was on sharing ideas and engaging in the construction of knowledge. Data revealed that WhatsApp's design philosophy was able to make a uniquely teacher-friendly package that represents the first generation of educational tools that were useful to both learners and teachers. Participants used their WhatsApp learning platform as a quick tool for sharing and overcoming mathematical problems. There was evidence that the platform was constituted of learner-generated content. Learners were self-determined to post their mathematical comments, trials, and questions. The thought-provoking activities were appreciated since intellectual rigor and constructive criticism was drawn. In school B learners were energetic and wanted more, but the teacher could not deliver, whilst in school C they were entertaining those benefits. In school A, learners were given a chance to freely share and be trusted by their teacher as resourceful.

Small portions and chaos described how knowledge was shared in this study. Learners were repeating similar answers and that was boring to others. Interestingly, in school B the teacher would pose the question; for instance, T2 "how can you describe a fraction?" Learner 1 attempted: "A fraction is not a whole number". Learner 2: "is a process of changing a polynomial to a monomial", and learner 3 came with the sound answer: "fraction uses integers where there is a denominator and a numerator." These different answers opened the platform for T2 to elaborate further on three different answers that were mentioned by learners. In some instances, participants confessed that what was happening was confusing to other learners who were willing to do some practices that were only done at school. It was thrilling when observing learners leaving voice notes to clarify and give proper explanation. In resonance to the teachers' understanding of the discussion taking place between learners, voice clips clarified a lot. The afternoon informal discussion enabled learners to grasp easily in an informal relaxed way because the group was repeating what was done in class. Since learners knew how to learn, they showed empathy and teamwork. There was an ongoing display of support and productive arguments. Mathematics became the center of a community of practice with the shift from having the subject teacher-centered to learner-centered (see screenshot in WhatsApp group VGN 11).



WhatsApp group VGN 11 School C 17/03/2016

In the WhatsApp group VGN 11, learners enjoyed their mathematics conversation in a relaxed manner. Surprisingly, their conversation improved teachers' presentation skills which were recapping from the previous discussion. In the vignette, the teacher mentioned recapping before they could embark on a new topic. In this case, connectivity infused mathematics culture and connections among participants (teacher and learners). This implied that connectivity could be measured by the amount of 'trust' and 'reciprocity' as the teachers applied to recap the work done. As observed, learners were coming up with their prior knowledge or understanding and adding it to the recapped knowledge. The two groups of participants (teachers and learners) were observed sharing the same responsibility of facilitating discussions. Teachers were not the only participants to facilitate discussions. Indeed, they initiated the formation of groups and opened the pedagogical spaces which in turn contributed toward the formation of learning spaces amongst learners. However, they were observed in the study gaining a deeper understanding of their situated practice. Learners were observed doing some reciprocal learning activities like reading carefully and summarising then posting some relevant questions to construct an explanation or some predictions. Learning was being transformed through some self-directive process, where learners could observe, compare or reflect on their thinking and voice out their responses. WhatsApp as a learning tool provided the potential of creating habitus (an embodied state) and dispositions that must be formed during pedagogy. WhatsApp group VGN 11 captures participants' arguments and agreements.



WhatsApp group VGN 12 School B 19/03/2016

In WhatsApp group VGN 12, the mutual collaboration was noted as participants were contributing to properties of the theorem of Pythagoras, where participants came with different properties of the content. The teacher at the end came with the polishing answer after a vibrant debate amongst learners. Learners are confessing that they understood algorithms after being involved in a WhatsApp communication. A learner from school B said, "*Oh ok I understand thanks*-----." The teacher was pleased with learners' responses and was convinced that all participants were on the right track. WhatsApp availed the platform where learners' evidence of either following the new knowledge construction or being lost is demonstrated. This would suggest that learning appeared to involve negotiation and interpretation which was not abstract, closed, or procedural. Online discussions appeared to be a field of inquiry that learners could use to discuss, share and construct mathematical understanding.

4.6 PRESENTATION OF THE FINDINGS FROM THE ANALYSED DOCUMENTS

This section presents the main document that was viewed for this study which was the school ICT policy. The aim of analysing the documents was to find the teachers' perceptions concerning the integration of social networks in teaching and learning

Table 5.1 Summary of documents analysed

	ICT Policy with traces of social networks guide	Any evidence related to learners' enhancement to use social networks
School A	No ICT policy. Stolen computers at school no computer usage policy. Have homework policy.	Mathematics performance records for the past 3 years are available. Nothing stipulated discussion about the social network in staff minutes before research. During the online discussion, I picked the correction done for what was done in the class. The first term CASS available for 2016.
School B	No ICT policy. Stolen computers at school no computer usage policy. Have homework policy.	Mathematics performance records for the past 3 years are available. Indication to incorporate ICT to enhance learning in staff minutes but was theoretical prior research. Similar work was picked during the online discussion which related to what they were doing in class. The first term CASS not yet done for 2016.
School C	2013 Acceptable. Use Policy on ICT. Have computers without internet. Have homework policy.	Mathematics performance records for the past 3 years are available. Staff minutes have been involved prior in a project where learners were communicating with their mentors using cell phone messages after school. Similar work was picked during the online discussion which related to what they were doing in class. First-term CASS not yet done for 2016.

Table 5.1 data confirms that similar documents were analysed in all three schools two themes and one subtheme under theme 1 was generated from this analysis, and are presented below.

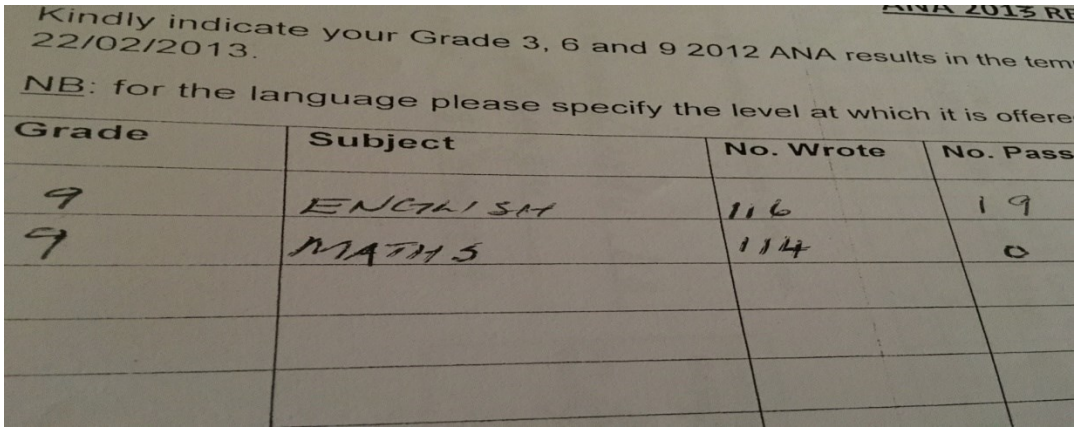
Data anchored theme 1 with subtheme, lack of ICT policies and guidelines. The documents revealed that there were no proper ICT policies or guidelines in all the participating schools. The finding indicated that two participating schools (A and B) had no ICT policy whereas school C was the only school with an outdated Acceptable Use Policy (AUP). These made it difficult for schools to adopt ICT for teaching and learning. It seems the AUP in school C was only developed during 2013 when the school received its computers. This implies that the policy was never reviewed or renewed to be aligned with the new developments. The policy indicated one teacher in charge of the computer room who used it as her office. There was no mention of a substitute teacher. This would mean that if the particular teacher is absent, the computer room will either be locked or not in use by both teachers and learners.

The policy addressed how teachers use the computer room to type their documents and did not specify how learners use the computers for learning. However, AUP emphasised that the teacher responsible for the computer room was the one to grant permission to use computers and to add new software to the computers.

Concerning the e-Education policies or the South African e-Education policy, they were not found in all three schools. This was unbelievable because in their turnaround strategies they mentioned that they were supposed to venture into new alternatives of teaching as a means of enhancing good mathematics performance. In this case, advancing to computer-related teaching was theorised and not practically applied. The important issue of handling homework (see Appendix 13) in these schools was very interesting.

Theme 10: WhatsApp improved learner performance in mathematics

The data from the documents studied revealed a consecutive high failure rate in mathematics in all the participating schools (schools A, B, and C), from 2013 to 2015. The summative results of mathematics as populated by the Annual National Analysis (ANA) were far below 50 percent. Figure 4.1 captures the 2013 ANA results of school B.


Kindly indicate your Grade 3, 6 and 9 2012 ANA results in the tem
22/02/2013.

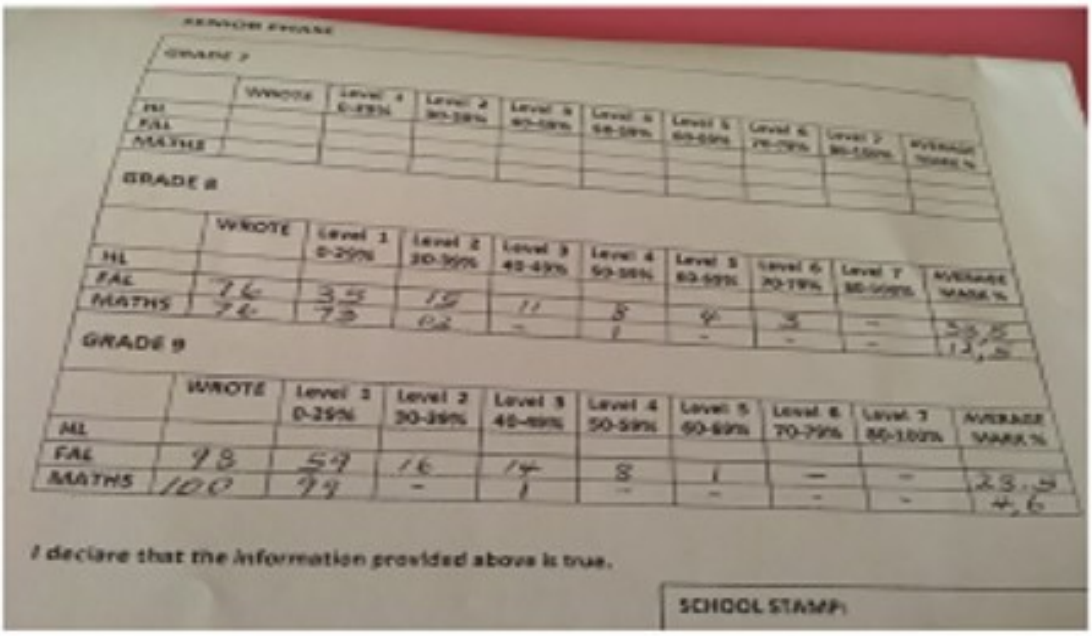
NB: for the language please specify the level at which it is offere

Grade	Subject	No. Wrote	No. Pass
9	ENGLISH	116	19
9	MATHS	114	0

Figure 4.1 Document evidence for 2013 ANA results in school B

The document in Figure 4.1 shows that 114 grade 9 learners wrote controlled ANA in 2013 for mathematics and no one passed the examination. They had their turn around strategies which aimed at improving these marks. They aimed at incorporating the use of ICT to enhance good performance as they were writing ANA. Another important evidence to learners' poor performance emanates from Continuous Assessment (CASS) 2016 results. In this regard, the results of the same learners from school A who had been registered for grade 8 in 2015 as

compared to their grade 9 first term in 2016 after incorporating social network in the learning of mathematics marks showed a drastic improvement. Figure 4.2 shows 2015 CASS results.



GRADE 8

	WROTE	Level 1 0-29%	Level 2 30-39%	Level 3 40-49%	Level 4 50-59%	Level 5 60-69%	Level 6 70-79%	Level 7 80-100%	AVERAGE MARK %
HL									
FAL	76	35	19	11	8	4	3	-	38,8
MATHS	76	73	02	-	1	-	-	-	13,5

GRADE 9

	WROTE	Level 1 0-29%	Level 2 30-39%	Level 3 40-49%	Level 4 50-59%	Level 5 60-69%	Level 6 70-79%	Level 7 80-100%	AVERAGE MARK %
HL									
FAL	98	59	16	14	8	1	-	-	23,9
MATHS	100	99	-	1	-	-	-	-	4,6

I declare that the information provided above is true.

SCHOOL STAMP:

Figure 4.2 2015 School A grade 9 marks

The results from Figure 4.3 were for school A mathematics grade 9 marks in 2015 indicating that 100 learners were assessed and only 1 learner scored between 40-49 percent with the rest of 99 learners scoring 20-29 percent. The statistics outlined a drastic need for urgent intervention since the whole class performed below 50 percent. Interestingly, after the introduction of this project, marks for the first semester showed a slight improvement. The vignette below shows transition in marks obtained comparing mathematics school A results for grade 9 in 2015 (Figure 4.2) and grade 9 in 2016 (Figure 4.3).

	43	43	73	43	42	36	54
	34	34	63	43	37	39	45
	25	26	46	33	23	27	32
	32	31	50	47	34	39	45
	34	44	59	42	44	40	39
	44	46	72	71	36	37	49
	36	39	59	40	26	33	46
	43	48	61	57	43	38	52
	72	41	74	76	58	46	56
	30	42	61	30	29	29	41
	23	36	62	23	25	25	35
	31	25	51	24	24	22	34
	47	44	72	65	50	58	56

Figure 4.3 Mathematics School A first-semester grade 9 marks, (focus is on two learners highlighted in yellow those that participated in WhatsApp learning)

The introduction of WhatsApp in 2016 in Figure 4.1 verified that there were changes in the improvement of learners' performance because two learners who participated in the afternoon (highlighted in yellow) scored level 2 (31%) and level 3 (41%) (see Figure 4.3). Although the intervention (WhatsApp tool) was just introduced at the beginning of the year in 2016, it shows that the online discussion was effective within a short time.

