Universidad de Valladolid

Escuela de Doctorado Universidad de Valladolid

PROGRAMA DE DOCTORADO EN INVESTIGACIÓN TRANSDISCIPLINAR EN EDUCACIÓN

TESIS DOCTORAL:

PRE-SERVICE MATHEMATICS TEACHERS' SOCIAL MEDIA USAGE AND ITS PERCEIVED IMPACT ON THEIR PERSONAL, ACADEMIC AND TEACHING CAREERS

Presentada por Eddie Mumba Mulenga para optar al grado de

Doctor por la Universidad de Valladolid

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Año 2020

DOCTORAL PROGRAM IN TRANSDISCIPLINARY RESEARCH IN MATHEMATICS EDUCATION

PRE-SERVICE MATHEMATICS TEACHERS' SOCIAL MEDIA USAGE AND ITS PERCEIVED IMPACT ON THEIR PERSONAL, ACADEMIC AND TEACHING CAREERS

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Submitted in [partial] fulfilment of the requirements for the degree of [Doctor of Philosophy in Mathematics Education]

School of Doctoral Studies
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2020.

Keywords

Attitudes, digital learning, mathematics, Mathematics Education, social media, student teachers, online learning, virtual classroom, virtual teaching, web 2.0 tools.

Abstract

Social media technologies have reshaped our lives today and Zambian teachers do a massive use of smart phones, tablets and other portable tools. In addition, they are continually searching for forefront innovations. Frequently, the utilization of these gadgets is not in manners foreseen by innovation advocates. This study focuses on exploring the use and the impact of such social media technologies in the teaching and learning of mathematics by Zambian pre-service (student) teachers. Globally, many studies have been conducted on the integration and benefits of social media in and out of the classrooms (see e.g. Tess, 2013). However, the global studies cannot be straightforward applied to the Zambian context and this is why we see the need of focusing on Mathematics Education. This study endeavoured to lessen the knowledge gap. Therefore, this study focuses on providing a deep insight into the way social media technologies are influencing the teaching and learning of mathematics at the Copperbelt University (CBU) as well as to identify which paths are open (or closed) to take into account in the future to improve both processes. Thus, a first target of this study is to explore the role social media is playing (and might play) in Mathematics Education via social networking among student teachers. A second target of the research is to explore aspects of university pre-service teachers' related online activities that might motivate them to participate in learning. Lastly, the author wish to open a discussion on the question of whether and how the use of social media tools may have an impression on the set of 21st century skills by both learners and teachers.

To explore student teachers' use of social media in their teaching and learning experiences, the author administered an adapted and validated research instrument via a mixed-methods survey system to a sample of 102 pre-service teachers from the Copperbelt University. Analysis of variance and multiple regression analysis were used to test the inter-play of relationships between pre-service teachers' attitudes towards the use of social media based on year of study and gender, social media use and classroom integration, social media use and mathematics pedagogy. Further, a statistical test was run to show whether positive correlations existed or not. K-means cluster analysis was used to organize data into clusters. The goal was to find out how many groups the data will be clustered into and explore the patterns in the data. Results

disclosed that respondents showed average use of social media tools in mathematics and provide a prediction model for pre-service teachers' future integration of social media in the teaching and learning of mathematics. Cluster analysis results revealed that online learning mathematics activities have significant mean differences in clustering. Cluster 2 recorded the best performance, implying that students in this cluster exhibited excellent online learning skills for mathematics in technology-rich environments in which they will be forced to study and work in the future. Furthermore, results revealed that participants' scores for digital learning in mathematics in cluster 2 were higher than those in both cluster 1 and 3. Qualitative findings elaborates that this is a clear indication that prospective teachers in clusters with low scores are more likely to exhibit low skill levels in the use of mobile technology and the adoption of social media in relation to mathematics pedagogy. This study has provided further evidence that mathematics prospective teachers can also learn and teach via online mode. In a nutshell, this study recognises that virtual learning in mathematics can offer personalised education for all, maximising the potential of every learner. However, the author wishes to recommend to the university management that a comprehensive and advanced pedagogic design should be implemented to render lessons through virtual classrooms.

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Acronyms and Abbreviations

CBU	The Copperbelt University
UNZA	The University of Zambia
SM	Social Media
SNS	Social Networking Sites
APPs	Applications
SPSS	Statistical Package of Social Sciences
Mxxx	Unknown Mathematics course code
ICT	Information and Communications Technology
AT	Activity Theory
TAM	Technology Acceptance Model
LMSs	Learning Management Systems
ECZ	Examinations Council of Zambia

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: ___________________________

Date: ___________________________

Dedication

I dedicate this doctoral dissertation to the gardener Eunice and my flower in it Jocelin who have been my heroines and the reason I was able to complete this terminal degree. I am thrilled to have them on my team and I am equally trilled to be on theirs.

I also dedicate this dissertation to the memory of my late first born baby girl, **Blessing** who only touched this Earth briefly and lifeless on 20th July, 2018 when I was overseas. Although we only had one day with this beautiful angel to experience both birth and death simultaneously, how grateful we are.

It is also dedicated to the memory of my humble brother Kennedy Chilufya who passed away in the same year, 2018. His life impacted mine in immeasurable ways.

Acknowledgements

My doctoral thesis has truly taken a village and I have many people to immensely appreciate.

First of all, this doctoral thesis could have been impossible without the unending support of my supervisor Prof. José María Marbán Prieto. Words could not adequately express my sincere gratitude to him. To say the least; he has been the bedrock, untangling my brain, helping me clarify my thoughts and being a dear friend. He has been perhaps my academic fairy 'godmentor' and cheerleader who has supported me in ways I will never forget.

I am highly grateful to my family - wife Eunice and daughter Jocelin who on one hand were patient with me during my long hours of absence from home and on the other hand endured my self isolation from family contact within the home too during my many hours of lonely studying nights. I am eternally indebted to them for putting up with my academic selfishness.

I will also forever remain indebted to Prof. Patrick Azere Phiri from the Copperbelt University, Zambia, for his input during my early doctoral dissertation journey. I would like to thank Sydney Hamafumba for his very dear friendship and support. In a special way, I would like to acknowledge the contributions of Prof. Sara Villagrá Sobrino from the University of Valladolid, Spain, who selflessly engaged me severally on the presentations of qualitative content analysis, codifying and taught me how to do content analysis using Nvivo network analysis software. Similarly, I wish to specially recognise the exceptional contributions of Dr. Rafael Alberto Méndez Romero from Universidad del Rosario, Colombia, who virtually trained me on the use of virtual spaces for the preparation of surveys, as well as the management of the Atlas.ti software for qualitative data analysis.

Equally important, I owe much to the support staff at the International Relations office of the University of Valladolid in Spain who also deserve a special mention here. I want to sincerely thank the entire staff for the wonderful opportunity (ICM-Mobility project) they offered me. In particular, I would like to acknowledge my indebtedness to Marian Calvo and Miguel Ángel Nuevo Pérez. The two staff, through their routine administrative work, helped me in no small way to ensure that I was properly oriented, had access to the university Library and to give me the necessary guidance whenever I needed one.

Finally, I wish to acknowledge the input of four experts in Mathematics Education who selflessly contributed to the review and validation processes of the research instrument used in this study. In the same vein, my utmost gratitude goes to all the participants of this study who have made this research-project possible. More than 100 people willingly gave their time, energy and consent during the data collection phases which has resulted to these ground breaking findings, and I am immensely indebted to them.

I also wish to sincerely thank all the members of the dissertation committee for their interest, suggestions and feedback.

To everyone of the individuals who deserve mention but have been incidentally left out, I say a big thank you.

Chapter 1: Introduction

This chapter outlines the background of the study (section 1.1) and context (section 1.3) of the research and its purposes (section 1.4). Section 1.5 describes the significance and scope of this research and section 1.2 provides a general definition of web 2.0 tools. Section 1.6 gives a descriptive account of the Zambian education system in relation to the latest curriculum for both secondary school pupils and pre-service teachers respectively. The subsequent sub-sections examines the secondary school teachers' teaching qualifications in Zambia relative to the characteristics of a profession so as to identify the challenges confronting teaching in the country in attaining professional status. Finally, section 1.7 includes an outline of the remaining chapters of the doctoral thesis.

1.1 BACKGROUND

For a long period of time, Mike Moran, Jeff Seaman and Hester Tinti-Kane believed that the term social media does not have a clear definition; however, when one platform emerged, that gave people an opportunity to be content creators, controllers and transparent users, to a great extent. Once this content is shared, it becomes a conversation, because all users who have accounts on social media platforms can interact with all posts (Moran, Seaman & Tinti-Kane, 2011). Social Networking is "the act of engagement," while social media is the tool used to communicate with mass audience (Hartshorn, 2010). Social Media is the platform that gives individuals the opportunity to interact, using a two-way communication, meaning that anyone who has online accounts can share their opinions with other social media users.

There are two types of social media users: digital natives and digital immigrants. Digital natives are the ones who were born after 1980 and they came to this world when the digital media existed. However, digital immigrants are the ones who were born before 1980 and adapted their lives to digital media (AntonSon & Christopher, 2014). Social media platforms vary from Web blogs, to micro-sharing platforms, to lifestreams, to social networks and much more (AntonSon & Christopher, 2014).

Today, it is crucial to determine the impact of social media on the academic performance of students. Technology is booming rapidly from year to year, and the younger generations are the ones caught in this rapid change. Social media has been utilized in so many different ways throughout the years. Zambia is known to be one of the heavy users of social media, specifically Facebook and WhatsApp (Akakandelwa & Walubita, 2018). Therefore, research must be conducted about the different social media platforms both secondary and university students are exposed to, that may affect them negatively or positively. This research in general terms aims at assessing the frequency at which both secondary and university students are social networking, and whether it has any effect on the pedagogy of mathematics.

The truthful learning requires daily social interactions between students and teachers from one side, and from the other side between students and the daily life events, "bridging the all-too-well-known gap between the classroom and the real world. The learning has meaning and relates to the real world because it is modeled on the systems of the real world" (Klopfer, Osterweil, Groff, & Haas, 2009, p.9). Schools aim to develop and to support methods to improve the effectiveness and efficiency of interaction and collaboration among students, and with their teachers. Most of web social media tools have been developed in order to maintain, manage, and improve social interactions between people where people can easily access, reuse or comment on content that is authored by others. The evolving learning environments are allowing students to learn anytime and anywhere (Wetzel, 2010). Educational research demonstrates convincingly that immediate and frequent feedback improves learning (Hodder, Rivington, Calcutt, & Hart, 1989; Dihoff, Brosvic, & Epstein, 2003, 2004; Dubner & Levitt, 2006; Hattie & Timperley, 2007; King & Sen, 2013). "Social networks may play an important role in raising awareness about the reliable resources of information among the students and society by providing alternative sources of knowledge" (Battrawi & Muhtaseb, 2013, p.1). A report published in the US by the National School Board Association (2007) found that 96% of youth in this age range have used social networking tools at some time, with their average engagement with them rivaling time spent watching TV at 9 hours a week. Yet perhaps the most stunning statistic of their study is that the topic of most conversation at these sites is education. Meanwhile, 60% of the students' surveys said they use the sites to talk about education topics and more than 50% use it to talk about specific schoolwork. (Klopfer et al., 2009, p.10)

Another report from the Pew Research Center (2010), revealed that 73% of teenagers use some form of social networking by incorporating social media into the lives of students in the classrooms, instructors also incorporate the new literacy that has become part of the students' out-of-school lives (Hahn, 2008; Casey & Evans, 2011). Mason (2008), describes some positive qualities of social media use in the classroom. For example, he points out that using social media in the classroom allows the teacher not only to incorporate multimedia and multimodal texts but also to share these quickly and easily, providing a collaborative learning environment where students can communicate at any time.

Great deal of research in education provides evidence for the effectiveness of using social media technologies directly in the context of traditional education situations or online education (Barab & Duffy, 2000; Graff 2003; Rovai 2003; Shea 2006; Dawson, 2006; DeSchryver, Mishra, Koehler, & Francis, 2009). Some studies have demonstrated the benefits of online social interaction in the learning process. Positive aspects of online interaction with teachers and peers include the following: access to peer and expert knowledge, ability to receive feedback from teachers and peers, and an opportunity to reflect on the exchanged messages (Ellis, 2001). By expressing their thoughts, discussing and challenging the ideas of others, and working together towards a group solution to a given problem, students develop critical thinking skills as well as skills of self-reflection and co-construction of knowledge and meaning (Brindley, Walti, & Blaschke, 2009).