Theme 11: Immediate feedback improved learning

Immediate feedback is critical to learners to improve their performance, (see Figure 4.3). The vignette below (Figure 4.4) presents the learner who got 41% in the 2016 first semester and confirmed her improvement in performance due to immediate feedback she was getting from the WhatsApp learning platform (confirmation attached in vignette 1 and vignette 2).

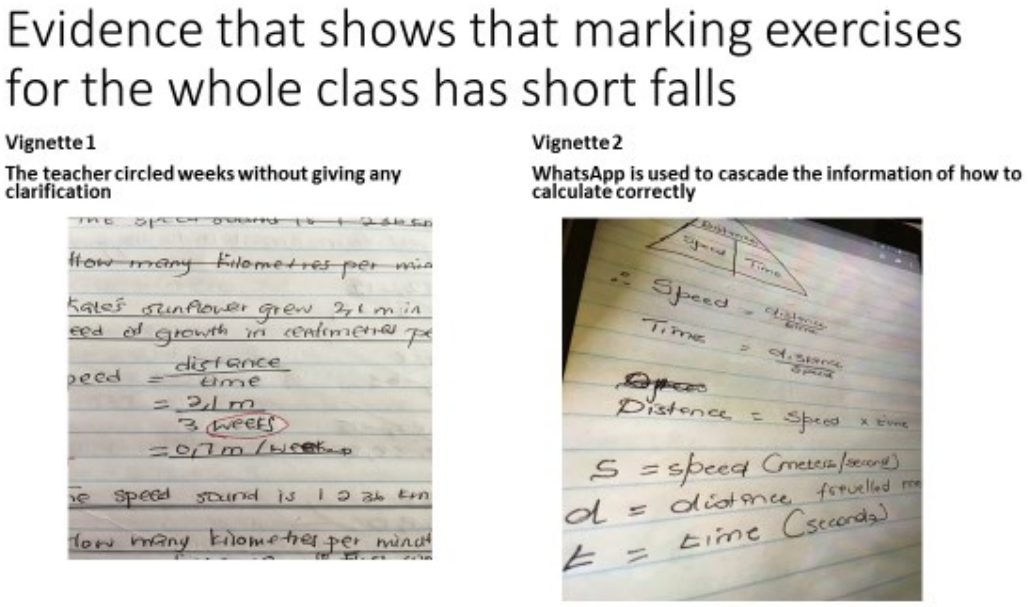


Figure 4.4 Vignettes from an exercise book and screenshot from WhatsApp conversation of school /03/2016 school A

The data from Figure 4.4 indicated how the marking of the exercises took place. In this task, learners were asked to calculate the speed. Taking the results of vignette one, the data revealed that the learners' marked work was left with no constructive feedback that would explain how to improve on the given exercise. The only evidence visible was that an answer 'weeks' was circled with no suggestions. This would mean that marking per se was not motivating a learner at all because there was no affordance to remedial work. A similar exercise was compared to an online discussion with detailed formula on how to calculate speed.

In comparison, vignette two where WhatsApp was used shows that the online tool made explanations easier because learners would know that a week that was circled was not in the right place according to the formular. WhatsApp made it possible to have content drilled several times unlike what was identified in their class-work. Participants in their discussion used concepts 'distance', 'speed', and 'time'. Repetition that happened made learning easier and more understandable as the drilling continued.

Furthermore, learners' exercise books confirmed that they could write correctly what they were discussing; this means there was the development of mathematical writing skills. Learners participating in the online discussion groups could also relate to the information shared on WhatsApp with fellow learners in their classes. In a nutshell, the comparison would mean that discussion in the classroom was not fruitful as compared to the online discussions.

4.7 CONCLUSION

This chapter presented the findings of the qualitative data collected from learners and teachers in rural secondary schools. These findings were presented thematically under data collection tools that were used in this study. Quotes were used to verify the findings and interpretations. The research revealed how WhatsApp as the social network tool was used as the emergent learning tool. Furthermore, it enhanced motivation among teachers to come with new pedagogies and learners to come with vibrant learning styles irrespective of insufficient ICT resources in their schools. Participants referred to the vital part of WhatsApp usage in the teaching and learning at uMkhanyakude rural secondary schools. However, some challenges proved to be substantially delaying the integration of WhatsApp as a learning tool to enhance teaching and learning of mathematics in rural areas. The next chapter presents the discussion of the findings together with concluding remarks and recommendations.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

5.1 INTRODUCTION

This study is about exploring the experiences of teachers and learners on teaching and learning mathematics through social networks. This chapter focuses on the discussion of the findings, followed by the conclusions and recommendations. In this discussion, the findings are firstly contextualised by recapping what this study sought to answer against what was found. Secondly, the findings are then located within mathematics and the technology body of knowledge by associating and locating the present findings with theoretical perspectives identified. The conclusions relate to providing a synopsis of what was found from the literature review, findings from interviews, online discussions, observations, and documents analysis. Finally, the recommendations are based on what needs to be done from this study viewpoint. This study was driven by the following research questions:

1. What types of social networks do teachers connect with learners to share mathematical content?
2. To what extent have learner-teacher interactions taken place?
3. What technological methods prevail in the learners' discovery of mathematics content knowledge?
4. To what extent has teaching and learning taken place through social network interaction?

5.2 THE FINDINGS

The findings are presented under four objectives as they were listed in chapter 1. The first set of findings emerged from an attempt to explore the different social networks used by teachers to connect with learners to share mathematical content. The second set of findings addressed the second question posed by this research, which explored the extent of learner-teacher interactions that have taken place. The third set of findings attempted to ascertain technological methods that prevailed in the learners' discovery of mathematics content knowledge. Finally,

the fourth set of findings related to identifying the methods prevalent in teaching and learning through social network interaction The argument that follows deliberates on the major findings that emerged from the data presented in the previous chapter. It is worth noting that eleven themes were generated from the data, and are discussed under the study objectives.

5.2.1 Social networks used to connect teachers and learners to share mathematical content

In exploring the different social networks used to connect teachers and learners in the sharing of mathematical content, two themes were developed from the analysis of data. The first theme was that WhatsApp platform improves collaboration, learning and overcome shortages of resources. The second was that WhatsApp platform overcame the shortage of teaching and learning resources. The third was about learners' perception of the WhatsApp tool. Findings presented teachers as the main drivers of change, initiating dialogue.

Theme 3: WhatsApp platform improves collaboration, learning and overcome shortages of resources

Teachers were interested in agreeing on the social network they were going to use as a group. An introduction of learners to a new zone of learning using the WhatsApp platform, wherein a new zone of proximal development transpired (Eun, 2019; Chaiklin, 2003). Teachers acknowledged the importance of consistently assessing learners to know the feedforward content suitable for them. In this case, teachers became 'architects of change' (Chapman & Heater, 2010). Surprisingly, teachers also learned some digital skills which in turn were for the betterment of their profession and quality education. This was in contrast to earlier scholars who believed that technology will only be effective once proper cognitive structures are in place (Clark, 1994; Kozma, 1994). The finding presented teachers who could decide to adopt WhatsApp as a teaching and learning tool. By adopting this idea, they became researchers too and they asked many questions but got few answers (Slykhuis et al., 2019; Foulger et al., 2017; Cai, Hohensee & Hwang, 2018; Bower, 2008; Nuthall, 2005). The finding supports literature about teachers who opt to employ cognitivism theories, social constructivism, and constructionism to identify learners' pedagogical needs (Lee et al., 2020; Eun, 2019; Jablonka et al., 2013 Picciano, 2002). It can be concluded that the extent of learning among learners in this study was reported based on first real-life tasks which were discipline and sharing of knowledge. Secondly, demonstrated actions included collaboration, discovering of knowledge before their teaching, and demonstrations of how answers were attained. This implied the great

need for teachers in rural schools who will be resourceful, receptive to learners' needs, and apply reflexive teaching.

Teachers confirmed that on the advent of using WhatsApp as a teaching and learning platform, a drastic change of teaching and learning process emerged, unintentionally. There was an understanding that the WhatsApp platform as it is, was used out-of-school enabled both teachers and learners to overcome the shortage of learning resources. As Kearsley and Shneiderman (1998) suggested, collaboration among participants was seen from their discussions and motivations. Both teachers and learners were surprised since they had never thought of teaching and learning that can happen outside their rural secondary schools. Interestingly, this method blatantly overcame the shortage of resources. Participants never thought that the encounter would give them opportunities to learn. This supported literature on Vygotskian principles that a learners' development (Murawski & Scott, 2020; Chaiklin, 2003) is acknowledged when learners could communicate, network, and collaborate with a group (Setlalentoa, 2012). Learners maintained consciousness as disciplined individuals about social understanding (Fernyhough, 2008). The Finding affirms that WhatsApp on its own could not solve the social problem of poor performance in mathematics (Castells,1999). Teachers should incorporate social constructivist learning theory to expand social interactions among their learners to construct, learn and share knowledge (Amry, 2014; Jablonka et al., 2013).

Interaction on WhatsApp indicated the manner both teachers and learners were thinking. This finding supported the literature which perceived 'engagement' as communication (Mupezeni & Kriek, 2018; Johnston & Taylor, 2018; Ally & Christiansen, 2013; Callaghan & Bower, 2012). This seconded an argument that social networks have 'the potential to bridge formal and informal learning' (Greenhow & Lewin, 2016, p. 6). Teachers managed to discover a new platform of teaching and learning, a space of collaboration, new language acquisition, and new methods of interaction about mathematics (Costa-Sánchez et al., 2020; Bouhnik & Deshen, 2014). Participation occurred outside of school premises (Durgungoz & Durgungoz, 2021), where there was evidence of learner-content interaction, learner-teacher interaction, and learner-learner interaction (Fares & Atef, 2018; Moore, 1989). Learners were meaningfully engaged in learning activities through interaction with others on worthwhile mathematics tasks (Kearsley & Shneiderman, 1998). However, although Kearsley and Sneiderman's (1998) 'relate-create and donate' engagement theory was adopted for this study, some strengths and weaknesses were identified. Both learners and teachers could communicate either verbally or nonverbally. The element of creation was staggering even though teachers did not provide

topics learners were having a sense of control. Concerning donating, both teachers and learners were to a certain extent satisfied, coming up with new techniques.

Theme 5: Learner perception towards WhatsApp tool

In this case, mathematics communication was conceptualised as a result of the non-dualist vision of human commognition (Sfard, 2020b, 2008a). Learners' understanding of their social milieu confirmed the reconstruction of their inner individuality (Vygotsky, 1978). Learners agreed to join the group. The introduction of social networks was financially demanding. However, they deliberately chose to use the tool for learning. This is because social networks are developed to provide an avenue for friends, relations, and even learners to interact to share common interests and ideas (Almu & Buhari, 2014). They have done this against various odds. Similar to other studies (Chirinda et al., 2021; Ramorola, 2018; Chigona et al., 2009), the majority of parents were not in favour of incorporating new digital innovations. Nevertheless, there was an exchange of information, improved measures to assess learners, and a reliable platform for revision. The finding indicated that learners preferred the usage of projectors since they were aware of Gauteng's development in ICT. This confirmed that there was internal dialogue among participants to gradually 'de-ritualize' (Lavie & Sfard, 2019) their routines towards 'exploration' (Lavie et al., 2019; Metsämuuronen & Räsänen, 2018; Ahad & Lim, 2014; Bruner, 1986). The finding in this regard constantly showed positive learners' perceptions towards WhatsApp tools in participating collaboratively and legitimately as humans at a peripheral level (Basitere et al., 2019; UNDP, 2019; Lave & Wenger, 1991). Their narrations as confirmed in online discussions indicated participation using discourses (Sfard, 2020a). Findings endorsed the discourses as stipulated by Sfard (2008b), which was the usage of specific mathematics words; special symbols as visual mediators; narrating how those symbols could be used and performed various repetitive mathematical patterns (Sfard, 2008b, p.133-134). These findings are incongruent to Lavie et al. (2019) as learners' routine and practice were giving birth to their new culture. Day to day language was converted to explain mathematics. In this case, there was 'concrete operation' learning which gave birth to 'information operation' then to 'concept operation' (Li, 2004) where the general intelligence was changed to body-kinaesthetic factors (Gardner, 1983) and learners' mood was enhanced (Sinclair, 2009). Learners expected more than mental processes; thus, they needed learning that would channel their 'rurality' not to be casual (Xu, 2019; Hardré, 2011; Li, 2004; Bruner, 1986). Their constructs and discourses revealed their resilience, striving for relevance as they shared their sim cards and phones with their siblings (Greenhow & Lewin, 2016; Dalvit, 2014:

Manca & Ranieri, 2013). Participants' actions in a 'socio-technical context' could be explained on social constructivist and connectivist notions of other scholars who outlined various models of theorizing WhatsApp as a space for learning (Shrivasta, 2018; Greenhow & Lewin, 2016; Pegrum, 2010).