Junco, Heilberger and Loken (2010), sought to discover a causal link between the use of Twitter and other social media and student engagement. Twitter has been studied in relation to its effect on student interaction and engagement, "students engaged with faculty and each other in a vibrant and connected virtual learning environment" (Junco et al., 2010, p. 8). Twitter was also used as a contact path between students and faculty, the use of Twitter encouraged students to cooperate, "students feel more comfortable asking questions they may not be comfortable with asking in class" (Junco et al., 2010, p. 9). Greenhow and Gleason (2012), explore the use of Twitter as a new literacy practice. They suggest that when used, it may lead to increased engagement and better interaction between students and teachers. This view is also shared by Fusch (2011), who argues that the tools of the trade are as important as the learning objectives, and that tools are needed which promote social presence, create a more interactive learning environment and foster collaborative study. (Dunn, 2013)

However, researchers and practitioners alike have found that interactions cannot be easily established in a learning environment. This often comes as a result of an inappropriate course design (Brindley et al., 2009) and/or the students' lack of collaboration skills, such as decision-making, consensus building, and dealing with conflict (Finegold & Cooke, 2006). Therefore, in order to yield the expected educational benefits, the technology in general and social networking tools in particular have to be accompanied with a sound pedagogical approach (Jovanovic, Chiong & Weise, 2012).

The UNICCO Media and Information Literacy Curriculum for Teachers (MIL) suggest that enhancing the appropriate use of media information among students requires that teachers themselves become media and information literate; this will enhance capacities to empower students with their efforts in learning to learn, learning autonomously, and pursuing lifelong learning. By educating students to become media and information literate, teachers would be responding first to their role as advocates of an informed and rational citizenry and, second, they would be responding to changes in their role as educators, as teaching moves away from being teacher-centred to becoming more learner-centred (Wilson, Grizzle, Tuazon, Akyempong & Cheung, 2011). Furthermore, the UNICCO MIL model argues that teachers are more likely to embrace the use of information and media tools if it connects with pedagogical strategies that improve how they teach traditional school subjects.

Some of the negative aspects of using social media technologies seen as that these technologies for learning minimize the active participation of the learner; in fact, such technologies are developed so that they can work for any learner, regardless of the motivation or the ability of the particular learner. Technologies for learning are essentially teaching technologies structured to reliably deliver and measure outcomes regardless of the context or the situation of the learner (Halverson & Smith, 2009). Teachers would need to become interdisciplinary facilitators of student creativity, readily able to guide learning toward intended outcomes while creating legitimate space for experimentation. Social media would allow students to create and test knowledge claims. Social media would extend communication networks, provide immediate access to information and facilitate new forms of creative expression (Halverson & Smith, 2009).

Accordingly, social networks could be employed in science education as virtual informal science learning settings. The characteristics of such technologies make them extraordinary media for raising interest and culture in science as they have been used for various educational purposes including peer-learning, teacher-student discussions, and scientist-public interactions (Battrawi & Muhtaseb, 2013).

In Zambia, there are a very limited research on the use of social media technologies in public schools because of the current regulations of bringing cell phones, Smartphones, iPads and other communication devices, where in case of bringing these devices to school, there will be a punishment for the student by conducting grades from behaviour and discipline due to the Ministry of Education (MOE) concerns in regards the safety and privacy of students. However, when secondary students make it for further studies, they are at liberty to use this web 2.0 tools. Notwithstanding the question of, to what extent do they use this web 2.0 community technology?

Although the MOE plans in developing learning and teaching, educational policy makers are putting real concerns of using these tools in education. Today, educational mobile technology is frequently used in online instruction in universities worldwide (Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013). It offers students increased choices and opportunities in the context of online instruction. Online courses that incorporate mobile technologies are becoming a more frequent component in universities, and the number of web-based mobile courses has increased (Inan, Flores, & Grant, 2010). The information and communication technologies shared between online students through social interactions on mobile tools promote opportunities for online cooperation and collaboration (Barhoumi & Rossi, 2013). Mobile educational technologies provide online learners with opportunities to communicate and share knowledge (Nelson, Christopher, & Mims, 2009).

Educational mobile tools have emerged and show great potential to help students construct and share information and knowledge for learning through computers or mobile devices (Pence, 2007). Online instructors and tutors are using mobile technologies in universities around the world. In this context, this dissertation sought to address three research leading sub-questions which are already stated on section 2.6.4, to restate them:

1. How do our students currently use social media?
2. How do our students see the impact of social media on Mathematics Education?
3. Do our student teachers believe that the official use of social media can enhance their learning and teaching experience in mathematics?

Social media is an interactive product in the virtual environment and developed from Web 2.0 technology. It has become an integral part of everyday life of average Internet users (Baro, Idiodi, & Godfrey, 2013; Voss & Kumar, 2013), regardless of what devices they use to access the Internet. Different definitions of social media are available in the literature, along with classifications, although they usually have similar meanings (Khobzi & Teimourpour, 2014).

According to a very popular definition: [. . .] social media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user generated content (Kaplan & Haenlein, 2010).

1.2 WEB 2.0 TECHNOLOGIES

Web 2.0 technologies are web services which center around user-provided content, like Flickr, YouTube, or Facebook. (Klopfer et al., 2009, p.13).

Mostafa (2015), defines social media in the Web 2.0 context as "[. . .] the usage of Web-based tools that link people and enable them to share information, videos, pictures, and so on".

The term social media is used synonymously with other terms, such as social networks, social networking sites, social software, social software tools, social media tools, social media technology, community websites, Web-based tools, Web 2.0 tools, Web 2.0 communicative technology, virtual worlds, virtual communities, online communities, collaborative software, e-communities and social network services. Some authors have taken considerable effort to classify or define some of these terms (Wickramanayake & Jika, 2018). Swaminathan, Harish and Cherian (2013), for example, divided social media into blogs, networking sites (Facebook, LinkedIn and Twitter) and community websites (Wikipedia and YouTube). According to Kaplan and

Haenlein (2010), social media included “[. . .] collaborative projects, blogs, content communities, social networking sites (SNS), virtual game worlds, and virtual social worlds”. Lim, Agostinho, Harper and Chicharo (2014), grouped them further “[. . .] into seven categories: text-based, media sharing, social networking, mobile-based applications, virtual world and games, synchronous communications and conferencing applications and mash-ups”. As Eke, Omekwu and Odoh (2014), asserted that social media can now be included into different platforms such as social, political, academic, business, sports, romantic and religious.

Swaminathan et al., (2013) opined that social media simply “[. . .] enabled users to exchange messages, maintain personal profiles, and create lists of ‘friends’”. It also facilitated sharing information and collaboration among the users in society at large and significantly in the context of education, business, marketing, advertising, recreation, banking and recruitment (Khobzi & Teimourpour, 2014; Lim et al., 2014). According to Singh & Gill (2015), a social media community with common issues or interests will share news, hobbies, religion and culture. The advantages of this technology are increasingly used by the health sector to widely disseminate health information (CDC, 2011).

The popularity and use of social media, especially among students and young populations, has rapidly increased over the past few years (Hamade, 2013; Swaminathan et al., 2013). It has now also become an important resource in the lives of university students and has affected every aspect of their lives, including learning. This might be because this generation is reported as “millennials”, “net intelligent”, “digital natives” or “net students” who rely heavily on electronic devices rather than traditional methods of teaching and learning (Hess & Shrum, 2011; Shittu, Basha, AbdulRahman, & Ahmad, 2011). This group quickly adapts to the newest forms of communication (Voss & Kumar, 2013), information sharing and recreation, as well as learning through new media, such as blogging, text messaging, googling, social networking and game playing. Especially among students in higher education, the application and integration of this cutting-edge technology is increasingly developing; “[. . .] computermediated social networks have become part of the life of university students” (Dogoriti, Pange, & Anderson, 2014) and “[. . .] Web 2.0 and the social software has become a tool in the hand of the present generation of students” (Shittu et al., 2011). Whether the process of communication is synchronous or asynchronous, social media creates collaboration and a shared learning environment among students:

The use of social media in university teaching adds a collaborative dimension to teaching and enhances interaction and communication between all those involved in the teaching-learning process, as well as enhancing the student experience by encouraging participation (Mostafa, 2015). In addition, the interactive, collaborative and participatory approach of social media encourages informal learning by students, which in turn enhances their engagement in formal learning methods (Cao & Hong, 2011).

Most aspects of student engagement with social media in higher education have been widely covered in the literature created in developed or industrialized countries. However, the application and experience of use of social media in the tertiary education sector in developing countries are still poor (Stanciu, Mihai, & Aleca, 2012), particularly in Africa (Munguatosha, Muyinda, & Lubega, 2011). Thus, more research is needed in the tertiary education sector of developing countries to explore what types of social media are effective for teaching in the classroom, how students use them in learning, to determine their different types of experiences with social media (Neier & Zaye, 2015) and to measure their attitudes towards social media use and scope of use of social media (Shittu et al., 2011).

Higher education institutions, and the way education is delivered and supported, are being transformed by digital technologies. Internationally, institutions are increasingly incorporating online technologies into delivery frameworks and administration – both through internal learning management systems (LMS) and external social networking sites (SNSs) (Sadowski, Pediaditis, & Townsend, 2017). Internationally, higher education faces intense pressure and change as a result of forces of globalization, competition and commercialization ("Global Agenda Council on the Future of Universities, 2012"). The rise of digital technologies is seen as a major force revolutionizing universities' learning and teaching models (Ernst & Young, 2012; Global Agenda Council on the Future of Universities, 2012). In their report about the future of universities, Ernst and Young (2012), predict that although the digital revolution will not eradicate campus-based universities, it will transform how education is delivered and supported, and the way higher education institutions create value. Overwhelmingly, universities use Learning Management Systems (LMSs), which are defined as "an online course space to share information and resources with students and manage student learning by structuring pathways through content and activities" (Federation University Australia, 2012) to support blended learning activities.

Although LMSs support universities to develop, manage and deliver blended learning, their value has been questioned amidst the dominance of social networking sites (SNSs) such as Facebook (Irwin, Ball, Desbrow, & Leveritt, 2012). SNSs are defined as "an online platform that allows users to create a public profile and interact with other users on the website" (Social Networking Site, 2016). Robbins and Singer (2014) provide a useful overview of different streams of social media platforms for sharing: short-form writing or micro-blogging (Facebook, Twitter, Google Plus), long-form writing or blogging (WordPress, Tumblr, Blogger), images (Snapchat, Pinterest, Instagram), videos (Vine, YouTube), audio programs/podcasts (iTunes, Stitcher), as well as synchronous communication tools (Skype, Google Hangouts, Second Life) and SNSs specifically for professionals (LinkedIn), some specifically targeting academics (ResearchGate, Academia). These diverse SNSs vary in their emerging cultures, with variations in network membership such as diverse membership versus membership by commonality in identity; focus on maintaining pre-existing social networks versus facilitating connections based on shared interests; plus the incorporation of new information and tools for communication (i.e., mobile connectivity, video or photo sharing) (boyd & Ellison, 2007).

1.3 CONTEXT

The younger generation that will be discussed in this dissertation are university students most likely between the ages of 14 and 30 years old. A few of the platforms they use are Facebook, YouTube, Google, and many others that will be discussed in the findings of this study. The younger generations are the individuals that will lead our world in the future, they must be well educated to be able to impact this world and make Zambia a better country on the road to success. Therefore, research must be conducted about the different social media technologies or online communities they are exposed to that may affect them negatively or positively. Hence, the primary obejecive of this study is to quantitatively assess the frequency at which the students are social-networking. This doctoral dissertation will also qualitatively endeavour to meet the secondary objectives, which explores students' opinions, attitudes, perceptions, intentions, experiences and barriers concerning social media use and its impact on the learning of Mathematics.

This doctoral thesis, which has been entitled “Pre-service mathematics teachers’ social media usage and its perceived impact on their personal, academic and teaching careers”, employed a mixed-methods approach from a sequential explanatory research design. This thesis will examine the concept of social media usage among student teachers both in the field of education in general and in the specific area of Mathematics Education. For this reason, a mixed-methods approach will be employed and their subsequent analyses techniques making an exhaustive review of the relevant literature using innovative techniques. To gain more understanding of the data, a reinterpretation of the results using the proposed theoretical frameworks of this study will be used. As a matter of fact, it is expected that the mixed-methods approach will explore the reality of teachers in practice and the way in which they perceive the relevance, the utility and their own evidence of the concept of teaching mathematics with social media technologies in their teaching practices.