5.2.2 The extent of learner-teacher interactions that have taken place

In response to the extent that learner-teacher interactions have taken place, both teachers and learners were important strands in understanding how learner-teacher interaction has taken place. In achieving this objective, semi-structured interviews (post-research questions) were firstly used, using the social constructivism lens. Theme 2 was generated from both semi-structured interviews and online discussion that social network platforms benefit users. The second tool of collecting data was the online discussions. Two themes were developed from this instrument, with category 1. Theme 10 was that WhatsApp improved learner performance in mathematics. Theme 6 was about challenges of using WhatsApp during research. Category 2 was about lack of ICT policies and guidelines. Findings presented collaboration, engagement, support, fluid routines, social connectedness and 'institutional' presence as key concepts of 'content'.

Theme 2: Social network platforms benefit users

Scanty knowledge of effective use of ICT resources has brought to inadequate use of ICT policies which has directly promoted mismanagement and risks of ICT equipment. Participants in the study were not aware of ICT policies, and staff minutes were absent with special reference to strategies to integrate ICT to enhance learners' knowledge. Furthermore, one of the schools (school C) had computers which were not stolen but were not functional due to lack of internet. This finding is in line with Greenhow et al. (2019), who uphold the current importance of social networks in education. In this regard, the South African sustainable goal number four of having the quality of education by 2030 which promotes the pledge to 'Leave No One Behind' by 2030, may not be met (UNDP, 2019).

As part of the comprehension of this objective, grade 9 mathematics teachers and learners agreed to become 'school mathematical actors' (Lerman, 2001) and they opted to use WhatsApp as a learning platform. Learners had solid reasons for choosing WhatsApp after teachers marketed the idea of forming groups. This finding showed the importance of socially situating what is globally happening in education to the learners of rural secondary schools

(Ndume et al., 2020; Marginson & Dang, 2017). It became evident that the major factor that affected the effectiveness of WhatsApp among the rural secondary school teachers was a shift of teachers' beliefs after they were engaged in a brief discussion concerning their pedagogical responsibilities as teachers. Evidence supports the implication that there was a turning point in their professional service which was heightened by the shift in their beliefs (Luna et al., 2015). Teachers as thinkers managed to draw learners to visualise (Bishop, 1985) the new learning opportunity of using WhatsApp as a learning platform; hence, they could afford it. In short, teachers intended to participate in researching mathematics as a tool and object of communication (Sfard, 2020a; Bower, 2008; Wittgenstein, 2001). Communication to both teachers and learners was making sense. The finding supported literature by emphasising the importance of learning to learn as the main evolution of learners' minds through the social and cultural processes (Siemens & Tittenberger, 2009; Nuthall, 1999) with correct language (no scolding by teachers) as an important tool for speech and thinking (Vygotsky, 1978). However, extensive communication draws to important criteria of teachers to understand the cognitive element of a learner (Morine-Dershimer, 2006; Bruner,1986). The user-friendliness (Rambe & Bere, 2013) and cost efficiency (Bouhnik & Deshen, 2014) were the main reasons for the adoption of WhatsApp; hence, other issues concerning instability of reception and 'data must fall campaigns' are still in place (Gillwald et al, 2018b; Saal, 2017). Findings implied that learners were afforded using WhatsApp as a learning platform, even though it was not free like in the developed countries (Corrado, Pretorius & Van Der Westhuizen et al., 2021; Church & De Oliveira, 2013).

Theme 10: WhatsApp improved learner performance in Mathematics

Improvement was on controlled assessment. Performance from the first controlled assessment indicated a slight change after the project (see Figure 4.4). Besides the gradual increase in their CASS, there was a quick method of making corrections, which confirms that there is something wrong in South African rural secondary schools (Putten, Stols & Howie et al., 2014; Taylor, 2008). WhatsApp as a learning tool was used consciously by learners and teachers to communicate mathematics. This supported literature on the change of beliefs and doing mathematics in the world of mathematics (Dowling, 1996; Lakatos, 1964).

Learners were able to engage and 'talk' mathematically. This negates literature that suggests that digital learning only serves the elite. Even though teachers were skeptical about sharing their details with learners, findings presented learners acknowledging their psychological and

social differences. This finding supports reclaiming of 'digitizen' (Brown & Czerniewicz, 2010; Pegrum, 2010; Pegrum et al., 2013; Walkerdine, 1990). Remarkably, these authors point out that the majority of schools lack interaction between teachers and learners. This challenged the social structures such that teachers were the only initiators of communication. Dalvit et al (2014) confirmed this notion of bottom-up content interaction which could be extensively enhanced by digital means. Learners' communication comprised of their language, symbols, and culture. This involved usage of vernacular language and emoticons where they are shared collectively (Giles, 2017; Sfard, 2008b; Atkinson, 2008; Downing, 2003; Foucault, 1966). In line with Dowling (1996), participants showed context interdependent discussion which indicated their high immersion in discussions. Knowledge appeared to be the 'function of the context'(Siemens & Tittenberger, 2009).

Theme 6 Challenges of using WhatsApp

There were challenges in using WhatsApp, which included poor internet reception, lack of data bundles, lack of phones, and difficulty to download shared documents. Learners' poor family background, learners sharing sim cards and cell phones were witnessed. Literature confirmed that challenges have been persisting in South African communities (Odeyemi, 2020; Dalvit, 2014; Dalvit et al., 2014; Parmaswar, 2014; Hardré, 2011).

Interestingly, challenges for learners differ from teachers' challenges. For instance, posting relevant educational content was highly challenging for teachers, since they were 'digitally naïve' whereas for learners, the challenge was cost but they were technologically fluent (Siemens & Tittenberger, 2009; Matthee & Liebenberg, 2007). Learners acknowledged their weaknesses concerning mathematics content and were willing to share their knowledge with other learners and their teachers. Teachers could not quickly respond either by using emoticons or by posting a vignette but mathematics communication was not broken. This finding supported the intensification of interactivity level as intensified by content-oriented interaction between the sender, WhatsApp (as a learning tool), and a receiver (Atkinson, 2008).

Learners were exposed to various social networks but had solid reasons to choose the WhatsApp learning platform since they could post content, revise their lessons and widen their critical thinking in a relaxed manner. In line with Popescu and Badea (2020), the mediating role of WhatsApp was observed in locating both teachers and learners in a new spatial engagement wherein social presence was felt. In this case, time dimension and proximity were

not the issues. Learning and teaching could happen on out-of-school premises. Learners displayed considerate actions (posting and using emoticons) through conditional communications while concretizing their ideas (Ankiewicz et al., 2015; Toerien, 2014). The emergent idea from this finding was the importance of reciprocity as part of the ongoing process. This finding on WhatsApp impediments included obstacles like poor usage of WhatsApp as a teaching and learning platform, no cell phones, no data, no internet, poor reception, and quick means for educational feedback. This paved the need to seek internet functionality on aesthetic dimensions, and transparent evolution of teaching and learning.

Category 1: Lack of ICT policies and guidelines

The findings verified the absence of ICT policies and up-to-date ICT guidelines in schools. It was interesting to see in school C that computer guidelines were for teachers only. This indicated that teachers did not see the urgency before this research to incorporate ICT in their teaching. This was surprising because their turnaround improvement plans indicated the need to incorporate ICT in their schools. This is indicative of their limited knowledge concerning the availability of the South African e-Education policies. Interestingly, the schools' homework policy was available which signified the need for family support towards learning. However, it was verified that all the schools' intended plans of using ICT to enhance education were limited; hence, the usage of WhatsApp as a learning tool unraveled those opportunities. Morine-Dershimer (2006) supported the notion of teachers learning while practicing. Furthermore, there was a need for context-dependency policy (TIMSSSA, 2019; Dahlman et al., 2016; Gronmo, Lindquist, Arora & Mullis et al, 2016; Putten et al., 2014) where teachers should learn the needs of their learners (system level), facilitation needs (school level) and teachers' attitudes (teacher level) (Buabeng-Andoh, 2012). It was from this perspective that the learners' postings at times with no critical thinking during online discussion could be used as the stepping stone towards critical thinking (truth) since dreaming and truth are fantasies of mathematicians.

5.2.3 Technological methods that prevailed in the learners' discovery of mathematics content knowledge

This research question intended to ascertain technological methods that prevailed in the learners' discovery of mathematics content knowledge. This objective was to be answered by once-off non-participating observations in all three schools (School A, B, and C) using the RTOP observation tool. Two subthemes were constructed. There was a lack of digital and

technological skills among teachers as they crafted their interactive lessons (subtheme of theme 4). The intention was to find out the technological methods that could prevail in the learners' discovery of mathematics content knowledge. The second subtheme for theme 6 was limited learner participation. To answer this question, theme 8 was formed. Participants' adherence to netiquette and development of communication skills were identified. The assumption was that participants 'interrupt routines' during their 'pseudo' classroom space as they involve themselves in 'deep mediazation' of learning (Couldry & Hepp, 2018).

Theme 8: Participants adherence to netiquette and develop communication skills

Learners initiated communication and engaged in socially responsive discussions. This showed that WhatsApp came with a solid triadic relationship and communication styles between the teacher, learner, and WhatsApp tool. Learning was not restricted to time, space and proximity. There were virtual, verbal, and non-verbal communications, which enforced the development of self-esteem, patience to one another, and trusting members, as well as the 'ontogenesis' of mathematical and 'individualisation' (Lavie et al., 2019). This concurs with Nuthall's (1999) argument that teachers can teach learners how to learn. Participants were continuing with their classroom concepts, belonging together while out-of-school by actual human interactions. Individual learners demonstrated mathematics culture in a public space. This finding supported 'routinization' of school out-of-school context wherein also their feelings could be portrayed (Eun, 2019; Lavie et al., 2019; Sinclair, 2009; Polanyi, 1958).

It was further established in this study that learners were no more scared of teachers but they received full family support in their homework, motivation, and developed trust. This supported literature that viewed poor parental involvement as the challenge towards adopting technological culture (Ndume et al., 2020; Ramorola, 2013). The finding revealed that learners suddenly developed trust in teachers such that they could indicate that they did not understand. This supported that WhatsApp could be used to add value to mathematics culture (Hlalele, 2018; Bouhnik & Deshen, 2014; Kirschner et al., 2006). On the other hand, teachers were expected to answer some learners' questions but opted to postpone them. At times, they apologised for their availability. This finding presented learners continuing to communicate irrespective of their teacher. They were playing mathematics. Siemens and Tittenberger (2009) maintained that the necessity of incorporating cognitivism together with other theoretical frameworks would be realised as learners began their conversation as 'play'.

Learners' communication and online answers were quick which meant that at first, they were not following the lesson. Interestingly, as they interact, they developed 'way-finding interaction' and made sense. Learners kept on saying "*give us another one sir*'', indicating commitment to one another, belonging, and rational thinking towards making sense (Bouhnik & Deshen, 2014; Wang et al., 2014; Dron & Anderson, 2007). Herlo (2017) emphasised that it was from teachers' support and learners' trust conversations that their content could be crafted.

5.2.4 Methods prevalent to teaching and learning through social network interaction

This research objective aimed to identify the methods that were prevalent in teaching and learning through social network interaction. To achieve this objective, two research tools were used namely: focus group interviews (FGA, FGB, and FGC) and documents analysis in all three schools (School A, B, and C). To articulate positive answers two questions were developed from semi-structured and online discussions theme 7 and 9, and theme 11 from focus groups and documents analysis. Two categories 4 and 6 or subthemes were generated after using RTOP classroom observations. Findings reveal the importance of having learners and teachers knowing their needs and goals; preparedness of internalisation; cognitive interaction between learners and teachers which enabled feed-forward and feedback. Unlike other teachers, findings revealed that teachers were not giving learners tasks that require learners to use technology (Jantjies & Joy, 2016).

Theme 7: Family support encouraged learners towards constructive learning

It has been found that family support enabled extensive and constructive learning, like Ubuntu principles and time management. Literature confirmed that extensive learning using WhatsApp after-hours enabled learners to socialize, acquire social habits, and identify important truths about cyberbullying (Chirinda et al., 2021; Khoza, 2020). The important finding on how to behave in cyberspace and the significance of Ubuntu connectivism was developed. Ubuntu principle was founded on the idea of sharing, trust, and understanding personhood. This communalism includes "I am a person through other people" (Halse & Mallinson, 2011, p. 628). The findings also are in line with how communication using emerging tools emancipate learning (Hung, 2014). In this case, it means using WhatsApp did not benefit mathematics pedagogy only but became a versatile ingredient for quality education. The finding further confirmed lack of social construct reality and new identities in the classroom (Knoblauch & Wilke, 2016; Naismith et al., 2006) when compared to the formation of new social construct

during online discussions. This finding supports the integration of social constructivism and connectivism ideas to enrich teachers and learners with a suitable 21st century pedagogy (Chai & Kong, 2017; Wang et al., 2014). This finding integrates well with Fink's taxonomy of significant learning as it goes beyond Bloom's cognitive taxonomy, and considers an aspect of learning like helping a learner with knowledge of how to learn, the impact of communication, how to adapt to change, and the interpersonal relationships (Heflin et al., 2017; Fink, 2003).

Theme 9: Teaching and learning strategies to knowledge sharing

This finding presented learners' positive perceptions concerning their knowledge sharing. Various boundaries of interactions were observed among participants which were towards new structures of knowledge sharing. It was interesting to see learners discussing, watching, doing, reading, and listening. Although this fluid learning happened randomly, these teaching and learning strategies could be linked to significant learning and different levels of knowledge (Janes, 2013; Churches, 2010) at different levels. Interestingly learners were engaging willingly and in their preferred learning style. To be more specific there was the destruction of power relations. Teachers were observed calling learners by names, coming down to their level, and identifying their mathematical problems. This continuous communication assisted learners not to be disengaged. Heflin et al. (2017) confirmed that speech, eye contact, and gestures are important elements to overcome disengagement. Emoticons posted maintained engagement, mostly benefiting slow learners. This indicated that using WhatsApp as the learning platform pushed the boundaries of pedagogical practices for both teachers and learners. Firstly, there were spaces for learners to open up to question, instruct and initiate learning content. Communication in WhatsApp groups verified constructs formulation which was understood by group members, which proved learners' cognitive presence (Armellini & De Stefani, 2016; Garrison et al., 2000).

Secondly, the new teaching and learning strategies involved family support, a novelistic intervention in rural secondary schools. The new classroom space was formed, delimiting boundaries between home and school. In this case, the visual connectedness is accompanied by similar concepts and descriptions from WhatsApp group members. WhatsApp interaction revealed personal and affective relations and each learners' social presence differs among themselves. This confirmed what other literature has described what was referred to as social presence when employing social constructivism, cognitivism, constructionism, and connectivism (Durgungoz & Durgungoz, 2021; Marginson & Dang, 2017; 4; Picciano, 2002).

Learners came with thought-provoking questions and learner-generated content. Ausubel (1968) in this regard wrote, "most important single factor influencing learning is what the learner already knows. Ascertain this, and teach him accordingly" (p.18). It was further important to identify learners' expectations as the main learning method identified in this study. Learners could answer or comment on the specific message and indicate when not satisfied. This finding aligns with literature (Muzurura et al., 2021; Bano et al., 2018) that indicated expectation as the driving force with powers to drive the attitude and produce a positive performance of WhatsApp usage as the learning platform (Baytiyeh, 2018).

Thirdly, the extent of teaching and learning strategies was the transformative effect of the school. The online discussion presented evidence of learners' recognition of prior knowledge. Teachers and learners co-operatively opened up spaces to question the status quo of poverty and lack of ICT resources. This supported literature on the benefits of employing technology in remote schools which transform both teachers' and learners' confidence (Umugiraneza et al., 2018; 2016). In this case, being within the institution could be evaluated based on the transactional presence (Shin, 2002).

Theme 11 Immediate feedback improved learning

The study discovered the urgency of having learners get instant feedback as the main pillar for effective communication. Vignettes from the exercise book and screenshots from WhatsApp conversations presented evidence of different dimensions of feedback attainment. This aligns with literature that acknowledged the integration of technology since it widens learners' opportunities for personalized engagement (Attard & Holmes, 2020). Findings from online discussions verified feedback as the basis for the feedforward too. Reckoning a similar finding is presented by teachers who admired progressive feedback as an important factor to strengthen pedagogy (Ingram et al., 2019).

Theme 1: Inadequate use of ICT policies and regulations promote mismanagement and risk to ICT equipment

The finding in this regard indicated that teachers use social networks for their matters; hence, their anticipation of integrating social networks to connect with learners was minimal. This tallies with the South African history of computers where teachers anticipated to have them play a major role in teaching and learning whereas there is a need for transition to technologies on the move (Matthee & Liebenberg, 2007). In the absence of computers, scholars have

indicated the necessity of emergent technologies that are not planned nor designed for teaching and learning but collectively share adequate goals and concerns for teaching and learning (Dron & Anderson, 2007). Initially, teachers were reluctant to share personal platforms with learners. In this regard, Kimmons and Veletsianos (2014) emphasised the need for teachers to be updated on how to keep their professional status during this current social networking age. The finding confirmed the strong link between teachers' beliefs and understanding of mathematics. Attestation from literature confirmed that teachers need assistance to guide their beliefs towards the necessity of social networks and reflect that in their contextualised policy (Badshah et al., 2021; Reene, 2020; Shah, 2017 Almu & Buhari, 2014; Boyd & Ellison, 2007; Ernest, 2006).

Poor performance was inevitable in mathematics because the turnaround strategy was hindered by contextual problems like theft and vandalism. The absence of computers, vandalism, and poor resources echoed the inability of participants to integrate technology in their teaching. Literature (Dahlman et al., 2016) confirms the reason why rural schools need to harness the digital economy. Ramorola (2013) stipulated that theft and vandalism were hindering the pedagogical rationale of ICT. In corroboration to this finding, the rural-urban split in South Africa could be traced by location; hence, rural secondary schools still suffer the backlog of poor educational resources (Ramorola, 2013; Spaull, 2015). On the contrary, this finding indicated that the absence of ICT resources in rural schools was not the hindrance but the main challenge was on how to efficiently use ICT resources. Further to this, literature confirmed the improvement of mathematics resources in South African schools (TIMSSSA, 2019) as a transition (Putten et al., 2014) to what it was before and during the apartheid era (Taylor, 2008). There was the absence of ICT policies and minimal staff meetings on the digital transformation of education to enhance good mathematics results. Moreover, the lack of digital knowledge challenged participants' teaching and learning. This, therefore, supports that context should not limit the educational opportunities of learners (Bagui & Mwapwele, 2019).

Theme 4: Lack of digital resources, knowledge, and skills challenged teaching and learning

Lack of digital skills was demonstrated by teachers while learners demonstrated lack of focus as they were answering. This was portrayed in boundaries of affective dimension regarding incorporating WhatsApp as a learning platform. Learners' premature quick responses were

noted. These learners' quick responses, however, confirmed interaction as not a one learner's show, but of interactive collaboration.

Another dimension of the skills was the usage of language. Other learners used language efficiently while others used vulgar language. The finding presents collaboration through language beyond social dimensions. This confirmed that beyond the dyadic collaboration, there is an inter-psychological plane to include the institutional and historical dimension (Eun, 2019).

This finding presents the participants transcending to temporal dimension in a classroom situation; notably, teachers acquired new digital skills. This echoes what literature suggested for teachers such as to keep learning, teaching, unlearn, reading, and empowering (Murawski & Scott, 2020; Jere et al., 2019). This was in line with equitable learning and collaboration that was previously observed in higher institutions of learning (Rambe & Bere, 2013) – learning by problem-solving (Klinger, 2009). It was noted that teachers in the classroom were teaching to cover the syllabus whereas during WhatsApp communication, their intention was to solve problems. For instance, learners could indicate that they understand, which implied that the negotiation process has taken place. It is important to emphasise that teachers must support learners with reasoning words and dialogic teaching as means of extensive scaffolding. Acquiring problem-solving basics was considered as the main pillar of adopting WhatsApp since these skills will enable learners to become responsible citizens.

It is worth noting that as some of the learners were posting without thinking deeply about their answers, some teachers acknowledged their efforts. The finding presents lack of acknowledging as the possible cause of learners' disengagement. It is worth noting that lack of focus among learners could not be overlooked since literature that has employed grounded studies found negativity in using WhatsApp for instructional purposes. Literature narrated negative dimensions that could be drawn from misuse, overuse, and out-of-objective (Yilmazsoy et al., 2020); negative inversion of writing (Bouhnik & Deshen, 2014); negative learning outcomes (Haßler et al., 2016); adverse influence on performance (Abu-Shanab & Al-Tarawneh, 2015). This finding confirmed the need for a 'loan of consciousness' (Bruner, 1986) wherein the learner will always have the responsibility of borrowing knowledge from their teachers to stay focused. In as much as learners were digitally literate as they were interacting using the WhatsApp platform, their teachers needed social situation development and mediation (Vygotsky, 1998) until they reach maturity and mathematical development. In this study, teachers were willing to share knowledge yet they were technophobic, while learners as

digital natives could quickly share without thinking properly the correct answer. Teachers were curating (Siemens & Tittenberger, 2009) learning on the WhatsApp platform. Social teaching and learning were confirmed by teachers to arouse their professional development (Vrieling et al., 2019). On the other hand, learners were observed adhering to netiquettes skills and developing good communication skills, and being deeply immersed in thought (Sfard, 2008a). In short, learners were supported by their teachers for the appropriation of their content.

Both teachers and learners uncovered new opportunities for learning; hence, technophobic teachers who could not send text or voice clips learnt from digital natives (learners) who were willing to explore every platform. Vygotsky's sociocultural theory would not suffice in this case due to its instrumental and systemic view of language as a tool and its dialectic basis (Barwell, 2016). Fernyhough (2008) described how Social Understanding (SU) model used higher mental functions of Vygotsky's dialogic nature. In this case, this study supported Bakthian dialogic rather than Vygotsky's. There was a need to reconceptualise and expropriate (Bakhtin, 1981) rather than appropriate and conceptualise (Vygotsky, 1978). Mathematical language according to Bakhtin changes every time depending on the context. The finding supports Vygotsky's intention to widen the scope of language, which is beyond taking turns in dialogue; hence, the study supported Bakhtin's 'relationality' of language (Barwell, 2016).

Category 4: There was a lack of digital and technological skills among teachers as they crafted their interactive lessons.

On a less positive aspect, the study found that classroom lessons were not designed in such a manner that learners would be further engaged as members of the learning community. Teachers' perception of incorporating WhatsApp was limited. This finding presents teachers as lacking to integrate their teaching with digital means. Furthermore, the study also attested that during the lessons, no communication related to what participants would do after school hours. In addition, the study authenticated that teachers were not incorporating digital teaching and learning resources but were just presenting their lessons without inviting or guiding learners towards investigating knowledge on their own. The final exposure of the study was corroboration of document analysis wherein there was no evidence of staff meetings where they crafted strategies on how to engage learners digitally. This was heartbreaking because teachers who were incorporating WhatsApp teaching and learning platform should craft various learning opportunities as initiators of afterschool projects to engage learners unceasingly (Sharples et al., 2016). This supports the literature that teachers are clueless on

how to engage learners and improve on interactive lessons (Garcia & Lee, 2020; Moreno-Guerrero et al., 2020).

There was evidence of limited learner participation in the study. Notably, in this construct was the passive learner participation since lessons were teacher-centered. I witnessed the lack of Technological Pedagogical Content Knowledge (TPCK) (Koehler & Mishra, 2008) among teachers. In this view, mathematics could not be viewed as a cognitive construct only but also a good social re-invented mathematics conversation using 'communicative approach' and be guided towards being autonomous as a means of 'deep mediazation' (Knoblauch, 2013).

Findings displayed that lessons did not encourage learners to seek and value alternative modes of problem-solving. Contrary to what was expected, learners were very passive, with no group discussions which could be postponed for out-of-school collaboration. This diverges from what was observed in online discussions, where the 'culture of silence' (Downes, 2017) was broken. Moreover, learners were not encouraged to generate conjectures and alternative strategies of learning. The classroom should have been used for the implications and planning for the digital community in identifying the exact time for communicating and disseminating knowledge (Sharples et al., 2016; Dron & Anderson, 2007). To support creativity, collaboration, communication, and sharing of resources, the classroom should have been used for exploring engagement in new ways together with adequate monitoring and evaluation of learning resources (Odeyemi, 2020; Kearsley & Shneiderman, 1998). This finding supported the notion that a large majority of public schools have an urgent need for pedagogical improvement since they deliver inadequate educational outcomes in the classroom (McCarthy & Oliphant, 2013). The finding verified that constructionism in these rural secondary schools could be understood only in line with Berger and Luckman's social constructionism (Berger & Luckmann, 1966; Knoblauch & Wilke, 2016). The teachers' negative perceptions on how they teach in the classroom together with learners' disengagement as compared to virtual spaces, as mentioned by other scholars (Murawski & Scott, 2020; Boitshwarelo, 2005). The study, therefore, viewed the lack of teachers in the classroom environment to use their teaching methods towards involving spatial activities as having been proposed by literature (Bishop, 1985). The lack of ICT related teaching and learning technologies could indeed be the cause of demotivation among both teachers and learner.

Category 6 Challenges of online discussion

Another finding from category 1 indicated the challenges of online discussion. Participants were discussing with no intention to cover specific topics. It was more of a revision on some items they have done during classroom encounters. This fluid routine during discussions with no intentionality has been identified as a challenge of online discussion (Boitshwarelo, 2011; Downing, 2003). Literature confirmed that limited "effective professional development and support opportunities for teachers" (Bano et al., 2018; Ramorola, 2018; Haßler et al., 2016; Masilo & Ramorola, 2013) could be inhibiting factors to furnish learners with an adequate range of tasks for effective engagement (Kearney et al., 2018; Bouhnik & Deshen, 2014; Kearsley & Shneiderman, 1998; Ausubel, 1968).

Teachers' anticipation of time as an inhibiting factor to engage with learners after school was confirmed. They were complaining about the interaction consuming their time where learners were excited to communicate for a longer time. Lack of ICT skills among teachers opened opportunities for learners to discover knowledge on their own. This supported Bakhtin who argued that "if an answer does not give rise to new questions from itself, it falls out of the dialogue" (Bakhtin, 1986, p.168).