In order to address and account for all the motivations of this doctoral thesis, the research exercise has been characterized by two main moments or stages. First, more extensive in time for the amount of information studied and analyzed, where the data and information have emanated from the web of science analysis through quantitative data analysis techniques. The collection and analysis of scientific data from this first moment involves the use of the Science of Science and CiteSpace, specifically for the analysis of co-citation and similarity, and for the analysis of a reinterpretation of the theories grounded in the literature. The second moment has been focused on the study based on student teachers’ responses and descriptions of teachers in practice.

Throughout this doctoral thesis each one of the assertions will be addressed. Section 2.6 will describe the theoretical framework or model on which this thesis is based and the most relevant background influencers of the scientific literature on the subject matter of investigation. With this in mind, we will examine studies on professional (pre-service) teaching models from a broad perspective on education, as well as those that move specifically in the Mathematics Education context. In order to understand the contributions of this thesis and the latent gap of the results from previous investigations, the existence of a tension of this study will be answered from the results that this doctoral thesis brings to the field of Mathematics Education that occupies us. By way of concluding, it is shown in the graph represented in Figure 1, the relationship between the context in which the doctoral thesis unfolds, the motivations that supported the research exercise and the contributions that the thesis leaves to the discipline.

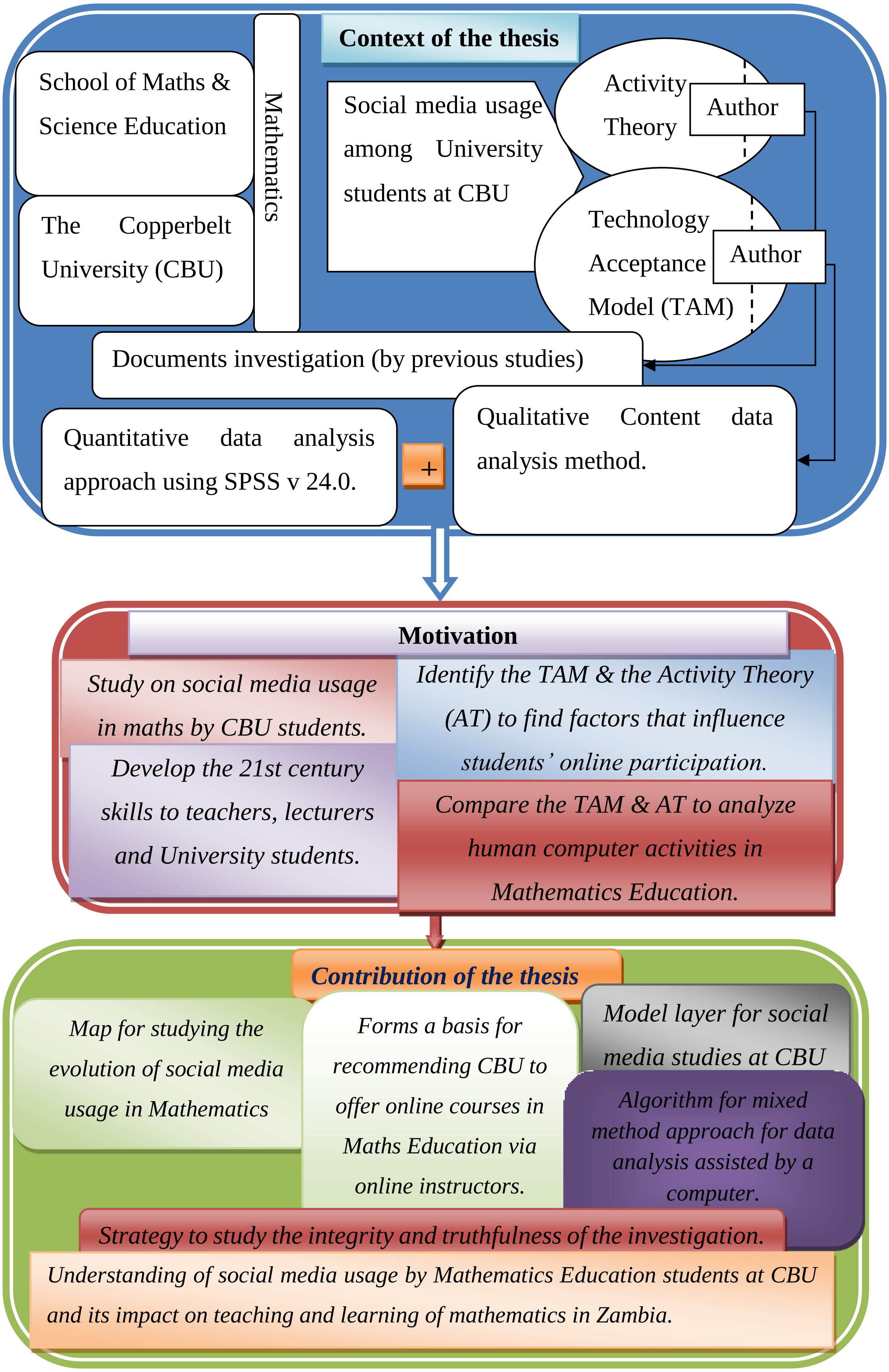


Figure 1: Context, motivations and contributions of the doctoral thesis.

Blended learning, integrating a variety of media to deliver teaching material to students is increasingly prevalent in university education. Blended learning is often associated with the use of web tools such as email, lecture recordings, blogs, discussion boards, etc. However, there are some suggestions that whilst learning management systems are well developed to manage processes such as student enrolment, exams, assignments, course descriptions, lesson plans, messages, syllabus, and basic course material, they are not well suited to self-governed and problem-based learning activities (Dalsgaard, 2006). In addition, these programs often lack an element of social connectivity and the personal profile spaces which today's students are familiar with (Mazman & Usluel, 2010). The emergences of social networking software and popular networking sites such as Facebook have raised questions regarding the value of course integrated learning management systems. Social networks have the potential to offer better support for self- governed, problem-based and collaborative learning processes (Dalsgaard, 2006).

Equally important, as someone who has passed through the Zambian education system, may I venture to highlight that most Zambian secondary schools and higher learning institutions do not have any social networking sites for learning mathematics. As a result, students either in boarding or day secondary schools are not encouraged to carry even mobile phones to class.

Nevertheless, educational mobile technology is today frequently used in online instruction in universities worldwide (Jimoyiannis et al., 2013). It offers students increased choices and opportunities in the context of online instruction. Online courses that incorporate mobile technologies are becoming a more frequent component in universities, and the number of web-based mobile courses has increased (Inan, Flores, & Grant, 2010). The information and communication technologies shared between online students through social interactions on mobile tools promote opportunities for online cooperation and collaboration (Barhoumi & Rossi, 2013). Mobile educational technologies provide online learners with opportunities to communicate and share knowledge (Nelson et al., 2009).

Educational mobile tools have emerged and show great potential to help students construct and share information and knowledge for learning through computers or mobile devices (Pence, 2007). Online instructors and tutors are using mobile technologies in universities around the world. In this context, the first research leading sub-question of this doctoral dissertation seeks to explore how university students currently use social media. It is expected that this first leading sub-question would help the author(s) of this doctoral thesis to further examine how mobile technologies such as WhatsApp, Facebook, twitter, Instagram, WeChat, e-mail and other web 2.0 tools in online communities are influencing the teaching-learning process of mathematics. In addition, this will help us to further interrogate wether it is better to use mobile technology to achieve cooperative learning or collaborative activities in a blended course. In a study by Preston and colleagues (2010), nearly 70% of the students stated that they learn equally well from online lectures as in-class lectures. Additionally, non-traditional students need an effective blended online learning strategy to pursue blended courses.

For these reasons, the present study is conducted with undergraduate students of Mathematics Education under two overall objectives and one specific objective. The first obective is concerned with the exploration of students' usage of social media. The second objective is to investigate the effectiveness of the blended scenario in a mathematics subject using the WhatsApp, Facebook, e-mails, twitter, Instagram, we chat, and other mobile applications compared to 100% in-class learning. Most importantly, the specific objective of this doctoral thesis is to explore the use of social media among Mathematics Education students and the perceived impact of social media on teaching and learning of mathematics in Zambia.

1.4 PURPOSES

The overall scope and objectives of the study are very interesting, particularly considering the main objective which focuses on exploring the use of social media and the impacts of such e-communities and social network services in the teaching and learning of mathematics. Since the study involves a mixed-methods approach, as a matter of priority, the quantitative phase of this research primarily deals with the real objective of the study concerned with examining pre-service teachers' social media usage in their personal, professional (pre-service) and academic lives and its perceived impact on the learning and teaching of mathematics as a scaffolding tool. All these social media tools, that is, phones, laptops, desktops, tablets and so on are equipped or ready for social media technological applications like Facebook, Twitter, Wikipedia,YouTube, WhatsApp, Telegram, and Instagram, which are part of what is known as Social Web 2.0. tools. Furthermore, three specific objectives are addressed from the qualitative phase of this study. The first one being to understand the attitudes, perceptions, opinions, experiences, barriers and values of Mathematics Education student teachers concerning social media use and the impact of social media in the learning and teaching of mathematics.

Therefore, the secondary objective of the qualitative investigation will probe participants on providing a deep insight into the way social media technologies are influencing the teaching and learning of mathematics at the Copperbelt University (CBU) as well as to examine which paths are open (or closed) to consider in the future in order to improve both processes. In order to compliment the quantitative phase of this study, the most important goal of this doctoral thesis on -one hand- is to qualitatively show the reader how university students of Mathematics Education have used social media technologies in their personal, academic and mathematics teaching careers. Through the participants' elicited views and opinions, the qualitative phase on the –other hand- aims at unearthing participants' thoughts, attitudes and feelings about social media usage in mathematics teaching-learning processes. Anyway, the major aim of the qualitative aspect is intended to give a clear description of the phenomenon under study. However, all the objectives that are attended to in this mixed-methods approach are explicitly stated on section 1.5.2 of chapter 1.

Thus, the purpose of this study is to provide important information for mathematics educators for mathematics classes about how to help both underprepared instructors and students improve their digital teaching-learning skills. Subsequently, it is hoped that the integration of social media and technological applications in the teaching-learning processes would improve the understanding of mathematics and students' performance. As a result of this doctoral thesis, researchers hope to gain insights into effective ways of preparing students in online mathematics courses to succeed in university mathematics. Results of this study may also guide pre-service teachers and instructors themselves to enact effective teaching-learning methods to succeed in future mathematics courses.

Although there is currently little (e.g. see Perienen, 2020; Daher, 2020; Mailizar & Fan, 2020; Mailizar, Almanthari, Maulina, & Bruce, 2020; Tossavainen & Faarinen, 2019) or no literature on the use of social media technologies in Mathematics Education in relation to educational studies, results from these few studies appears to reflect the presence of critical contrasts or interpretational inconsistencies among them, a reality of certain significance as such results are by and large the reason for policies of education, curriculum changes and educational reforms.

Studies aimed at the conceptualisation of mathematics instruction with social media technologies, digital tools and technological applications endeavor to clarify their nature and structure in terms of teacher-student-content mathematical interaction relationship, and furthermore to distinguish the factors that impact teaching and learning approaches in a mathematics virtual classroom with regards to the notable instructional Pedagogical Triangle (Cohen, Raudenbush, & Ball 2003; Aaron & Groot, 2011; Herbst & Chazan, 2020). Hence, it is not surprising that this doctoral thesis like many other scholars (e.g. see Mailizar et al., 2020) similarly examines and reports the responses of pre-service secondary school mathematics teachers on social media implementation at four different levels which are; teacher, school, curriculum and student.

1.5 SIGNIFICANCE, SCOPE AND DEFINITIONS

Once educational practices become sensitive to social media, it is inevitable to make teachers and students aware of the structure of their social networks. Learning in a classroom is still the dominant practice for primary, secondary and tertiary education in Zambia. How can social media penetrate this paradigmatic situation? Social media typically deal with the personal situation and lifestyle of the student. Very few social media have been configured to address the group of students as a class. Social media have entered education because of students' need to keep in contact with their peer group, and not necessarily only with their classmates. Social media have emerged from technological features (Web 2.0 tools) that have allowed youngsters to establish their "presence" and have helped with their identity-building processes.

The significance of this study is to explore the impact of and the role social media can play in Mathematics Education via social networking among students. Social media in most Zambian colleges and universities are not yet a sustainable solution for the traditional problems of education. However, they provide opportunities that are changing the way we learn. For example, in the realm of life-long learning during one's professional career, they facilitate the sharing of practical solutions and make colleagues aware of new trends and topics.

Because anyone can register in social media networks, and because these are growing in popularity, UNESCO's objective should be to raise awareness of their educational relevance and to find ways to integrate them into the teaching process. Networking systems like Facebook and LinkedIn, micro blogging like Twitter, Wikis, MSN and Flickr — all of them are free to subscribe to. Similarly to the ICT applications that penetrated education the last four decades, the best recommendation is to allow social media in the classroom to explore the benefits and limits of the new level of social networking that they offer. Recent projects, such as web-based communities for teachers (e.g. Mirandanet in Great Britain), show that social media can be used not only for the exchange of didactic methods and ideas. They also allow sharing more subtle personal concerns, such as legal conflicts and emotional states related to career development, which can be discussed with colleagues from other institutions and even other countries in order to avoid affecting hierarchic relationships within the school. As school reports are coming out now, we see social media as bridges between individual education and mass education.

In order to account for all the motivations of the objectives of this doctoral dissertation, the study was characterised by two different stages. The author of this doctoral thesis started this work to explore the use and impacts of social media on teaching and learning of mathematics in general education because he first wanted to understand how these new technologies were impacting the lives of secondary school pupils. He began in 2017 with a sample of 288 pupil-participants. In 2018, the research was extended to higher education with a second stage sample of 102 pre-service teacher-participants on exploring social media use among university students of Mathematics Education in their personal lives, professional development and teaching careers. Because of the different stages of the investigations, the objectives listed below are very specific according to the period, method used and the time of the investigation.

As iterated earlier, the overall objective of this research is to evaluate the frequency at which the students are social networking, and whether it has any effect on their academic performance. If there is any impact on their academic performance, in what way does it affect it?

1.5.1 Objectives of the study at the secondary school

This study sought to understand Zambian pupils' profiles of social media usage, in particular in mathematics learning environments, mainly focusing on Facebook.

1. The first objective of this study is to examine the Zambian secondary school pupils' profiles of social media use in mathematics and, especially, the use of Facebook in the learning of mathematics at Wusakile secondary school.
2. The second specific objective of the research at the secondary school is to explore aspects of a secondary school students' related web community that would motivate students to participate in its activity.
3. The third objective is to examine the role that social media play -especially Facebook- in secondary school settings and on Internet public activities. For this reason, the authors' interest was to investigate how secondary school pupils use Facebook for academic purposes and to find out the purposes for which secondary school pupils use Facebook.
4. The fourth specific objective is to explore if the use of these social media platforms may have an impact on the development of 21st century skills among school pupils and teachers.

1.5.2 Objectives of the study at the Copperbelt University

In addition, this doctoral thesis endeavoured to better understand the online experiences of students with various social media platforms after leaving secondary school. Specifically, the author was interested in the extent to which all the participants were able to transfer their online social media interactions [experiences] to enrich their mathematics teaching-learning practices. Therefore, the study at the Copperbelt University (CBU) is two-fold (quantitative and qualitative). Thus the objectives that are attended from a quantitative approach included the following specific objectives.

1. The first specific objective of the study at CBU is to investigate the use of social media in the teaching and learning of mathematics as a scaffolding tool, and the impact of that on students of Mathematics Education in Zambia.
2. The second specific objective was to explore the impact of social media on Mathematics Education in Zambia and the student-teacher social media interaction during and after mathematics instructions.
3. The third objective of the study focuses on exploring the use and impacts of

smart phones, iPads and other portable devices in the teaching and learning of mathematics. All these smart phones and other portable devices are equipped or ready for social media applications like Facebook, Twitter, Wikipedia,YouTube, WhatsApp, Telegram, and Instagram, which are part of what is known as Social Web 2.0. tools.

4. The fourth specific objective is intended to find out how the use of social media could help develop the 21st century skills of lecturers and university students in the teaching and learning of mathematics.

In order to appreciate the overall research target and some of the global figures that will be reported in the first stage of the investigation, the qualitative phase of the study elicits general reasons why students use a particular social media platform or technological application and how it has benefited them to support their mathematics teaching-learning processes. Using a representative sample ($n = 33$) of teaching faculty from the Copperbelt University, the study will interrogate and probe respondents' use of social media, as well as what value they have seen in including social media sites as part of the mathematics instructional process. The study will require the narratives of thirty three mathematics pre-service teachers' written thoughts, feelings, opinions, comments and suggestions. For this reason, the specific objectives that are attended from the qualitative approach are listed below:

1. The first objective of the the qualitative study is to unearth participants' views, thoughts, attitudes and feelings about social media usage in mathematics teaching-learning processes. The author would particularly be interested in determining both the positive and negative impacts of social media on the teaching and learning of mathematics in Zambia.
2. The second objective is to show the reader how pre-service teachers of Mathematics Education have used social media tools in their personal, professional and mathematics teaching careers.
3. Finally, the last objective is intended to ignite the fire and leave an open discussion concerning the questions of whether and how social media technologies have influenced the teaching-learning processes of mathematics in Zambia and what paths are open (and closed) for future impact.

1.6 THE EDUCATION SYSTEM IN ZAMBIA

The Zambian education system has expanded at an unprecedented rate from the time of independence, and if history is fair to Zambia and to the academic institutions, then the present generation will be properly recorded as the period from which the history of this young nation started since Independence. In no uncertain terms, enrollment in secondary schools has increased rapidly. However, there are still financial challenges to accessing secondary education by the poor Zambian families. The term -system of education- refers to a general public's absolute pattern or formal schools, agencies and organizations that exchange knowledge and the the social legacy that impact the social and intellectual development of the individual (Brickman, 1988; Mkandawire, & Ilon, 2018).

According to the Zambian National Policy on Education, Educating Our Future (1996), the current structure of the Zambia's formal education system has a 7—5—4 structure, with seven years of primary education (four years of lower and three years of upper primary), five years of secondary (two years of junior and three years of senior secondary), and four years of university to first degree level. Progress from primary to secondary educational levels is controlled by competitive national examinations towards the end of Grades 7, 9 and 12. In the past, primary and secondary education were offered in separate schools, but this however, changed with the increasing number of basic schools which provide the first nine years of schooling (Masaiti, 2018; Moonga, Changala, & Lisulo, 2018). By implication, at present, there are two parallel but related paths for educational progression after Grade 7: A selected few pupils proceed into Grade 8 in a basic school, while others proceed into mainstream secondary schools that run from Grade 8 to Grade 12. In any case, they probably must have performed well in the selection assessment or examination held towards the end of Grade 7, since there is room in Grade 8 for only 33% of the pupils who complete Grade 7. The new structure of the education system, the fundamental units around which Zambia's education system will from now on be sorted out are basic schools, offering Grades 1 to 9, and secondary schools, offering Grades 10 to 12 (Masaiti, 2018a; 2018b; Masaiti, Njobvu & Kakupa, 2018).

This advancement implies that the Zambian formal education system will have a 9—3—4 structure, composed of 9 years of junior or basic education, 3 years of secondary school education and, as in the past, 4 years of university training for undergraduate degrees. This structural change is in excess of a matter of classification. It presents the fact that the first and basic level of education will last for 9 years. In an attempt to discuss both secondary and tertiary education as presently provided in Zambia with the focus on highlighting key stakeholders, particularly curriculum developers who have partnered with government in the provision of education, there is a lot to learn (Masaiti, 2018a; MoGE, 2013). Thus, it is a steady update that the objective of the education system is that each youngster in Zambia ought to access 12 years of good quality secondary education. It likewise draws our attention to the need to re-compose the secondary school curriculum and that of pre-service teachers with the goal that both react progressively to the prerequisites of the new structure (Masaiti, 2018a; 2018b).

1.6.1 The structure of secondary schools

The secondary school course runs for five years. It is composed of two segments. For instance, the Junior Secondary running from Grades 8 to 9 and senior secondary running from Grades 10 to 12 (Banja, Mofu-Mwansa, Serenje-Chipindi, & Chakulimba, 2018; Educational Reform, 1977). The existing secondary schools in Zambia that run from Grade 8 to Grade 12, continues to play an integral part of the education system during the time of progress to universal basic education. As provision for Grades 8 and 9 increases in basic schools, the need for these grades in mainstream secondary schools will slowly decline. The Ministry will logically change these schools into high schools, offering Grades 10 to 12 (as it has been done as of now on account of secondary technical schools). As a transitory measure, the assignment 'Junior Secondary' will be solely used for Grade 8 and 9 provision in schools that offer Grades 8 to 12, yet as these schools are changed into high schools this assignment will steadily drop out of utilization (Mulenga, & Kabombwe, 2019).

Admission to high school depends on performance in the final examination, presently called the Junior Secondary School Leaving Examination, that pupils take towards the end of Grade 9. This is a public examination, prepared and marked by the Examinations Council of Zambia (ECZ). Based on the performance in this examination, nearly 30% of the school pupils’ applicants progess to Grade 10. On completion of high school, towards the end of Grade 12, pupils take a further public examination, likewise prepared and marked by the Examinations Council of Zambia. This is the Zambia School Certificate Examination, which is generally what could be compared to the Ordinary-Level ('O'-level) standard in the British system. Admission to tertiary education and training and prospects for 'wage or salary-sector' employment pivot basically on School Certificate performance.

In Zambia, the senior secondary education is a preliminary educational requirement for going into universities or training colleges. It is expected that this program prepares secondary school leavers for life-long challenges ahead since a large portion of its graduates will either after completing their schools join university education or the world of work.

1.6.2 The secondary school curriculum

Although the secondary school curriculum has undergone several changes, the major ones includes the creation of two curriculum paths at Grade 8: academic and vocational. The academic path is meant for learners with passion for academic subjects and desire for careers in that direction. The vocational curriculum which includes computer studies as a compulsory subject has already been started being implemented in secondary schools which have the personnel, facilities and equipment (MoGE, 2013; Mulenga, & Kabombwe, 2019). It is worth noting that computer studies has been introduced as a subject at this level in order to equip learners with essential skills necessary for them to have basic knowledge of the computer. The first secondary schools to implement the vocational curriculum are the already existing technical secondary schools (national and regional schools). The vision of the Ministry of General Education is to transform certain secondary schools into specialist schools for Technology with an emphasis on mathematics (MoGE, 2013).

The secondary school curriculum is expected among other things to build a strong foundation by consolidating the learning skills acquired in stage one of junior secondary school or basic education; identify secondary school pupils' special talents or aptitudes and encourage their growth; help pupils to acquire employable necessary skills and knowledge through or work oriented programmes; help pupils acquire intellectual abilities and apply knowledge intelligently (Kimaro, 2012; Mulenga, & Luangala, 2015). The author of this doctoral dissertation has analysed the Zambian education system adoption of the competency-based curriculum whose revision begun in the year 2013 and then gradually implemented it until 2017 (Mulenga, & Prieto, 2018; Mulenga, & Kabombwe, 2019). Given the increasing trends of integrating technonlogy in the education system, the Zambian government through the Ministry of General Education revised the school curriculum in 2013 with the introduction of ICT as a compulsory subject at the junior secondary level and an introduction of an ICT topic in Grade 10 mathematics. It is envisaged that the adjustment of the school curriculum will accelerate the use of digital devices both inside and outside the classroom (Mulenga, & Phiri, 2018). The objectives of the 2013 revised Zambian curriculum are to produce citizens who are self-motivated, life-long learners, confident and productive individuals, holistic, independent learners with the values, skills and knowledge to enable them to succeed in school and in life (Zulu, 2015).

Thus, it is the vision of the Zambian education sector that through the competency based curriculum, secondary school pupils will be expected to posses three critical educational elements namely; worthwhile skills, appropriate attitudes and applicable knowledge which make up competences (MoGE, 2013; Mulenga, & Kabombwe, 2019). Competences are abilities critical to the performance of specific tasks. For example, school learners can be competent enough to use technological applications such as Facebook, YouTube, WhatsApp and the like. One would be right to conculude that the Ministries of General and Higher Education in Zambia had read the Zambian educational needs correctly because currently the pandemic has forced almost all the Zambian institutions to go digital and this is only possible if the curriculum is highlighly strengthend with the already included technological component. The revised secondary school curriculum is expected to provide practical and relevant skills to learners in secondary schools starting at grade eight up to grade twelve (Manchishi, & Hamweete, 2018; Mulenga, & Kabombwe, 2019).