5.3 SUMMARY OF THE RESEARCH

This section presents a summary of all five chapters into which this study was organised. It is worth noting that this research project, together with the recommendations, achieved the main objective. There was an exploration of the extent of emerging technologies and social networks in enhancing the teaching and learning of mathematics in rural secondary schools at uMkhanyakude District. However, this thesis would have been much more significant had the number of schools and number of participants been larger because the focus would have been on the district rather than on three schools. Nevertheless, the research project has a denser view of the answers to the four research questions the study aimed to answer. The findings supported the implementation of connectivism theoretical framework which incorporates social constructivism, constructionism, and cognitivism (Herlo, 2017; Goldie, 2016; AlDahdouh et al., 2015; Bell, 2010, 2009; Kop & Hill, 2008); hence, teachers and learners participation and interaction in WhatsApp demonstrated "the need for content and support" (Downes, 2010, p. 28). The whole study is revisited to check philosophical rigor, positionality, reciprocity (Nieuwenhuis, 2016; Lincoln, 1995), procedural criteria, the process followed, and accuracy of the study (Creswell, 2013; 2007) and aesthetic qualities (Reichertz, 2004; Richardson,

2000;1994).

Chapter 1

As discussed in Chapter 1 (section 1.3), the main aim of this study was to explore the extent of emerging technologies and social networks in enhancing mathematics teaching and learning in rural secondary schools at uMkhanyakude. The chapter presented the background to the study, introduction, study context, problem statement, the purpose of the study, objectives which were the propelling forces for the study. It followed with delimitations of the study, review of literature, the significance of the study, ethics, definition of terms and the exposition of the study. The research problem and the definition of important concepts for the study were also covered in this chapter.

Chapter 2

In this chapter, I reviewed literature about the usage of social networks in teaching and learning mathematics in the rural context. This was accomplished by exploring what influenced teachers to adopt the usage of emerging technologies and social networks to share information with learners. In this regard, the chapter began by identifying the types of social networks and emerging technologies that teachers used to disseminate mathematics information to learners. The second was the review of literature about learners learning using social networks. Third, the theoretical perspectives that reflected the changing view of education in the context of the rapid technological advances, concerning social constructivism, cognitivism, constructionism, and connectivism about these learning theories.

Chapter 3

Chapter 3 started with the description of this study's philosophical worldview. Here, in essence, it was stated that the study's philosophy was interpretive, in the sense that I followed the qualitative method. So, issues relating to the research design were discussed. For example, the discussion involved explanations of data collection methods using different instruments such as semi-structured interviews, focus group interviews, non-participant observations, online discussions, and documents analysis. Measures on the trustworthiness of the research process were stipulated in depth.

Chapter 4

Data analysis and interpretation of semi-structured interviews, focus group interviews, non-participant observations, online discussions, and analysed documents were presented in this chapter. Whenever applicable, the pertinent quotes provided in the open-ended responses were employed to illustrate important points on the findings. The analysis generated 11 themes that were harvested as per data collection tool. It was from the semi-structured interviews with three teachers where four themes and three categories were developed. There were two themes from pre-research findings as well as from post-research. Online discussions gave birth to three themes and two categories. The non-participant observations generated two themes and categories, whereas the focus group interviews developed two themes. Finally, the document analysis generated two themes and one category.

Chapter 5

This is the concluding chapter which contains the study summary, discussion of the main results, recommendations, and limitations of the study. It concludes with suggestions for further research, reflection on the research as well as the conclusion.

5.4 RECOMMENDATIONS

This section deals with recommendations based on the findings of the research. Using a social network to interact and share mathematics content in a rural setting is an important but daunting task faced by both teachers and learners, especially since there are limited ICT resources such as the internet, gadgets, and data bundles. Research produced to date provides evidence that Information and Communication Technologies (ICT) such as social media or social networks can foster constructive communications between teachers and learners which enable an effective learning environment. However, the problematic issues discussed in the study point to co-construction of knowledge in the approach to mathematics teaching about:.

- Inadequate use of ICT policies and regulations which promote mismanagement and risks to ICT equipment;
- social network platforms benefit users;
- lack of digital resources, knowledge and skills challenged teaching and learning;
- learners' perception towards WhatsApp tool challenges of using WhatsApp following recommendations are made;
- family support encouraged learners towards constructive learning;

- participants adherence to netiquette and develop communication skills;
- teaching and learning strategies to knowledge sharing;
- WhatsApp improved learner performance in mathematics;
- immediate feedback improved learning.

5.4.1 Recommendations for grade 9 mathematics teachers

Given the distinctive area of study, the research needed to come from the perspective of "technophobic" participants who in this study blossomed and drove the whole study. Specifying the professional gap presented between the biographical data of learner participants (see Table 3.3) and demographic data (see Table 3.2) of teachers, brought a glimpse of rationale about continuing with this project. Enhancing rural secondary teachers' schools with emerging technologies and training on how to incorporate social networks in their teaching and learning of learners is imperative. Further studies will have the potential to benefit the uMkhanyakude District and the environment where poor performance is prevailing due to a shortage of extensive digital resources. Findings have presented crucial elements, which were enlargement of learning opportunities for teachers, engagement between teachers and learners, and extensive interaction. These have added value to the teaching and learning process. The study endorsed the importance of SWOT analysis among teachers. This could enable them to identify whether they lack content knowledge, Pedagogical Content Knowledge (PCK), Mathematical Pedagogical Content Knowledge (MPCK) (Luna et al., 2015), or even TPCK (Koehler & Mishra, 2008). The study recommends the constant training of mathematics teachers on mathematics conceptual and contextual usage. Findings verified rural schools as still lagging in numerous resources. It is therefore recommended to have teachers shift their focus from what they do not have to have their beliefs and attitudes tally with intention of enhancing teaching using WhatsApp.

Narratives from pre-research interviews (see Appendix 6) indicated no out-of-school communication between participants. The potential recommendation is to have teachers keep a room for extensive communication with their learners. The study verified different levels and dimensions of language crucial for learners and made sense to them.

The improvement in controlled assessment after a few weeks of WhatsApp out-of-school communication supported the urgent need for intervention. This ideal transactional learning

fosters teaching and learners' abilities, coming on board with turn-around strategies while promoting the government's call towards quality education by 2030 (UNDP, 2019).

The themes harvested indicated the urgency of training teachers to facilitate the effective incorporation of social networks for learning. Further, intentions to learn among learners were observed thus teachers need to know how to support their learners with relevant internet sites. Challenges identified are a call to rethink the core skills and competencies needed by contemporary learners that could be acquired through pedagogical encounters. I recommend a future study that is aimed at espousing an iterative approach in developing rural teachers towards achieving Mathematics Pedagogy Content Technological Knowledge (MPCTK).

The advisable recommendation is to have the beliefs of the teacher need to be in line with their calling for teachers' professionalism. The teacher will not be ashamed to expose his/her lack of knowledge while being receptive to a change irrespective of social class or status. In this regard, teachers are advised to seek assistance from digital natives (learners) to facilitate exciting teaching and learning, wherein learners become teachers too (vice versa).

Teachers are encouraged to read unceasingly, learn and unlearn, be willing to empower learners, other colleagues, and the society at large. This ensures the urgent need for teachers who will come with digital innovations and are not limited by resources, space, or location. Findings showed teachers postponing answers. These findings identified the need of having teachers who will pause, reflect, pursue the vision of excellence by trying and achieving a quality culture of education. This could be enhanced by being knowledgeable (socio-cultural); acknowledging mental processes to influence learners' internal and external factors (Bruner's cognitivism) in parallel to Gardner's multiple intelligence to allow learners to explore; reflect on learners' abilities (constructionism) and look for the tool to supplement knowledge (connectivism). This calls for teachers to enable learners to find own pivotal role in learning (Lee et al., 2020; Nuthall, 1997; 2004) to bring mental processes and sharpen metacognition (Sfard, 2020b; Chirinda & Barmby, 2018; Aprayadi & Marfianti, 2013), transform learners to apply what was learned in their zone (Ackermann, 2004; Knoblauch & Wilke, 2016) through orchestration of knowledge and continually evaluating it (Duke et al., 2010; Kop & Hill, 2008). These transformative skills will balance and acknowledge that learners are human beings with heads, hearts, and hands (Sipos et al., 2008).

5.4.2 Recommendations for grade 9 mathematics learners

The rethinking of digital competencies for learners and teachers in rural secondary schools has the potential of breaking boundaries between school and home. I, therefore, recommend accountability among learners, being sensitive and alert towards their current learning to engage in constructive dialogues, enrolling in educational mathematics platforms. Learners are expected to be aware of the learning opportunities available irrespective of the challenging times they are facing. I therefore recommend good behavior among learners during communication. I propose the abandonment of 'pre-social models of human cognition' among learners for a model that acknowledges 'psychological and social differences of learners'.

Since challenges presented in the study have been persisting among South African communities, learners are advised to be conscious of time; add value to their learning, and overcome their rurality by understanding their socio-cultural context. As they are living during the 'knowledge surplus era', their true identity and liberation will be through pushing the boundaries of poverty by reading, critically engaging in discussion, and being able to discern what is good or bad.

Findings presented the importance of ascertaining the challenges and limitations of using WhatsApp; hence, as learners they will need guidance towards accessing safe digital resources and other social network platforms or apps. They must admire challenges and communicate problems, as problem solvers of today, leaving the room also for accommodating their teachers as a 'problem'.

Learners' perceptions towards using the WhatsApp tool revealed the importance of introspection among learners and discover the best technology they are prepared to use to enhance their learning. It is therefore recommended that learners from rural secondary schools could employ out-of-school communication since it became easy for them to seek help when they could not understand. Connectivism will sustain them in all their needs. They will be able to think objectively and act rationally which will enable them to become responsible citizens. This is recommended to alleviate the common problem of having learners without family support due to various reasons. Engagement and participation in this study have verified the accumulation of tacit values where learners learned self-esteem, confidence to have their voice heard, willingness to participate, and work as a team. Although there were power trappings with teachers, they learned to respect them.

Learners' observation of their teachers being technophobic could teach learners that their deficiency in computational and mathematical reasoning skills may be attributed to their teachers' mathematical anxieties, attitudes, and behavioural patterns related to their past learning. This could add value to power relations that persist in the country. In as much as learners are learning under a constrained environment, they must acknowledge that their teachers can also learn a lot from them as 'learners on the move' (Matthee & Liebenberg, 2007) and WhatsApp as an ever-present tutor. This could fight mathematical difficulties among teachers which were demonstrated in the study wherein teachers postpone answers and delay feedback (Luna et al., 2015). Learners should simulate a critical learning style to stay focused when posting their ideas. It would be better to monitor individuals' idiosyncratic (verbal, non-verbal, and textual) learning and meaning. Visual effects enable them to get used to metaphorical thinking, linking voice to image and speculating the emotions, and analysing contexts.

Learners were using emoticons which indicated solid triadic transactional presence (Sinclair, 2009; Shin, 2002). However, according to Sfard (2008b), using gestures may at times have negative results. This suggests having teachers that maintain the curatorship role (Mupezeni & Kriek, 2018; Siemens, 2004).

5.4.3 Recommendations for grade 9 secondary schools

The study was confined only to three secondary schools in the uMkhanyakude District. However, this study achieved its aim of exploring participants' perceptions of using WhatsApp to enhance their mathematics teaching and learning. The issue raised from the findings here was the dimension of transformation within school A, B and C that only transpired during WhatsApp engagement. However, they need to adapt to new strategies of knowledge harvesting to produce globally competitive citizens. Also, the new transactional classroom was formed in the new space of learners' cognitive presence, social presence, and teacher presence. Findings proved that schools are environments where teachers and learners interact; thus, they gradually develop a shared knowledge, language, and culture.

These previously-mentioned findings link with the following recommendations for further research:

The positive perceptions from participants suggested that the study be extended to other high schools within the district and other districts to obtain a vast understanding of perceptions of

teachers and learners in most rural areas. Every school has a responsibility to become a school of excellence irrespective of geographical location and environmental factors.

It is recommended that since social networks were able to construct transactional presence in mathematics class, other classes, may also utilize WhatsApp resources either for tutoring or to become institutional centers of transformation.

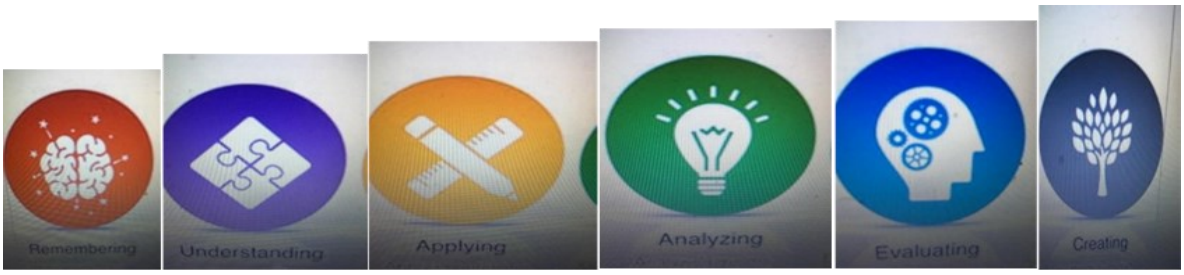
It is therefore recommended to have schools use every opportunity they can afford for the betterment of their dragging resources especially if they are in rural schools.

Adoption of the social network may vary depending on contextual factors. The longitudinal studies should be done on exploring social networks informal usage after hours as means to enhance teaching and learning, not only for mathematics but also for other subjects in the rural secondary schools. Contextual constraints of poor reception, high rate of vandalism, and poor SMT support concerning the integration of technology in teaching and learning are still common, hence teachers and learners' needs vary.

Findings suggests the awareness schools' constraints rather than ignoring them and "adapt (to emerging) tools rather than the tools adapting to their needs". Since findings identified the gap of quick response during the WhatsApp transactional space where teachers could not give quick feedback, this study, therefore, recommends emojis which can be used in WhatsApp as adapted from Bloomberg taxonomy.