Presently (e.g. see Masaiti, 2018a; Masaiti et al., 2018; Mulenga, & Kabombwe, 2019), the Grade 10–12 curriculum is composed of a few number of required or compulsory subjects (English, mathematics, a science subject) and a wide scope of discretionary subjects in the fields of humanities (languages and different social sciences), science, mathematics, commerce, technical, practical and aesthetic areas. Proof from School Certificate performance data throughout the past highlights that nearly all school-pupils take biology and geography; about half take history, commerce, or science, while between a third and quarter take agricultural science, literature in English, religious education, or one of the Zambian languages. Below 15% take any of the practical, technical or art subjects (Home Economics, Technical Drawing, woodwork, metalwork, art & craft, fashion & fabrics, etc.) (Hoppers, 1985).

This is demonstrative of the weighty scholarly predisposition that in reality is overwhelming at this level and the overall inability to utilize the wide scope of potential outcomes catered for by the secondary school curriculum (Mwansa, Mulenga-Hagane, & Siankanga, 2018). By extension Goma (1969), highlights that for any tertiary learning institution to fufill its mission in the field of national development, it needs to establish itself both quantitatively and qualitatively. However, this is only possible if it could build on the base of strong secondary education.

1.6.3 Secondary School Mathematics Teachers

In their paper, Banja et al (2018) scholarly discusses the current trends towards professionalisation of teaching in Zambia and highlights that professionalism rather than professionalisation should be the focus of any attempts to improve the status of teaching. To improve the teaching fraternity in Zambia, it is argued that mathematics teachers themselves ought to be trained in technological aspects so as to digitalise their teaching-learning processes. In this discourse, secondary teachers of mathematics are not left out. However, to achieve this, Banja et al (2018), emphasised that the development of teacher education must include the expansion of existing institutions, re-stocking them with digital devices, the establishment of new teacher training institutions, qualification requirements for teachers, teacher enrollment and programmes targeted at preparing teachers for secondary teacher training institutions.

Therefore, mathematics teachers for the secondary level are trained for a minimum period of 3 years in colleges in order to obtain a Diploma or for 4 years in public universities for bachelor's degrees after passing their grade 12 exams. In addition, UNESCO (1964), posited that teacher' colleges should take an explicit aim the encouragement in professional matters of independence of thinking by their students. Post School Certificate courses of three years' duration should be continued for thoses training for teaching in junior secondary schools.

The University of Zambia (UNZA) and other colleges continues to offer courses to train mathematics pre-service teachers for the full range of secondary school programmes on a large scale (Annual Report for 1984; 1987; Masaiti et al., 2018; Masaiti, & Simuyaba, 2018). The University of Zambia awards degrees in Education and Diplomas in teacher educalion to successful candidates. In addition, "…the university is the main supplier of graduate Zambian teachers for secondary schools and colleges…" (Banja et al., 2018; Educational Reform, 1977:68~69).

1.6.4 The curriculum for teachers

Although different higher learning institutions offer different courses depending on the students' majors, some coures are common at every institution. Therefore, courses offered at teacher training colleges of education are not limited to the following (Mbuzi. 21-09-88):

- Education
- English
- Zambian Languages
- Mathematics
- Mathematics Education
- Psychology of Education
- Sociology of Education
- Science
- Social Studies
- Physical Education
- Handwriting and Audio~vlsual Aids
- Music Education
- Creative Activities
- Home Economics
- Practical Subjects
- Library Science
- Production Work
- Political Education

In particular, mathematics pre-service teachers tend to be trained in the content of these courses and methodological handbooks (Kelly, Nkwanga, Kaluba, Achola, & Nilsson, 1986). Courses taken at first-year level act as pre-requisites at second-year level. There are no courses that are dropped at second-year level (Kanduza, 1988) making the teacher education structure and curriculum rigid as one progresses towards the end of the study programme. The Examination Council of Zambia –ECZ- is once again responsible for the conduct and administration of examinations which are taken by candidates in primary, secondary, teacher training and technical and vocational training colleges. Likewise, the ECZ has the mandate of formulating syllabuses for examinations and conducting research in examinations. The Examinations Council of

Zambia also manages external examinations in the interest of different Boards (Annual Report for the year 1985).

1.7 THESIS OUTLINE

In this dissertation, each of the research questions, problem statement, research hypotheses, objectives and targets of the study have been addressed through the six chapters that compose this document, which are described in general below.

The first chapter of this doctoral dissertation gives a comprehensive background of the study. It describes in detail the genesis of the research problem, what motivated the author to investigate on the proposed research problem and uncovering the deep underlying issues surrounding the statement of the problem. In addition, this chapter has laid down plainly both the theoretical and constitutive definitions of social media. In some instances, the term social media has been used synonymously with other terminologies such as; web 2.0 tools, social networks, online communities and so on. Finally, this chapter discusses the context in which this doctoral dissertation unfolds, the motivations that supported the research project and the contributions that the thesis leaves to the field of Mathematics Education.

The second chapter describes an in-depth review of scientific literature by the use of innovative techniques for compiling data and a reinterpretation of research and its subsequent analysis. Relevant literature has been extensively reviewed covering various topics ranging from social media use to their impacts in Mathematics Education. This chapter discusses the teacher knowledge frameworks used in Mathematics Education, the two theoretical frameworks (Activity Theory and Technology Acceptance Model) on which this doctoral dissertation is initially based and the most important and influential theorists and progenitors in the scientific literature concerning the research subject.

As a way of concluding, based on the methodological discussions in the reviewed literature, this chapter gave special attention to the formulation of appropriate research hypotheses for quantitative aspects, research objectives for qualitative aspect and research questions which were of primary importance to the perceptions and expectations of undergraduate students in regard to the use and the impact of social media in the teaching and learning of mathematics in Zambia.

The third chapter is the engine of this study. It describes the methodological framework and methodological design utilized in this study in great detail. Taking into consideration the mixed-methods sequential explanatory design of this research, thus the mixed-methods sequential explanatory design (Creswell, 2014) together with the case study research tradition (Stake, 1995) guiding the qualitative data analysis both have been reviewed and placed in the context of this research. Above all, this chapter has visualized the methodological coherence and consistency by conceptually illustrating the research design (see Fig. 14) and Stake's case study (see Fig. 13) using clear pictorial graphical representations. Additionally, chapter three also discusses the embedded research design approach that was used to describe, quantify and qualify the data that was collected by both quantitative and qualitative survey techniques. Thus we see the complementarity rationale associated with this study. This is because a mixed-methods approach is a technique used for gathering, interpreting and "mixing" or coordinating both "quantitative" and "qualitative" data at some phase of the research process within one study in order to increase a superior comprehension of the statement of the problem (Tashakkori & Teddlie 2003; Creswell, 2005). The methodological proposal and design of this study was guided by the purpose and significance of the study, problem statement and the research questions arising from it, as well as the methodological discussions in the literature. The choice of this mixed-methods approach was seen as the "most suitable methodology" for effectively answering the research questions of this doctoral dissertation. Finally, this chapter proposes that in order to increase the credibility (trustworthiness) and transferability of the research findings (Rossman & Wilson, 1985; Creswell, 2003), qualitative methods were used to complement the quantitative findings of the study. That is, the qualitative method only played a less dominant role (embedded) in the study by helping the researcher to explain the findings of the main approach (quantitative).

The fourth chapter presents and discusses the research findings of the study. It is therefore dedicated to answering of the research questions of the study and making an express footprint of this doctoral dissertation on the field of Mathematics Education that it tries to deal with. The chapter likewise proposes the existence of a tension that has been investigated and answered based on the research results that this doctoral dissertation brings to the field under consideration.

The fifth chapter gives a comprehensive discussion of the overall findings emerging from a mature analysis of step-by-step interpretation of both quantitative and qualitative research results. In addition, a summary of the conclusions of the doctoral dissertation's work proposed in the previous chapters is likewise included.

Finally, the sixth and final chapter begins with the conclusion which shows that the existence of a tension of this study has been answered from the original results that this study brings to the field that occupies us. Moreover, this chapter highlights that special attention was dedicated to the careful writing of the conclusion to try to establish in a plain way to see how conclusions and research objectives are linked. Additionally, establishing also a clear way to ease the reader to connect both. This chapter summarises all the foregoing chapters and advances all the final conclusions and suggestions. The chapter also suggests understanding further studies derived from the research findings of this doctoral dissertation. In addition, the rationale of this study is also clearly explained on the implications section. The overall limitations of the study and recommendations are highlighted.

1.7.1 Exposition of Chapters

Chapter 1 – Introduction – Research proposal

Chapter 2 – Literature Review – Global perspective

Chapter 3 – Research Design – Methodology

Chapter 4 – Results

Chapter 5 – Overall Discusion

Chapter 6 – Conclusions

List of sources

Appendices – Appendix A

– Appendix B

– Appendix C

– Appendix D

– Appendix E

– Appendix F

Chapter 2: Literature Review

This chapter begins with providing an overview of the main sources of knowledge and how the data was organized for retrieval from different databases. The chapter reviews literature on the following topics: Sources of scientific literature (section 2.1): this section tabulates how knowledge was generated and organized through the use of tools such as Sci2 and CiteSpace; Literature review research techniques (section 2.2): this section describes how two special scientific software tools - the Sci2 (Science of Science) and the CiteSpace - were used in this whole study to retrieve, collect, organize and generate knowledge and scientific literature from different data sources; Literature review analysis by CiteSpace (section 2.3): this section gives a diagrammatic summary of the process report which illustrates the most essential visualizations and analytic functions of CiteSpace; Visualizations (section 2.4): this section gives pictorial presentations of the literature of co-citation analysis based on cluster view timeline between 2014 and 2018. Section 2.5 highlights the literature reviewed based on 4 clusters, implications arising from the literature; section 2.6 describes the teacher knowledge frameworks and develops the theoretical frameworks for the study (section 2.6.1). Finally, section 2.7 states the hypotheses guiding the present study from which the research questions are developed.

2.1 Sources of Scientific Literature

Below is Table 1 showing the understanding of how knowledge was generated and organized through the use of tools such as Sci2 and CiteSpace. It provides an overview of the main sources of knowledge and how the data was organized for retrieval from different databases.

Table 1: Literature review sources

Main Data Source	Data Source	Data Source
Web of Science	**ScinceDirect**	**Other Sources**
- Science Citation Index (SCI).	-Textbooks	-Seminars

- Social Sciences Citation Index (SSCI),	- Journals	-Libraries
-Arts & Humanities Citation Index (A & HCI),	-Theses	-Meetings
	-Conference papers	-Workshops
-Conference Proceedings Citation Index	-Reports	-Congresses
	-Anthologies	
- Science, Conference Proceedings Citation Index		
- Social Science and Humanities		
-Journal articles		

2.2 LITERATURE REVIEW RESEARCH TECHNIQUES

In this whole study, two special scientific software tools will be used to retrieve, collect, organize and generate knowledge and scientific literature from different sources/datasets. These tools are the Sci2 (Science of Science) and the CiteSpace and have been extensively used by different researchers around the world during their research to quicken and easy up their literature reviewing process.

The Science of Science (Sci2) tool is a modular toolset specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualization of scholarly datasets at the micro (individual), meso (local), and macro (global) levels (Sci2 Team, 2009). Many users of Sci2 have acknowledged how good this software is for network visualization and mapping scientific literature by a single click.

CiteSpace, on the other hand, has been used by people at many cities around the globe. However, to start with CiteSpace usage, geographically speaking, not too many people have been exposed to CiteSpace and according to the CiteSpace website 101, Beijing has the largest number of unique IPs and the longest duration of use on average. China, European countries, the US, and Brazil are among the highest concentrations of CiteSpace users while Africa ranks the least. All in all, we can safely say that CiteSpace is designed to make it easy for a researcher to answer questions about the structure and dynamics of a knowledge domain. The design of CiteSpace is inspired by Thomas Kuhn’s structure of scientific revolutions. The central idea is that centers of research focus change over time, sometime incrementally and other times drastically. The development of science can be traced by studying their footprints revealed by scholarly publications.

Members of the contemporary scientific community make their contributions. Their contributions form a dynamic and self-organizing system of knowledge. The system contains consensus, disputes, uncertainties, hypotheses, mysteries, unsolved problems, and unanswered questions. It is not enough to study a single school of thought. In fact, a better understanding of a specific topic often relies on an understanding of how it is related to other topics (Chen, 2004).