In exploring the possible underpinnings of these aspects in future research, it may be possible to understand some of the subtler mechanisms relating to integrating social networks. It was noted that WhatsApp has limitations as a learning platform as it was designed for general communication. It would be more relevant if WhatsApp groups could use relevant emojis for the school context or get the platform or App that can be used by teachers and learners in any school to avoid the struggle of what to post and what is relevant to a particular subject. The study recommends social and technological extension of scaffolding. The usage of the following emoji could excite learners and have a common understanding between teachers and learners themselves.

(https: www.macrumors.com>how-to-create-and-use-animoji-and-memoji?)



Remembering Understanding Applying Analysing Evaluating Creating

Figure 5.1 Emoji's which can be used in WhatsApp as adapted from Bloomberg taxonomy (Churches, 2010)

The proposed emojis in Figure 5.1 needed to be embedded in the WhatsApp tool for quick response in the group chats, without any distorted meaning. This is expected to indicate the teaching and learning comments that directly talk to the learner in terms of the higher-order levels of thinking. It is therefore highly recommended to have the restructuring of strategies to enhance no borders in learning between school and home. WhatsApp is recommended to remotely monitor learners' work.

5.4.4 Recommendations for policy planners

The proposal is for the formulation of school-based-social-networks policies and practices based on values and practical wisdom to ensure smooth facilitation of teaching and learning without any technophobia and cyberbullying in social networks among learners.

I propose the opening of wider philosophical spaces for Mathematics Annual Teaching Plans (ATP) since the National Curriculum Statement Grades R-12 aims to produce learners that are efficient in problem-solving. This will talk about the implementation of the 2018 mathematics framework application in schools. Schools need to widen their spaces so that learners can solve problems within their context using multiple operations and WhatsApp as their identified tool. In the same breath, the SA government has a responsibility of supplying the internet to widen connectivity in rural areas.

This would suggest the policy which is contextually re-conceptualised. There should be in-service training for teachers in the field on how to identify, and use emerging technologies to enhance teaching and learning using a bottom-up approach to talk to their contextually designed teaching and learning design.

5.4.5 Recommendations for further research

Based on the limitations of the research (see Paragraph 5.5), this study can be replicated on a larger scale. A study could be conducted on problem-solving skills enhanced by collaboration on WhatsApp in proportion to mathematics content achievement. One unique finding that may warrant further study relates to unravelling extensive research methods to investigate how WhatsApp instant educational emoticons (emoji's) will shape the future of rural secondary education.

Future research could look into other distinct structural features of WhatsApp teaching and learning platforms where the potential for interaction with the diffusional effect of the distribution of knowledge can be identified. This has become imperative since WhatsApp has been extensively incorporated for instructional learning where other scholars have found the negative impact on its constant use.

This study was only a preliminary baseline study of WhatsApp used for exploring the perceptions and challenges encountered by teachers and learners in rural secondary schools as they interact after school hours. However similar findings would lend credence to those found in this study; hence, dissimilar findings would indicate that these findings need to be revisited or further explanation must be attached due to differences in context. Each of the four objectives set for this study was achieved. Notably, several possible future research projects are apparent.

This research intended to explore the integration of social networks in teaching and learning to improve poor performance in mathematics. However, research questions were framed to focus on learning activities. This could suggest that the initial step for future research is to ascertain whether learning activities or processes did occur during knowledge acquisition among learners using.

Further research based on a larger sample size of rural secondary schools concerning after school hours of WhatsApp usage not only on mathematics but enhancing different subjects is suggested.

The future study will explore implications of transforming teaching and learning with emerging technologies, a case study at the secondary rural school at uMkhanyakude District. Another one will explore the adoption of the social network usage policy at the school level. I think the bottom-up approach in adopting emergent technologies would be more proper and realistic as it will be contextually crafted. I anticipate exploring the descriptive powers and deeply

conceptualize digital Bloom's taxonomy and Fink's Significant Learning in rural secondary schools. This draws me back to the question of What it is that other teachers from rural schools refer to as learning? Could it be every link to instructional strategies and not motivational principles or outcomes? How can the extent of engagement be categorised? Does it include efforts or tests and projects?

There are numerous publications concerning the incorporation of WhatsApp since the country has been on pandemic due to COVID-19. It is fascinating that still to date, I have not encountered literature that unpacks proper framework to be used when employing WhatsApp as the only learning platform for teaching and learning; therefore, a conceptual framework will be crafted from this study as advancement of research within this field.

5.5 LIMITATIONS OF THE STUDY

It cannot be underestimated that this thesis was produced when knowledge usage of WhatsApp prevailed extensively. I was chunking and chopping some information to align to research principles and produce a sound doctoral thesis in terms of the current situation. The provision of valuable insight through the shifting of puzzles was a long journey exercise that widen also my research scope and produced in-depth subject knowledge.

Although similarities with other schools may exist, this study was undertaken in three schools within one district of KZN. The findings of the study are somewhat limited since a small-scale qualitative study was employed; thus, the findings cannot be generalized in any way. The main aim was to improve the situation in the relevant schools, which may contribute lessons to other similar contexts.

Dealing with humans and their handling of social networks was intruding into their private lives, which limited the study in terms of the genuineness of the findings. In the rural area, poverty supersedes primary needs, not to mention buying data for secondary learners. This limited research because the study ended up having a very limited number of learner participants. Also introducing another venture of using social networks was demanding.

It was noted in the study that the availability of data and reception was a challenge that prompted other learners to respond later. This hindered the researcher from identifying the real-time flow of the responses and their efficiency. Ideally, it would be better if the schools were using their monitored WhatsApp to ensure the flow of communication and that no further conversations were happening outside the WhatsApp group that was formed particularly for this research purpose. Lack of educational features and less 'interactive instructive' WhatsApp

platform demands the social group to have reliable answers to avoid poisoning learners' content knowledge.

The availability of time and resources are the constraints that were anticipated. The density of networks and statistical analysis of dimensions for engagement and participation regarding findings should the study be following the quantitative approach. However, since the study was exploring the effectiveness of WhatsApp as an instructional tool, there were limitations on using it as an instructional platform but perceptions of participants were well captured using a qualitative approach. The study intended to have a platform wherein scaffolding is incorporated in an online learning environment using cognitive support and strategies for finishing learning tasks for the individual learner. Exploration in this study, however, portrayed minimal cognitive support to learners because teachers had no supporting context to allow learners to navigate through their performance. Secondly, there was no range of tasks offered by teachers. In this regard, the distance between the learners' actual developmental level to a higher level of potential development could not be tracked.

5.6 REFLECTIONS ON THE RESEARCH

The study identified a common problem of the high failure rate of mathematics in rural secondary schools, and sought to explore the integration of social networks by teachers and learners in three schools. Three WhatsApp groups were formed, worked together as a team to address a problem. Participants were not exposed to any of the platforms as the means to enhance rural learners' after-hours discussion. The majority of learners could not bring back their consent forms. WhatsApp was not free.

The study taught me a lesson that emanated from findings that having rural learners engaged in the WhatsApp platform has diverse benefits. Learners are taught to interact in public conversations and respect others' opinions. In the same vein, pedagogical beliefs are crucial factors that lead to a shift in teachers' beliefs. Interpretations to this notion are beliefs of teachers' change as they began to use WhatsApp to enhance teaching. On the other side, learners' beliefs emancipated into trust realisation. In 2020, during the COVID 19 outbreak, the findings from this study were more feasible; hence, there were urgent means for parental involvement and monitoring of homework.

The second lesson emanates from the first lesson and relates to theoretical underpinnings that justify the determining factors for improving the mathematics failure rate. The study presented

the limitations of Bruner's vicarious form of consciousness since teachers themselves could not delve into scaffolding problem-solving mathematical structures. A further extension to this is anticipated in incorporating higher levels of Ausubel's abstraction (Ausubel, 1968) and inclusiveness to identify meaning in verbal, non-verbal, and textual learning. The recommendation presented in 5.4.3 anticipates exploring emojis that teachers can use to inform learners' levels of development (Churches, 2010; 2007).

I anticipate unpacking concepts like 'understand' and 'create' which have the descriptive powers to affect learners' performance about cognitive levels and domains (Churches, 2010; Fink, 2003). There is literature (Walkerdine, 1990; Sinha & Walkerdine, 1974) that claims the concept 'understand' as dependent on the discourse and the evolving norms of the mathematics community.

The lesson was that for an educational activity to take place, team effort is required. The lesson clarified what can be done to support learners and teachers in the use of ICT and social networks for teaching and learning. Research has not been only about getting answers but also about questioning things. Throughout this project it was clear that connectivity applies in all spheres; hence, the process does not come to an end easily. In as much as schools mostly adhere to Bloom's taxonomy, I value significant learning as it includes more than cognitive learning and the human dimension which will enable mathematical learners to become resilient in their context. It also becomes clear that the answers to research questions are not readily available but require digging even deeper to obtain answers, indeed there are no shortcuts. The reflection process in data analysis validates the interpretation of the generated data. In short, this study taught me, that problem-solving strategies as multi-intelligence are currently needed for every learner's effective educational sustainability.

The study equipped my scholarship identity using a connectivism theoretical framework. Since digital developments are not static, my future intention is to initiate collaborative research for the benefit of my participants and community at large. Writing this thesis from a different, rural secondary schools' angle, enabled me to expand my relationship with my study which in turn widened more ventures to be explored.

5.7 CONCLUSIONS

This study focused on exploring the participant's perceptions regarding the extent of emerging technologies and social networks in enhancing teaching and learning in rural secondary

schools. The study was conducted at uMkhanyakude District. The semi-structured interviews focus group interviews, online discussion, non-participant observation, and document analysis used as data collection methods were outlined in chapter 3, section 3.4.

I analysed data qualitatively, using themes and categories to describe rich data using social constructivism, social cognitivism, constructionism, and connectivism theoretical framework (see chapter 4).

All the objectives of the study which were discussed in chapter 1, section 1.3, were achieved. Objective 1 focused on exploring the different social networks, teachers use to connect with learners to share mathematical content. From the data collected, it was found that there are positive perceptions regarding the integration of WhatsApp in enhancing teaching and learning. The challenges that were encountered were stipulated henceforth recommendations were made and my future study reflections cover that.

Objective 2 aimed at finding out the extent of learner-teacher interactions that have taken place during the research. Findings implied that this research was of vital importance to assist learners' transactions from a remote style of living and learning. In as much as the target of having learners pass their mathematics subject was a priority, there was a great need for teachers to have learners equipped to practice their knowledge in the real context. In this case participants' culture, structure, and language (spoken and visual) were observed simultaneously as relational ties fused as a sociocultural and sociotechnical setting in this study. It was therefore assumed that attaining contemporary knowledge would be impossible if teachers could not teach learners some of these skills. Surprisingly, observation unfolded the reality as the findings indicate.

Furthermore, the findings revealed that teachers and learners in secondary schools can utilise the benefits from social networks in facilitating effective and efficient teaching and learning. The role of the teacher cannot be superseded by technology; thus, the framework suitable for enhancing teaching and learning using digital technologies should incorporate all the four theories as proposed in chapter 2, section 2.4. However, it should be recognized that data attainment will not solve problems in rural education. What is required is the emancipation of an efficient pedagogical model that could fit the scope while enabling rural secondary schools an opportunity to improve their education.

Objective 3 was to ascertain technological methods that prevailed in the learners' discovery of mathematics content knowledge. Findings indicated that in as much as teachers were skeptical

about learners' behaviour which was anticipated to be wild, the study proved learners as able to co-operate in online discussion.

The last objective 4 was to identify the methods prevalent in teaching and learning through social network interaction. This study concludes that learners are called to be open to criticism and be willing to contribute to meaningful collective debates. The study is indeed an urgent call to have relevant learners question the status quo, and engage in conversations that could take their teachers to the edges of their boundaries and cause reframing. This was further emphasised by the re-emergence of SA grade 9 exit policy debates. In many cases, ICT can be used to liberate learners rather than perpetuating inequalities in the schooling system, by using ICT or social networks in school and out-of-school contexts.

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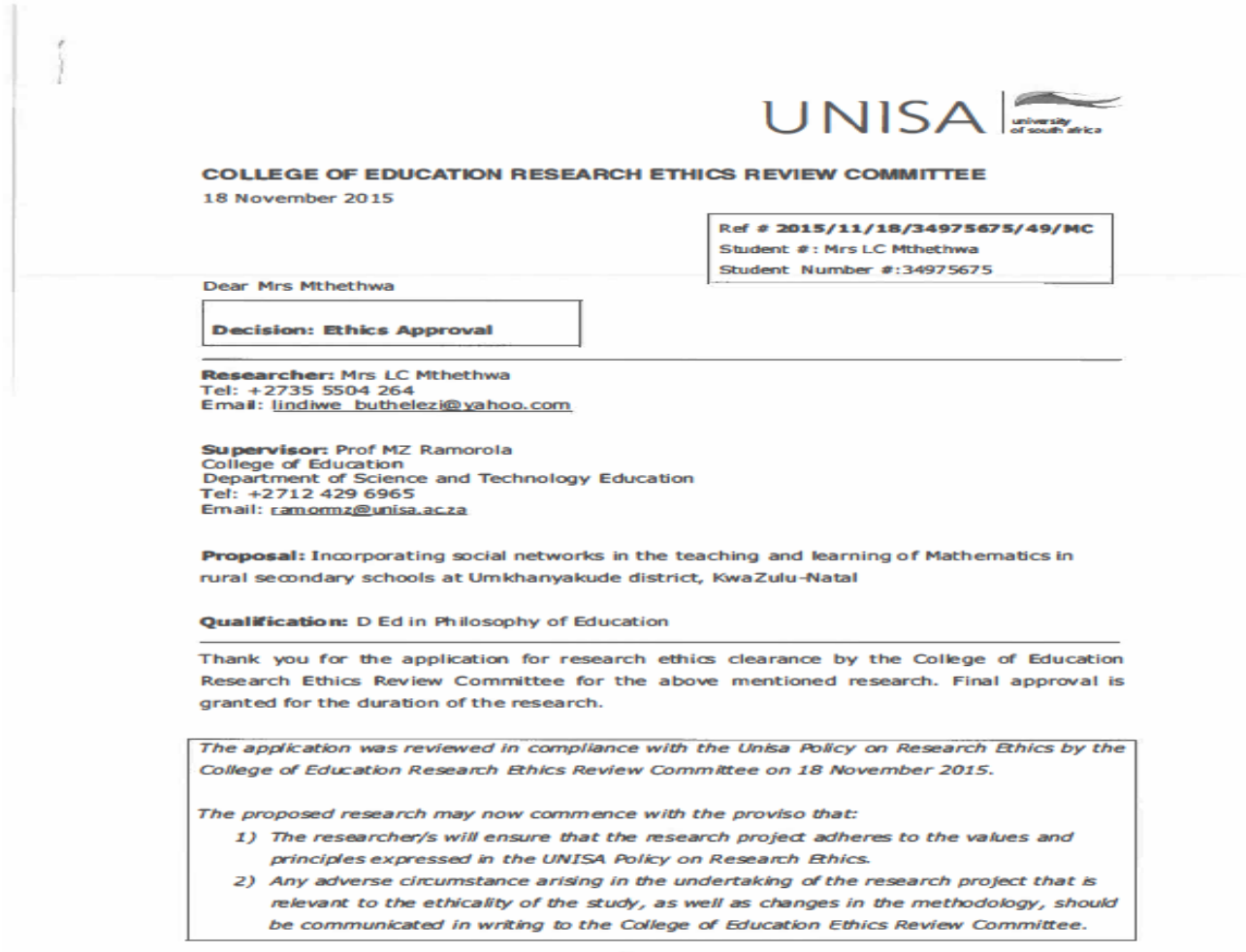
the case of 10 schools in KwaZulu-Natal under Umlazi District. [KwaZulu-Natal]. https://ukzn-dspace.ukzn.ac.za/handle/10413/19067

APPENDICES

Appendix 1: Ethical clearance



UNISA

COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE

18 November 2015

Ref # 2015/11/18/34975675/49/MC
Student #: Mrs LC Mthethwa
Student Number #:34975675

Dear Mrs Mthethwa

Decision: Ethics Approval

Researcher: Mrs LC Mthethwa
Tel: +2735 5504 264
Email: lindiwe_buthelezi@yahoo.com

Supervisor: Prof MZ Ramorola
College of Education
Department of Science and Technology Education
Tel: +2712 429 6965
Email: ramormz@unisa.ac.za

Proposal: Incorporating social networks in the teaching and learning of Mathematics in rural secondary schools at Umkhanyakude district, KwaZulu-Natal

Qualification: D Ed in Philosophy of Education

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the research.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 18 November 2015.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee.*

An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.

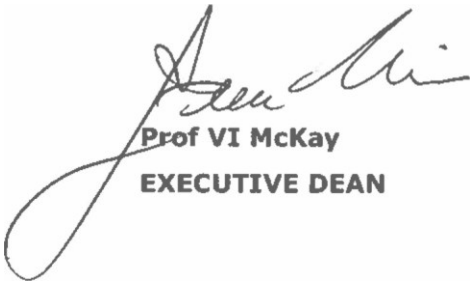
3) The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

Note:

The reference number 2015/11/18/34975675/49/MC should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the College of Education RERC.

Kind regards,

Dr M Claassens
CHAIRPERSON: CEDU RERC



2014

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Appendix 2: Permission from the Department of Education-KZN

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Nomangisi Ngubane | Tel: 033 392 1004 | Ref.:2/4/8/596

Mrs LC Mthethwa
PO Box 3028
MTUBATUBA
3935

Dear Mrs Mthethwa

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"INTEGRATING SOCIAL NETWORKS IN THE TEACHING AND LEARNING OF MATHEMATICS IN RURAL SECONDARY SCHOOL, A CASE STUDY OF UMKHANYAKUDE DISTRICT",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 13 January 2016 to 31 January 2017.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

UMkhanyakude District

Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 10 December 2015

KWAZULU-NATAL DEPARTMENT OF EDUCATION

POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa
PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004
EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za / Nomangisi.Ngubane@kzndoe.gov.za
CALL CENTRE: 0860 596 363; Fax: 033 392 1203 WEBSITE: WWW.kzneducation.gov.za

Appendix 3: Letter to the circuit manager

P.O. Box 3028

Mtubatuba

3935

20 October 2015

Enquiries: Lindiwe Carol Mthethwa

Telephone: (Cell) 083 XXXX XXX/ (Work) 035 XXXX XXX

E-mail: MthethwaC@unizulu.ac.za

The Circuit Manager

---------- Circuit

Dear Sir

Re- requesting permission to conduct research in your circuit starting from the 08th of February up to the 25th of March 2016

I, Lindiwe Carol Mthethwa, am doing research with Prof M.Z. Ramorola, is a Professor in the Department of Science and Technology towards a Doctor of Education degree at the University of South Africa.

The aim of the study is to explore the integration of social networks **in the teaching and learning of Mathematics in rural secondary schools. Two** schools in your circuit ------ and --------- high schools have been selected purposely because of their performance which is below the district average in the three consecutive years, which is 2013, 2014 and 2015. The study will entail the usage of social network as the means of facilitating communication between the learners and their teachers. I would like to explore whether communication after hours will enhance effective learning of

mathematics. This is one strategy that will explore improvement in Mathematics, so my study will focus on the usage of social networks as means of communication outside normal notional teaching time. The benefits of this study are expected to sharpen learners' inquiry method and improve connectivity between the learners themselves and their teachers.

Cyberbullying and misappropriate behaviour through social networks like posting illegal activities and learners trashing teachers is strongly prohibited. Posting confidential information or anything not related to Mathematics for grade 9 is forbidden. Should any learner be found contravening this, I request that he/she be withdrawn with immediate effect and parent will be informed.

For any queries you may contact me at 083 XXXX XXX or my promoter, Prof M.Z. Ramarola at: **ramormz@unisa.ac.za / 012 XXXX XXX.**

Yours sincerely

Lindiwe Carol Mthethwa

Signature ----------Date----------

I ---------- the circuit manager of ----------

Agree / disagree in allowing Mrs L.C. Mthethwa to conduct research titled "Integrating social networks in the teaching and learning of Mathematics in rural secondary schools at Umkhanyakude district, KwaZulu-Natal" at ---------- and ---------- Schools.

Signature ----------Date----------

Appendix 4: Letter to the principal

P.O. Box 3028

Mtubatuba

3935

20 October 2015

Enquiries: Lindiwe Carol Mthethwa

Telephone: (Cell) 083 XXXX XXX/ (Work) 035 XXXX XXX

E-mail: MthethwaC@unizulu.ac.za

The Principal

----------High School

Dear Sir/Madam

Requesting permission to conduct research in your institution starting from the 08th of February up to the 25th of March 2016

I, Lindiwe Carol Mthethwa, am doing research under supervision of Prof M.Z. Ramorola, a Professor in the Department of Science and Technology, towards a Doctor of Education degree at the University of South Africa.

The aim of the study is to explore the integration of social networks **in the teaching and learning of Mathematics in rural secondary schools.** Your institution has been selected to participate in the study.

The study will entail the usage of social networks as the means of facilitating communication between the learners and their teachers. I would like to explore whether communication after hours will enhance effective learning of mathematics. This is one strategy that I think will improve high achievement in Mathematics, so my

study will focus on the usage of social networks as means of communication outside normal notional teaching time. The benefits of this study are expected to improve connectivity between the learners themselves and their teachers. I am requesting the data on the 2013, 2014 and 2015 results of the controlled tests; to use voice recording during the interviews and to observe the classroom on the 25th of March 2016. The data that will be collected will be used for research purposes only.

I would also ask you to disclose to me your school policy on Information Communication Technologies (ICT) on the 18th of January 2016. This will be needed to verify that proper measures regarding the irresponsible usage of social media are in place and learners are well orientated regarding the matter. Cyberbullying and misappropriate behavior through any social network like posting illegal activities and learners trashing teachers is strongly prohibited. Posting confidential information or anything not related to Mathematics for grade 9 is forbidden. Should any learner be found contravening this, I request that he/she I be withdrawn with immediate effect and parent will be informed together with the disciplinary steps according to what your school policy stated.

For any queries you may contact me at 083 XXXX XXX or my promoter at: **ramormz@unisa.ac.za / 012 XXXX XXX.**

Yours sincerely

Lindiwe Carol Mthethwa Signature ----------Date----------

I ---------- the principal of ----------
Agree / disagree in allowing Mrs L.C. Mthethwa to conduct research titled

“Integrating social networks in the teaching and learning of Mathematics in rural secondary schools at Umkhanyakude district, KwaZulu-Natal” in my respective institution.

Signature ----------Date----------

Appendix 5: letter to the grade 9 mathematics teacher

P.O. Box 3028

Mtubatuba

3935

20 October 2015

Enquiries: Lindiwe Carol Mthethwa

Telephone: (Cell) 083 XXXX XXX/ (Work) 035 XXXX XXX

E-mail: MthethwaC@unizulu.ac.za

Dear Respondent

RE: Request you to participate in a research project

You are humbly requested to participate in a study on **integrating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu-Natal. I am a doctoral student** at the University of South Africa.

The proposed research is intended to explore the impact of social networks in teaching and learning mathematics and achieve the following objectives:

1. To explore the different social networks used for Mathematics information dissemination.
2. To find out the extent to which the learner-teacher discussions are taking place in social networks.
3. To identify the technology methods prevalent to Mathematics information discovery by the learners.

4. To investigate the type of learning taking place in social networking technologies as the evidence of learners mastering Mathematics after using social networks.

I would like to have semi-structured interview with you whereby, I will be expecting to have your views and opinions on the importance of communication between you as a teacher and learners even after hours. May I request you to organise at least 20 learners who will have access to the smart phone or computers after hours for social networking communications. I request that you form the social networking group with your learners so that it become possible to continue communicates with them even after school hours. I will follow you in your social network group, your social conversation after school between you and your learners as from the 08th of February 2016 up to the 25th of March 2016. Your participation in this study is voluntary. May I also request to access the district controlled assessment records of grade 9 from 2013, 2014 and 2015. I will compare learners' achievement with what they will get from the first quarter controlled Mathematics grade 9 assessment. Research will involve an interview of approximately 45 minutes in length to take place in a mutually agreed upon location at a time convenient to you. You may decline to answer any of the interview questions if you so wish. Furthermore, you may decide to withdraw from this study at any time without any negative consequences. On the 24th of March, may I come and observe your classroom teaching and learning experience, just for one period. After school I would request to meet learners who will be my focus group in the study.

May I request to have the interview audio-recorded to facilitate collection of accurate information and later transcribed for analysis. Shortly after the transcription has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or to clarify any points. All information you will provide will be considered completely confidential. Your name will not appear in any publication resulting from this study and any identifying information will be omitted from the report. However, with your permission, anonymous quotations may be used. Data collected during this study will be retained on a password protected computer for 5 years in my locked office. I would like to

refer to your school policy on usage of Information Communication Technologies (ICT). Cyber-bullying and misappropriate behavior through social networks like posting illegal activities and learners trashing teachers is strongly prohibited. Posting confidential information or anything not related to Mathematics for grade9 is forbidden.

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact my promoter: Prof M.Z.Ramarola, at ramormz@unisa.ac.za.

Thank you for your participation.

Lindiwe Carol Mthethwa

Signature

_____Date_____

I (participant)…….have been fully updated of the research and I understand what is required from me. I consent to participation in the study. I have read the information presented in the information letter about the study on **integrating social networks in the teaching and learning of Mathematics in rural secondary schools at Umkhanyakude district, KwaZulu-Natal** in education. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions regarding the study. I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses. I am also aware that excerpts from the interview may be included in publications to come from this research, with the understanding that the quotations will be anonymous. I was informed that I may withdraw my consent at any time without penalty by advising the researcher. With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

Participant's Name (Please print): _____

Participant's Signature: _____Date_____

Appendix 6 Semi-structured interview questions

1. Do you use any ICT related forms of technologies as resources for teaching and learning in this school

2. Which forms of technologies are commonly used in your teaching?

3. Do you have ICT policy? How does the school ICT policy promote interaction between the learners and teachers?

4. What challenges do you as the teacher encounter in integrating technology and other methods of teaching?

5. Are there any intervention programs in place which cater for learners' individual needs?

6. Are there any strategies in place of actively engaging learners?

7. What methods are prevalent in learner information discovery?

8. Are you using any social network in your private life? What for?

9. Are there any discussions that are happening between learners and teachers outside the stipulated notional time?

10. Have you ever thought of utilizing those social networking skills in engaging your learners after school?

11. What types of social networks do you think you can use it freely when parents do allow their children to engage for this research after hours that you think will enable you to disseminate information to learners?