As with any tools, CiteSpace is designed to support a set of core tasks and some other tasks along the way. The primary goal of CiteSpace is to provide a computational tool for exploring and understanding a set of scientific publications. There is no restriction in terms of the discipline of such publications. In fact, CiteSpace has been applied to the study of numerous different scientific fields (Chen, 2015).

The unit of analysis in CiteSpace is a knowledge domain. Scientific publications are considered relevant if they may lead to a better understanding of the knowledge domain in question. Thus, the data collection is a critical step in using CiteSpace because the coverage of your data will directly influence the scope of your subsequent analysis. The general advice is that you should use a data set that sufficiently covers the topical area of your interest, even when your data may include irrelevant or seemingly irrelevant data points (Chen, 2015).

According to Chen (2015), CiteSpace is a freely available computer program written in Java for visualizing and analyzing the literature of a scientific domain, or a knowledge domain. CiteSpace takes bibliographic information, especially citation information from the Web of Science and generates interactive visualizations. Users can navigate and explore various patterns and trends uncovered from scientific publications and develop a good understanding of the scientific literature much more efficiently than an unguided search through the literature. The full text content of many scientific publications can be easily accessed by a single click through the interactive visualization in CiteSpace. CiteSpace can generate a summary report at the end of a session to summarize the key information about the literature you just analyzed.

2.3 LITERATURE REVIEW ANALYSIS PRESENTATION BY CITESPACE

Literature was mainly reviewed and analysed with the help of an innovative scientific software known as CiteSpace (Chen, 2015). CiteSpace takes bibliographic information, especially citation information from the Web of Science and generates interactive visualizations. Below is the diagrammatic summary of the process report which illustrates the most essential visualizations and analytic functions of CiteSpace.

Table 2: Summary of literarure reviewed between 2014 and 2018

Range:	[2014-2018]	
Records:	100	
References:	3623	
Distinct references [valid]	3611	99.6688%
Distinct references [invalid]	12	0.3312%

The Table below shows the report of the analytic functions of CiteSpace concerning the literature of co-citation analysis based on a 5-cluster view timeline between 2014 and 2018.

2.3.1 CiteSpace Process Report

Table 3: CiteSpace analytic function process report

1-year slices	criteria	Space	nodes	Links/all
2014-2014	top 50	115	0	0/0
2015-2015	top 50	302	4	6/6
2016-2016	top 50	222	0	0/0
2017-2017	top 50	1315	71	142/471
2018-2018	top 50	410	10	20/22

Time slice	File name	Record in file	Record in slice	Time taken

2014-2014	Download_2017	100	8	0.156
2015-2015	Download_2017	100	16	0.157
2016-2016	Download_2017	100	14	0.219
2017-2017	Download_2017	100	47	0.156
2018-2018	Download_2017	100	15	0.156
Files are	Shortened for	formatting		
Records in	the dataset:	100		
Records within	the chosen range	97		
Number	Document type			
300	Article			
55	Article; Book	Chapter		
15	Editorial material			
115	Proceedings paper			
15	Review			
Merged network	Nodes=78	Links=167		

The total number of references generated from all the data sources was 3623. After the CiteSpace analysis, the sum of all types of documents (literature) which includes, articles, article book chapters, books, editorial materials, proceeding papers, reports, dissertations and review papers to be read was found to be 500. The merged networks had 78 nodes and 167 links as shown by the visualization below. The co-citation network contains 3623 cited articles between 2014 and 2018.

2.4 VISUALIZATION

Information visualization is concerned with the design, development, and application of computer generated interactive graphical representations of information. This often implies that information visualization primarily deals with abstract, non-spatial data. Transforming such non-spatial data to intuitive and meaningful graphical representations is therefore of fundamental importance to the field. The transformation is also a creative process in which designers assign new meanings into graphical patterns. Like art, information visualization aims to communicate complex ideas to its audience and inspire its users for new connections. Like science, information visualization must present information and associated patterns rigorously, accurately, and faithfully (Chen, 2010).

The goal of information visualization is to reveal invisible patterns from abstract data. Information visualization is to bring new insights to people, not merely pretty pictures. The greatest challenge is to capture something abstract and invisible with something concrete, tangible, and visually meaningful. The design of an effective information visualization system is more of an art than science. Two fundamental components of information visualization are structuring and displaying (Chen, 2013).

The origins of information visualization involve computer graphics, scientific visualization, information retrieval, hypertext, geographic information systems, software visualization, multivariate analysis, citation analysis and others such as social network analysis. A motivation for applying visualization techniques is a need to abstract and transform a large amount of data to manageable and meaningful proportions. Analysis of multidimensional data is one of the earliest application areas of information visualization. For example, Alfred Inselberg demonstrated how information visualization could turn a multivariate analysis into a 2-dimensional pattern recognition problem using a visualization scheme called parallel coordinates (Inselberg, 1997).

The tradition of deriving higher-level structures from word-occurrence patterns in text originated in the co-word analysis method developed in the 1980s (Callon, Courtial, Turner, & Bauin, 1983; Callon, Law, & Rip, 1986). Chen (2013), highlights further that Co-word analysis is a well-established camp in scientometrics, which is a field of quantitative studies of science concerned with indicators and metrics of the dynamics of science and technology at large. The outcome of co-word analysis was typically depicted as a network of concepts. One can trace a network of citations to find out the history and evolution of a chain of articles on a particular topic. The goal of citation analysis is to make the structure of such a network more recognizable and more accessible.

Today, major resources for citation analysis include Thomson Reuters' Web of Science, Elsevier's Scopus, and Google Scholar. The Figure below shows a visualization of a document co-citation network of publications in Literature review used in this study.

In order to make an incisive analysis and have a clearer visualization of this network, it was decided to significantly reduce its size by suppressing (conservative) edges between nodes that had been cited more than once and eliminating the same any future isolated node. Such a strategy left us with 167 links and 78 nodes, many of which were isolated documents that were no longer connected to the network. Finally, you have a network of similarity and co-citation (Figure 1) without isolated nodes and with edges between nodes that have been co-cited more than once. It consists of 78 nodes, 167 links and 500 articles which are directly connected to the network.

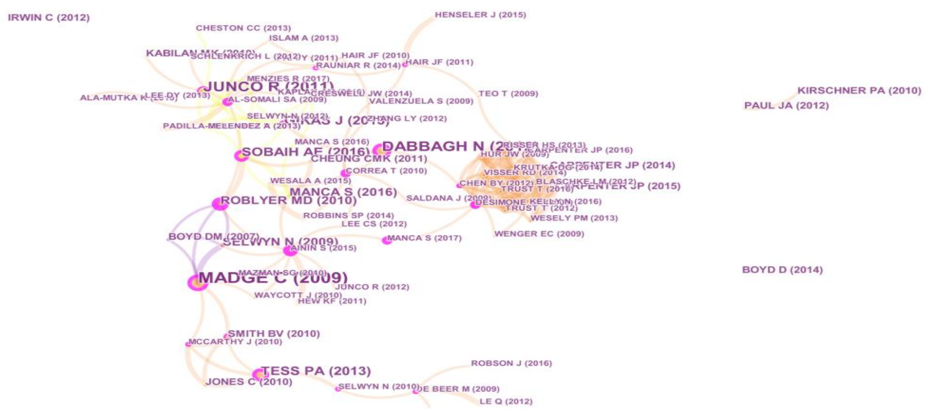


Figure 2: A visualization of the literature of co-citation analysis made between 2014 and 2018

Researchers began to focus on the structure of scientific literatures in order to identify and visualize specialties, although they did not use the term "visualization" at that time. In the 1970s, information scientists began to focus on ways that can reveal patterns and trends reflected through scientific literature. Henry Small demonstrated the power of SCI-Map in mapping the structure of research in AIDS (Small, 1994). Henry Small and Belver Griffith initiated co-citation analysis for identifying and mapping specialties from the structure of scientific literature (Small & Griffith, 1974). In 1989, Garfield and Small explained how software like SCI-Map could help users navigate the scientific literature and visualize the changing frontiers of science based on citation relationships (Garfield & Small, 1989). Henry Small described in detail his citation mapping approach to visualizing science.

We conclude this section with a visualization of the literature of co-citation analysis. The visualization in the two Figures (Fig. 3 and 4) below shows a network of co-cited references from articles that cited either Henry Small or Belver Griffith, the two pioneers of the co-citation research. The visualization is generated by CiteSpace based on citations made between 2014 and 2018. The age of an area of concentration is indicated by the colors of co-citation links. The earlier works are in colder colors, i.e. green. The more recent works are in warmer colors, i.e. in yellow and blue. Each cluster is automatically labelled with words from the key words of articles that are responsible for the formation of the cluster.

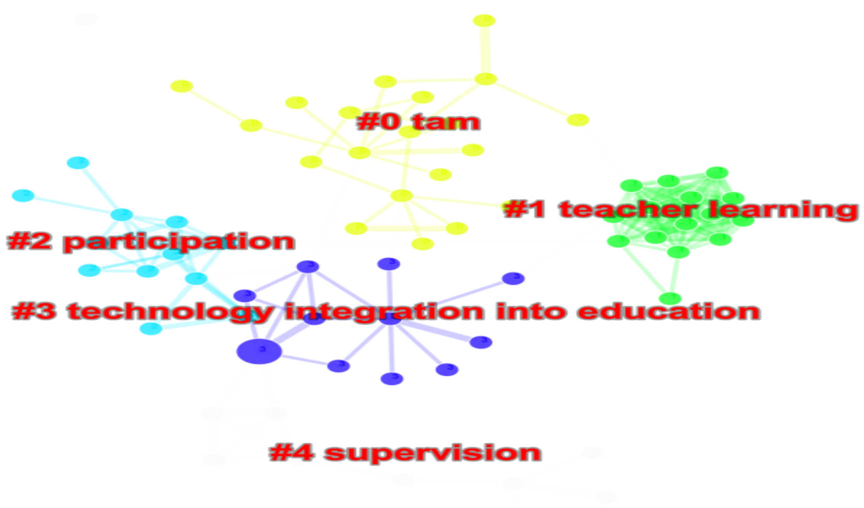


Figure 3: The visualization of the literature of co-citation analysis based on clusters

Figure 4: A discipline-level enlarged map of 5 clusters of journals and proceedings. Each node is a cluster. The size of a node represents the number of papers in the cluster.

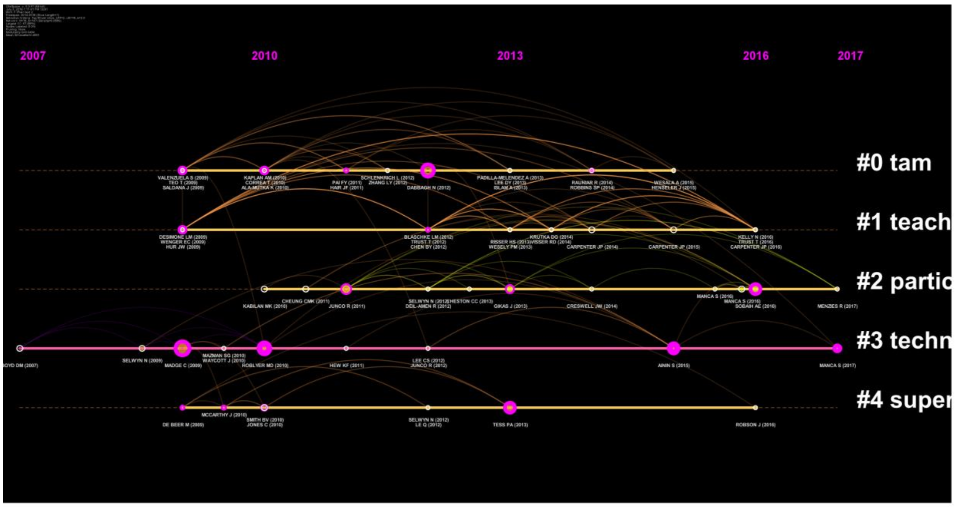


Figure 5: The visualization of the literature of co-citation analysis based on cluster view timeline between 2014 and 2018.

Clustered data families

After the debugging of the network in Figure 2, a particular grouping in the nodes emerged. Areas of high density were observed that allowed to distinguish large groups that in turn were associated with others, a group of remarkable size disconnected from the others and some small groups of isolated nodes. Each dense group was considered or called as a family. Family grouping can be observed in Figure 3. What characterizes each family is a very well-defined thematic affinity, all the nodes of the same family are based on a particular topic.