12. Can I please ask you to give the learners the chance of communicating with you after hours using social network that you will find suitable to all that are willing to participate in the study, and include me as the non-participant observer, so at to take notes on daily basis about your interaction with your learners and learners among themselves after hours

13. How did you end up using this social network?

14. How does the school ICT policy promote interaction between the learners and teachers?

15. What challenges do you as the teacher encounter in integrating social network and other methods of teaching?

16. Did you manage to track individual performance of learners who participated in the group?

17. How was the performance of the learners in Mathematics after using social networks communication with them after hours?

18. To what extent have learner-teacher discussions taken place when using social networks? Were learners expecting you to start the conversation always?

19. Was the intervention program of communicating with learners useful to cater for learners' individual needs?

20. How can you rate learner-teacher interaction before and after this integration process of social network? Substantiate your answers.

21. Was there any creation of the intellectual environment where serious Mathematical thinking is a norm? Was there any promotion of learner information discovery?

22. Did you manage to measure on daily basis that each learner can practice Mathematics as an individual?

23. How learners' knowledge of Mathematics has been actively built on the applying new knowledge on everyday encounter? Was it always for revision or even to explore for new information?

24. Do you think that learners got fun in their learning when integrating their learning with the social networks? Elaborate on your answer.

Appendix 7 Non-participant observation checklist

Reformed Teaching Observation Protocol (RTOP)

1. BACKGROUND INFORMATION

Name of the teacher_____ Number of learners_____

School_____ Date of observation _____

Start time _____ End time _____

2. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space below, a brief survey of any contextual background of learners that includes their gender, ethnicity and usual time of their participation in the communication will be given.

_____
_____
_____

3. LESSON DESIGN AND IMPLEMENTATION	Never 0	1	2	3	Always 4
1) Lesson encouraged students to seek and value alternative modes of problem solving					
2) The lesson was designed to engage learners as members of learning community					
3) The instructional strategy respected student's prior knowledge					
4) Learners come up with ideas which drive the focus of the lesson					

4. CONTENT	Never 0	1	2	3	Always 4
5) Learners were reflective about their learning					
6) Intellectual rigor, constructive criticism and challenging of ideas were valued.					

7) Learners were actively engaged in thought-provoking activities.					
8) The critical assessment of the lesson is conducted					
5. COMMUNICATIVE INTERACTIONS	Never 0	1	2	3	Always 4
9) Learners were involved in the communication of their ideas using social networks.					

10) There is respect in the communication					
11) Student's questions and comments often determine the focus					
12) There was a high proportion of learners' talk among themselves.					

6. LEARNER/TEACHER RELATIONSHIP	Never 0	1	2	3	Always 4
13) Active participation of learners was encouraged in the class and also to group discussions in social network.					
14) Learners are encouraged to generate conjectures and alternative strategies.					
15) In general the teacher was patient with learners					
16) The teacher acted as a resource person, aiming at enhancing learners' investigations					

Recording salient events here

Time	Description of Events

Appendix 8: Inform assent letters to grade 9 mathematics learners

P.O. Box 3028

Mtubatuba

3935

20 October 2015

A LETTER REQUESTING ASSENT FROM GRADE 9 MATHEMATICS LEARNERS TO PARTICIPATE IN A RESEARCH PROJECT

Title of study: **Integrating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu-Natal**.

Dear ……

I am doing a study on **integrating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu-Natal** as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special participant of my study. I am doing this study so that I can explore ways that your teachers can use to improve your mathematics performance better. This is anticipated to motivate you and many other learners of your age in different schools, to continue engaging on the lesson even after school hours. This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may communicate with me to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I would like you to engage with your classmates and your mathematics teacher after school communicating mathematics problems and solutions, with the hope to

enhance your understanding of Mathematics. I will also conduct the focus group interview (for only forty five minutes), with all of you as learners who are participating in this study to talk openly what you think can work when incorporating social networks to facilitate effective teaching and learning. Meeting you as the group will be once after school hours so that I do not tamper with your daily classroom time table. I will start following you in your group as from the 08th of February to 25th of March 2016 so as to have at least twenty learners from your school that will become part of the study. Your Mathematics teacher will form the social network group where you will communicate after school with your teacher and your peers strictly on learning Mathematics. I will come and address you as the group (my focus group) where will be discussing with me your experience while you were communicating with the group in capacitating one another in learning Mathematics after the normal school notional hours. I request you to allow me to use the voice recording during our interviewing process. On the 25th of March I am requesting to come and observe you in classroom.

I will write a report on the study but I will not use your name in the report or say anything that will let other people know who you are. You do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time. You may tell me if you do not wish to answer any of my questions. No one will blame or criticise you. When I am finished with my study, I will return to your school to give you a report back on my findings, where you will be definitely be invited to come and listen to my presentation.

I would like to refer to your school policy on usage of Information Communication Technologies (ICT). Cyber-bullying and misappropriate behavior through social network like posting illegal activities and learners trashing teachers is strongly prohibited. Posting confidential information or anything not related to Mathematics for grade 9 is forbidden. Should any learner be found contravening I will request that he/she be withdrawn with immediate effect and parent shall be informed.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me at 083 XXXX XXX. Do not sign the form until you have all your questions answered and understand what I would like you to do.

Researcher: Mthethwa Lindiwe Carol Phone number: 035 XXXX XXX/ cell no. 083 XXXX XXX or contact my promoter: ramormz@unisa.ac.za.

Signature: ---------- Date: ----------

Do not sign written assent form if you have any questions. Ask your questions first and ensure that someone answers those questions.

****

WRITTEN ASSENT

I have read this letter which requested me to be part of a study at my school. I have understood the information about this study and I know what I will be asked to do. I am willing to be in the study.

Learners' name (print) _____Learners' signature_____ Date: _____

Witness' name (print) _____ Witness; signature_____ Date: _____

(The witness is over 18 years old and present when signed.)

---------- ---------- ----------

Parent/guardians' name (print) Parent/guardians' signature: Date:

---------- ---------- ----------

Researchers' name (print) Researcher's signature: Date:……

Appendix 9: Consent letters addressed to parents

P.O. Box 3028

Mtubatuba

3935

20 October 2015

Dear Parent

A LETTER REQUESTING PARENTAL CONSENT FOR PARTICIPATION OF MINORS (THE GRADE 9 MATHEMATICS LEARNER) IN A RESEARCH PROJECT

Your child (_____) is invited to participate in a study entitled: **Integrating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu-Natal.** I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to explore the incorporation of social networks **in the teaching and learning of Mathematics in rural secondary schools** and the possible benefits of the study are the improvement of Mathematics pass rate in grade 9. I am asking permission to include your child in this study because I am working in particular with grade 9 learners. I expect to have forty learners including your child, which will be twenty learners from this school participating in the study. If you allow your child to participate, I shall request him/her to:

- Take part in a focus group interview (where I will be discussing with them as the group of 20 learners) and have some voice recordings to ensure that every data is captured.
- I will be following them as the group in the social networks where they will be communicating after school with their Mathematics teacher and as class.
- I will look at your child's performance in Mathematics for the first term next year (2016).

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

The study will entail the usage of social networking as the means of facilitating communication between the learners and their teachers. I would like to explore whether communication after hours will enhance effective learning of mathematics. My study will focus on the usage of social networks as means of communication outside normal notional teaching time.

Cyberbullying and misappropriate behavior through social networks like posting illegal activities and learners trashing teachers is strongly prohibited. Posting confidential information or anything not related to Mathematics for grade 9 is forbidden. Should any learner be found contravening this, I will request that he/she be withdrawn immediately.

Your child will receive no direct benefit from participating in the study. Neither your child nor you will receive any type of payment for participating in this study. Your child's participation in this study is voluntary and may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place afterhours whereby I will be following them in their social network group's conversation with the prior approval of the school and your child's teacher. I will meet them once for classroom observation and as a focus group. In addition to your permission, your child must agree to participate in the study and your child will also be asked to sign the assent form which accompanies this letter. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

If you have questions about this study please ask me or my study supervisor, Prof M.Z. Ramorola, Department of Science and Technology, College of Education, University of South Africa. My contact number is 083 XXXX XXX and my e-mail is MthethwaC@unizulu.ac.za. The e-mail of my supervisor is ramormz@unisa.ac.za. Permission for the study has already been requested form department of Education (Kwa-Zulu Natal) and the Ethics Committee of the College of Education, UNISA.

If you are making a decision about allowing your child to participate in this study, your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Yours Sincerely

_____

Researchers name (print) Researcher's signature Date:

Name of child: _____

_____

Parent/guardian's name (print) Parent/guardian's signature:

Date:

Appendix 10: Consent letter for learners to sign for the focus group interview

P.O. Box 3028

Mtubatuba

3935

20 October 2015

A LETTER REQUESTING ASSENT FROM GRADE 9 MATHEMATICS LEARNERS TO PARTICIPATE IN A RESEARCH PROJECT AS THE FOCUS GROUP

Title of study: **Incorporating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu-Natal**.

Dear ……

I am doing a study on **incorporating social networks in the teaching and learning of Mathematics in rural secondary schools, at Umkhanyakude district, KwaZulu Natal** as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special participant of my study. I am doing this study so that I can find ways that your teachers can use to improve your mathematics performance better. This will help you and many other learners of your age in different schools, to continue engaging on the lesson even after school hours.

This letter is to explain to you what "Focus group" means? This means that you will form the group of learners that I will be focussing on paying attention as to how you can benefit from using social networks to facilitate better communication amongst you and your teacher. I will be following your conversation in your social network group. On the 25th of March 2016, I would like to have some questions that I will pose to you as the group after school, which will be based on your experiences as from the 08th of February up to the 25th of March 2016. I would like to conduct the

focus group interview, with all of you, as learners who were participating in this study to talk openly about what you think can work when incorporating social networks to facilitate effective teaching and learning. I request that during the focus group interview, I will use the audiotape to assist me to capture all our conversation. Meeting you as the group will be twice after school hours so that I do not tamper with your daily classroom time table. They will last for only forty five minutes. The first meeting will be on the 04th of February 2016, whereby I will be explaining our engagement that will start on the 08th of February and collect all the consent and assent letters. I am expecting twenty learners from your school that will become part of the study. I request to use the voice recording so as to capture all the verbal information.

There may be some words you do not know in this letter. You may ask me to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study. I would like you to engage with your classmates and your mathematics teacher after school communicating mathematics problems and solutions. I will write a report on the study but I will not use your name in the report or say anything that will let other people know who you are? You do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time. You may tell me if you do not wish to answer any of my questions. No one will blame or criticise you. When I am finished with my study, I will return to your school to give a report back on findings. I will invite you to come and listen to my presentation.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me at 083 XXXX XXX or contact my promoter: ramormz@unisa.ac.za.

Do not sign the form until you have all your questions answered and understand what I would like you to do.

Researcher: Mthethwa Lindiwe Carol Phone number: 035 XXXX XXX/ cell no. 083 XXXX XXX

Signature---------- Date ----------

Do not sign written assent form if you have any questions. Ask your questions first and ensure that someone answers those questions.

FOCUS GROUP ASSENT AND CONFIDENTIALITY AGREEMENT

I_____ grant assent that the information I share during the group discussions (focus group interviews) may be used by the researcher, Lindiwe Carol Mthethwa, for research purposes. I am aware that the group discussions will be audio recorded and grant consent/assent for these recordings, provided that my privacy will be protected. I undertake not to divulge any information that is shared in the group discussions to any person outside the group in order to maintain confidentiality.

Participant‘s Name (Please print):- _____

Participant’s Signature:-_____

Parent’s Name :-_____

Parent’s Signature :-_____

Researcher’s Name: (Please print):-_____

Researcher’s Signature:- _____

Date:-_____

Appendix 11: Focus group interview questions

1. Were there any discussions that were happening between you as learners and the teachers outside the stipulated notional time which facilitates more effective teaching and learning of Mathematics, prior this engagement of communication using social networks?
2. Which social network do you prefer or use most of the time, and why?
3. Would you recommend the usage of social network or other technological methods of communication in facilitating effective learning?
4. Were the technological methods that you were using challenging you to think critically and be able to voice it out openly?
5. What is it that makes mathematics classroom environment lively?
6. Were you learning effectively yet in a relaxed manner when using technological resources? Substantiate your answer
7. Is there any integration of social networks or technology by teachers to facilitate effective teaching and learning of Mathematics in other rural secondary schools?
8. How can you describe the period you have experienced while you were sharing the information using social networks after school

Appendix 122: Turnitin report

Turnitin Originality Report

- Processed on: 13-0ct-2021 21:11 SAST
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in teaching and learning of mathematics in rural secondary schools By Mthethwa Lindiwe

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Appendix 133: Letter from the editor

PO Box 77214
Empangeni
3880

Mobile: 074 9211 480
Email: zanibaz@yahoo.com

Professional EDITORS Group | An association of editors in educational, academic and general publishing

To whom it may concern

This serves to confirm that the document whose details appear below has been expertly proofread and edited.

Document Title: INTEGRATING SOCIAL NETWORKS IN THE TEACHING AND LEARNING OF MATHEMATICS IN RURAL SECONDARY SCHOOLS

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Date: 2022/03/28

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