Figure 6: Network of co-citation and similarity grouping via families

Although the objective is not to describe broadly the selection of literature previously defined, it could be enlightening and worthy of mention to review some important nuances that initially were used to come up with families of network of co-citation and similarity as shown by each of the following Figures below.

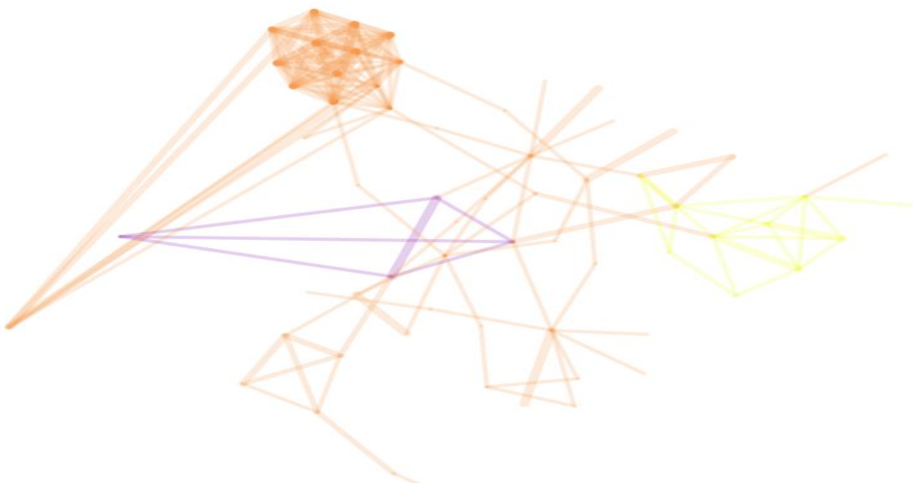


Figure 7: Family 2 of the co-citation network and similarity

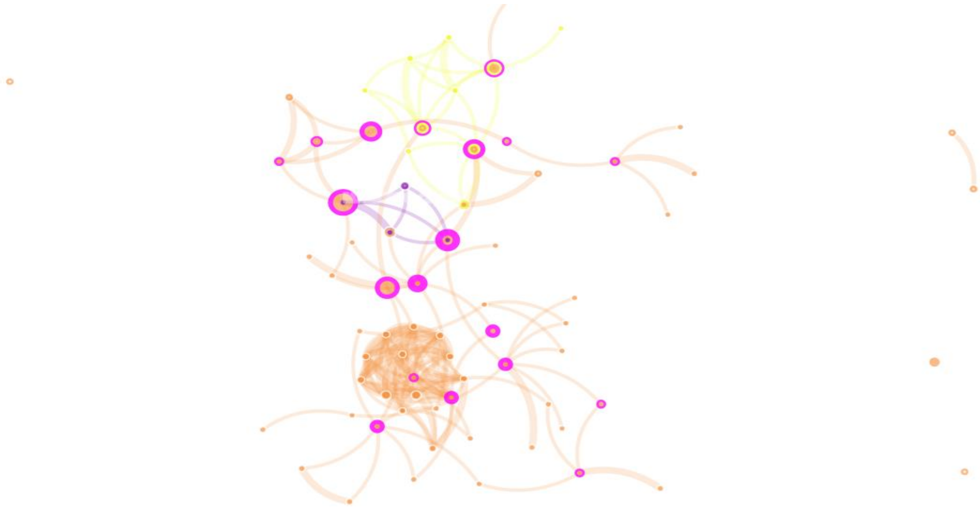


Figure 8: Family 3 of the co-citation network and similarity

2.5 PREAMBLE

Web 2.0 technologies involve information sharing and collaboration between users. The term includes social networking sites (SNS), video sharing sites, wikis, blogs, and folksonomies (also known as collaborative tagging or social indexing) where users are increasingly involved in creating web content as well as consuming it. Web 2.0 applications are increasingly embedded in the daily routines of everyday life, particularly for young people in many places and a variety of different social settings (Hargittai, 2007; Kim & Yun 2007; Lange, 2007; Leander & McKim, 2003; Tufekci, 2008). To date, research on SNS has received most sustained interest (Boyd, 2007a; Boyd & Ellison, 2007; Thelwall, 2008). In the field of education, such interest has tended to revolve around students' educational use of SNS (Ellison, Steinfield, & Lampe, 2007; Selwyn, 2007), the use by educators of SNS in their pedagogic practice (Hewitt & Forte, 2006; Mason, 2006; Mazer, Murphy, & Simonds, 2007) and related issues of trust and privacy (Acquisti & Gross, 2006; Boyd, 2007b; Dwyer, Hiltz & Passerini, 2007; Griffith & Liyanage, 2008; Mitrano, 2006). This work has primarily focused on the higher education sector, in a range of different educational institutions, mostly located in Zambia. However, it is equally very clear that there still remains a dearth of empirical data exploring on the use of social media by undergraduate students in Zambia. Later alone, how online social networks could aid Mathematics Education pedagogy into higher educational institutions and culture, how such SNS are then used by students for support and collaboration purposes whilst at the university and how these SNS might be used by higher educational institutions to support the media Internet-based learning process in the future.

According to Beer and Burrows (2007), the exciting potential offered by Web 2.0 technologies for ‘reworking hierarchies, changing social divisions, creating possibilities and opportunities, informing us and reconfiguring our relations with objects, spaces and each other’ is yet to be fully explored. Nowhere is this more evident than in the arena of teaching and learning, where empirical studies of how developments in social software are impacting on pedagogy and educational social relations remain a sparse, if growing, field of research (Selwyn, 2007).

Whilst recent studies suggest that over 95% of British undergraduate students are regularly using social networking sites, we still know very little about how this phenomenon impacts on the student experience and, in particular, how it influences students’ social integration into university life (Madge, Meek, Wellens, & Hooley, 2009). As Boyd and Ellison (2007), suggest, ‘vast and unchartered waters still remain to be explored’ in research on SNS.

2.5.1 Social Media Use

Rachel and Nielsen (2017), in their most recent published paper, they scholarly argued that teachers are best situated to influence students’ use of social media for learning purposes when they have an understanding of students’ social media practices for learning and can leverage and/or support students to develop the ability to benefit from the high levels of connectivity. In addition, it is important to recognise that application of social media technologies for learning are strongly influenced by teachers and instructors (Bennett, Maton, & Kervin, 2008).

According to Sadowski, Pediaditis and Townsend (2017), in their study conducted between September 2014 and April 2015, with 355 students from all campuses and domestic partner institutes (this study was part of a larger research project at a regional Australian dual-sector institute with campuses across regional Victoria) university students’ use of social media were explored and statistics suggest that 68% of Australian Internet users have an SNS presence, with 24% checking at least five times per day (Sensis, 2015). Facebook is the most used SNS in the world, with Facebook (2016) reporting a staggering 1.13 billion daily active users across the globe as of June 2016. Fifteen million Australians used Facebook in March 2016

(Cowling, 2016), with this SNS used by 93% of all Australian users in 2015, who spent an average of 8.5 hours per week accessing the site (Lord, 2016). Nearly as many Australians (14.2 million) accessed YouTube during this time period (Cowling, 2016).

Research into social media use and learning generally begins with an examination of how frequently students use social media. However, the most recent reports of social media use among teens acknowledge the challenge of trying to determine frequency of use because 24% of teens access social media sites almost constantly (Lenhart et al., 2010; Lenhart, 2015) largely due to increased access to smartphones. While Facebook is still the most popular social networking site, Lenhart (2015), noted that teens' social network use has diversified to include Instagram, Snapchat and Twitter. In a recent report of college-age users, Blodget (2012), noted a declining trend in Facebook use, while comScore (2011), identified another trend in reporting a 59% decrease in email use among 12–17-year-olds in 2010. Clearly, social media practices are evolving to reflect what Van Dijck (2013), has called 'interpretive flexibility' (p. 68).

The findings of many large-scale studies of youth and social media use vividly capture the extensive use of social media applications such as Facebook by the younger generation, but the studies also reveal that this use is not nearly as sophisticated as has been imagined (Ito, Baumer, Bittanti, Boyd, Cody, Herr-Stephenson, & Tripp, 2010; Jones, Ramanau, Cross, & Healing, 2010; Pedro, 2012).

Ito et al., (2010) found that, the online social interactions of youth could be framed as either friendship-driven practices, as reported by Watkins (2009), or interest-driven practices as posited by Ellison, Steinfield and Lampe (2007). In fact, Oblinger & Oblinger (2005) claimed that this generation of learners prefer active learning to passive learning, while Prensky (2001a), argued that they want to receive information quickly. However, research has also shown that learners rarely take advantage of the collaborative and creative potential of Web 2.0 technologies (Moll, Nielsen, & Linder, 2015). In addition, it is important to recognise that application of social media technologies for learning are strongly influenced by teachers and instructors (Bennett et al., 2008). In 2010, Selwyn proposed three interrelated concepts to justify the use of social media in higher education contexts: the changing nature of the student who is highly connected, collective and creative, the changing relationship between today's university and knowledge consumption, knowledge creation and formal education and the emergence of ‘user driven’ education. Social media use has become a potential value in educational contexts and this has been recognized by most scholars. For instance, United Kingdom’s education think tank, The Education Foundation, published the Facebook Guide for Educators: A Tool for Teaching and Learning (Fordham & Goddard, 2013). Although the guide was commissioned by Facebook, there are other indicators that social media has become a significant type of educational technology. Examples include research compilations such as The Social Classroom (Mallia, 2014) and Tess’s (2013), recent review of the role of social media in the higher education classroom.

While research into social media use and learning has been undertaken in higher education contexts, as noted by Kandroudi, Bratitsis and Lambropoulos (2014), no methodologically structured empirical studies have been conducted in lower levels of education. Claims have been made that social network use can lead to more complex communication patterns (Schroeder & Greenbowe, 2009) and even to higher engagement and achievement (Junco, Heiberger, & Loken, 2011) but there have also been calls for more consistent application of a theoretical framework for implementing the technology as a learning resource (Merchant, 2012). A recent review of Facebook use in education found that ‘the pedagogical affordances have only partially been implemented’ (Manca & Ranierit, 2014 p. 313).

Faculty use of social media can only be described as superficial. Research indicates that faculty members use social media more for personal than instructional use and that their main use is consumptive – most often sharing online videos in their classes even as they acknowledge that social media can be effectively used by students for collaboration (Moran et al., 2012). However, faculty also indicate scepticism about the pedagogical value of social media, which can be attributed to tensions between the informal and colloquial sharing of information that social media are designed to promote and the professional relationships that faculty tend to value (Martinez-Aleman, 2014).

Facebook is the most widely used social network and thus most widely studied (Tess, 2013). Some research has focused on affective outcomes or examined the relationship between learning outcomes, student achievement and the educational use of social networks. Research provides evidence that students rarely use social media for educational purposes, preferring to have a separation between their personal/social lives and their academic lives (Jones, Blackey, Fitzgibbon, & Chew, 2010; Madge et al., 2009). Other research demonstrates that social networks facilitate more effective communication between peers (Brady, Holcomb, & Smith, 2010) or help students to build relationships (McCarthy, 2010). Other studies conclude that instructors need to involve students in critical engagement by facilitating posts to be 'horizontal' or 'liberating' (Rambe, 2012).

Interestingly, negative relationships have been found between social network use and student achievement (Kirschner & Karpinski, 2010; Paul, Baker, & Cochran, 2012). While literature is continuing to build in the area of social network use, specifically Facebook, in education it is also necessary to broaden understanding of social media use in order to account for the diverse tools that students may use to support their learning (Moll & Nielson, 2017).

Facebook reaches more than half the world's global online audience (55%) as reported by comScore (2011), and is the second most visited site worldwide (Alexa Internet, Inc., 2016). As educators, our ability to integrate the use of social media tools into our classrooms will enable our students to more fully utilise and benefit from the connectedness, and thus learning potential, that social media tools can provide (Moll et al., 2015).

A growing body of literature explores the use of SNSs in higher education (Kurkela, 2011; Maloney, Moss, & Ilic, 2014; Peck, 2014; Tess, 2013; Usher et al., 2014; Wang, Tchernev & Solloway, 2012). In recognition of a lack of empirical evidence about the efficacy of SNSs in higher educational settings, Tess (2013) conducted a literature review of research. He notes that the majority of studies investigating learning outcomes and student achievements in relation to SNSs in educational settings report positive outcomes. For example, a study of 50 online graduate students using Ning (Brady, Holcomb, & Smith, 2010) reveals students' positive perceptions of the capacity of Ning to make communication with other students more possible than face-to-face delivery (70%), communicate with peers outside of class (82%) and reflect and comment on peers' work more effectively than within a face-to-face setting (74%). However, the findings of other studies are not as positive, with a cross-institutional study by Jones et al., (2010) suggesting that students rarely use SNSs for educational purposes. Tess (2013) reaches the conclusion that there is insufficient research evidence to definitively state whether SNSs are an “efficient and effective software solution for the higher education classroom” (p. 66). Not surprisingly, given its popularity, much research attention has been paid to Facebook (Cuesta, Eklund, Rydin, & Witt, 2015; Irwin, Ball, Desbrow, & Leveritt, 2012; Kabilan, 2016; Madge et al., 2009; Ratneswary & Rasiah, 2014; Santos & Cuta, 2015; Vivian, Barnes, Geer, & Wood, 2014). Manca & Ranieri (2013) conducted a literature review of 23 peer-reviewed articles focusing on Facebook as a learning environment to explore “the extent to which its pedagogical potential is translated into practice” (p. 487), explicating three themes: instructional efficacy, supportive and interactive learning tool and students’ reactions to Facebook as an instructional tool. Although 11 studies exploring instructional efficacy report positive outcomes, findings about Facebook as a supportive and interactive learning tool were mixed.

Although some studies argue that Facebook increases learner participation, encourages discussion and information exchange, other studies highlight students’ reluctance to engage with Facebook in the educational setting. Likewise, studies exploring students’ reactions to Facebook as an instructional tool provide mixed results. Facebook’s capacity to enhance student learning is reinforced in a number of studies. For example, in their study of 24 students participating in a closed Facebook forum, Cuesta et al., (2015) found that forum participation enhances the understanding of academic culture and knowledge production of higher education students from diverse backgrounds. Ratneswary and Rasiah (2014) highlight Facebook’s capacity to enhance teaching and learning in team-based environments by providing innovative ways of involving and motivating students. Facebook’s capacity to facilitate positive peer connections is a strong and consistent theme across the literature (Irwin et al., 2012; Madge et al., 2009; Santos & Cuta, 2015). In their study of 501 students from different nationalities, Santos & Cuta (2015) conclude that “social networks are the modus operandi of the new generation”, with their findings suggesting that Facebook helps students to “accumulate and maintain bridging social capital” (p. 41).

Social media has become a necessity for the younger generation, especially among undergraduates (Hamade, 2013; Swaminathan et al., 2013). Studies have confirmed that this generation now has a psychological addiction with the Internet in general (Chou & Hsiao, 2000; Qiaolei, 2014) and particularly with social media (Cabral, 2011; Hong, Huang, Lin & Chiu, 2014). This may be because students in higher education are now regular users of social media in different forms, as shown in several studies. Hong et al., (2014) found that the average time that university students spent on Facebook was more than 4.5 h per day. This is a higher volume when compared with several other studies conducted in the higher education sector. According to Singh and Gill (2015), 70.1% of students spent about an hour daily on social media, while Hamade (2013), reported that 60% of students accessed their social media account many times a day. Stanciu et al., (2012) found that 67% of students accessed social media one to five times a day, while Neier and Zaye (2015), found that 88% of students accessed them daily. Fasae and Adegbilero-Iwari (2016), emphasized that over two-thirds of the respondents (70.3%) used social media daily, while 18.1% used it occasionally and only 0.7% used it never. Stainbank and Gurr (2016), also found that the majority of students (52.3%) used social media one to four times daily and over 40% of them accessed social media over five times a day.

A study conducted by Al-Daihani (2010), disclosed that blogs, video sharing, collaborative authoring, communication and social networking received the higher mean scores of 3.49, 3.48, 3.39, 3.36 and 3.24, respectively, from the midpoint (3) in a scale of one to five. As this study further revealed, a considerable number of respondents gave least mean scores (below the midpoint of 3) for some other social software tools, such as calendaring (2.98), image sharing (2.33), file sharing (2.21) and social bookmarking (1.67). Fasae and Adegbilero-Iwari (2016), found that students were interested in using social media for entertainment and communication activities more than learning. This study further stated that only “for sharing academic events with my peers” (65.2%) was the recorded response of more than 50% of students. Other academic related activities, such as “for submitting assignments” (34.1%) and “to interact and exchange idea[s] with my lecturers” (9.4%), were the responses recorded by less than 35% of the students.

Studies have shown an association with the types of electronic devices used by students to access social media. The major tools that students used to access social media were reported to be laptops followed by desktops and mobile phones (Singh & Gill, 2015; Stanciu et al., 2012). Interestingly, some studies found that Facebook was more popular among female students than male students (Hamade, 2013; Ruleman, 2012). Stainbank and Gurr (2016), also found that more female students (63.5%) use social media than male students (36.5 %). However, in general, students prefer Facebook followed by Twitter, YouTube, Googleþ or Skype. Fasae and Adegbilero-

Iwari (2016), found that the majority of the respondents (93.5%) use Facebook, followed by Googleþ (63.8%) and Twitter (47.8%). This study further found that Googleþ (52.2%) was the most beneficial social media system to students, although they mostly preferred Facebook (93.5%). Singh and Gill (2015) found that Facebook was the most popular social media among students (84.7%), followed by YouTube (43.6%) and Googleþ (41.1%). Stanciu et al., (2012), showed that Facebook was the most widely used (87%) social media, while Hamade (2013), found instead that it was Twitter (89%) followed by Facebook (62%). Ruleman (2012) found that 79.1% of university students preferred Facebook, followed by Skype (27.8%), and Stainbank and Gurr (2016), disclosed that Facebook was most popular (84.6%) compared with Twitter (15.4%). University students are increasingly using social media, as recent studies have observed, for entertainment and communication rather than studious activities, such as learning. Singh and Gill (2015), highlighted that 49.7% of students used social media for entertainment followed by communication with family and friends (48.1%) and for socializing (40.5%). Hamade (2013), pointed out that the majority of students (70%) used social media for entertainment. Stanciu et al., (2012), asserted that 60% of students used it for communication and further noted that students did not use this technology much for communication related to education. This finding correlates well with the results of Ezeah, Asogwa and Obiorah (2013), who found that students devoted more time to social media for activities other than learning and even used this media to chat with their friends and loved ones during class times.

Further, Al-Daihani (2010), found that 56.0% of students preferred social software “to chat with friends” followed by “for up-to-date information” (5%), for networking (31%), for self-expression (28%) and to “share files” (23%). This study, however, confirmed that students had moderate answers with regard to the use of social software in education. Fasae and Adegbilero-Iwari (2016), measured student awareness of social media. In total, 43% of the respondents were very knowledgeable about social media, while 37.0% were partly knowledgeable. However, 20% of the respondents were not knowledgeable about social media.

2.5.2 Impact of Social Media on Students’ Learning

Several studies have observed that social media has a significant impact on students’ learning in higher education, confirming that students use social media to communicate with teachers/instructors and for collaboration, sharing and discussions.

A study conducted by Stanciu et al., (2012), found that the majority of university students (62.0%) used social media to communicate with teachers; however, around 25% of students were of the opinion that social media had no value or impact concerning education. The study of Lim et al., (2014), had a contrasting result – about 90% of the students used social media for academic purposes. Among these, “assignments/project collaboration discussions” recorded the highest percentage (97.59%) followed by “sharing of documents” (91.57%), “communication” (87.95%), “knowledge/information sharing” (83.13%), “activities/event updates” (80.72%) and “sourcing for information” (72.29%). Interestingly, this study found that teachers/instructors also used this technology during academic engagements. For this purpose, teachers/instructors were also given the same categories to rank their priorities: communication had the highest percentage (80.5%) followed by “assignments/project collaboration discussions” (79.3%), “sharing of documents” (78.1%), “activities/event updates” (73.2%), “knowledge/information sharing” (67.1%) and “sourcing for information” (42.7%).

Based on content analysis of 11 previous studies, Piotrowski (2015) reported that 55% of business students and business faculty members had a positive attitude for applying social media to teaching, 30% indicated both positive and negative results on the adaptation of social media to learning, and two studies derived negative views about social media application in education.

Dogoriti et al., (2014) found that social media and learning management systems were beneficial for teaching and learning. The majority of students responded positively to the 14 survey questions. Interestingly, 75% confirmed that “social networking sites help students to strengthen English skills” and 75% agreed that “social networking sites help to build/strengthen a sense of community within a learning environment”, while 69% were of the opinion that “social networking sites can enhance the learning process among students”.

2.5.3 Students’ barriers to Social Media Engagement

The barriers to the social media engagement of students were particularly demonstrated in several recent studies. A study by Singh and Gill (2015) stated that “time consumption” (37.2%) was the main barrier faced by students to access social media, followed by “fear of misusing their personal information” (29.2%), “lack of security and privacy" (23.2%) and, interestingly, "access not allowed by university" (10.0%). Mohamed and Sumitha (2011) disclosed that students feared most the misuse of private information (39.5%) and lack of security and privacy issues (48.5%). Hamade (2013) was also of the opinion that students lacked security and privacy issue knowledge related to social media: 70% of the students allowed everybody to view their privacy information, while 30% adjusted their privacy settings to control unauthorized access – this study also highlighted that social media had negatively affected students' study and work (60.0%) and their use of time (58.0%). According to Lim et al., (2014) social media creates distractions and loss of focus in student study (66.7%).

Interestingly, 38.3% of the undergraduates confirmed that their social media-related activities were monitored by university authorities and 81.5% of the students said that universities made necessary arrangements to dam social media access within university networks during teaching hours. Al-Daihani (2010), measured problems that prevented students from using social media sites. There were ten statements out of which only "not received training" scored 3.71 of the mean, which meant students agreed moderately to the statement. All other statements got a coffee rating by the undergraduates. According to Fasae and Adegbilero-Iwari (2016), "poor Internet connectivity" (79.0%) was the major barrier to using social media followed by "receiving unwanted messages/ pictures" (63.8%) and "electricity failure" (52.2%).

2.5.4 Impacts of Social Media in Mathematics Education

Based on the extant literature reviewed, there is a significant body of research relating to technology-enhanced Mathematics Education and the perceived potential of digital tools to enhance the learning experience (Aibhín & Brendan, 2017). Discovering how best to use technology in classrooms remains a priority research theme and "continuing challenge" in Mathematics Education (English & Kirshner, 2016) as well as other areas (Kim, Kim, Lee, Spector, & DeMeester, 2013). Kim et al., (2013) found that even participating in a four-year project, with teachers receiving the same resources, technology and professional learning opportunities, "the levels of technology integration were not the same" (p. 84). Technology use was a major focus of the research project described here with Texas Instruments Australia being an Industry Partner in the project, providing mathematical software and hardware to teachers and students in the project. This included graphing calculators (including, but not exclusively, CAS-enabled graphing calculators), and software including TI-Interactive (a CAS), spreadsheets, various geometry packages, and GridPic (an application developed specifically for the project, available http://extranet.edfac.unimelb.edu.au/DSME/RITEMATHS/general_access/ curriculum_resources/).

The rise of digital resources has had profound effects on mathematics curricula and there has been a concurrent increase in teachers flipping their instruction—that is, assigning instructional videos or multimedia for students to watch as homework and completing problem or exercise sets in class rather than vice versa. These changes have created a need to better understand not only the features and learning affordances of these videos but also the phenomena of instructional videos taking the place of textbooks altogether (De Araujo, Otten, & Salih, 2017).

To conceptualize instruction, we draw on Cohen, Raudenbush and Ball (2003), and the instructional triangle (see Fig. 9) wherein teaching is defined through the interactions that occur among and between teachers, mathematical content, and students. Furthermore, each of these aspects and their interactions occur within various environments (e.g., classroom, school). Students not only interact with one another, but also with the teacher. These interactions may be student or teacher led, but are conducted with the purpose of facilitating students in understanding the content. The students interact with the content through the tasks and experiences the teacher selects or designs. In a non-flipped class, the teacher may lecture, and witnessing the lecture is the experience through which the students interact with the content. Similarly, in a flipped class, lecture videos may serve as a proxy for the teacher's live lectures. Beyond lectures, there may also be investigations or problem sets, selected or designed by the teacher, through which the students have opportunities to learn mathematical content (Zandra, Samuel, & Salih, 2017). In order to understand the epistemological nature of the didactics of mathematics, a re-interpretation of the didactical triangle by Bruno D’Amore and Fandiño (2002), of mathematical interaction between pupil-teacher-knowledge is shown below:

Instruction as Interacation

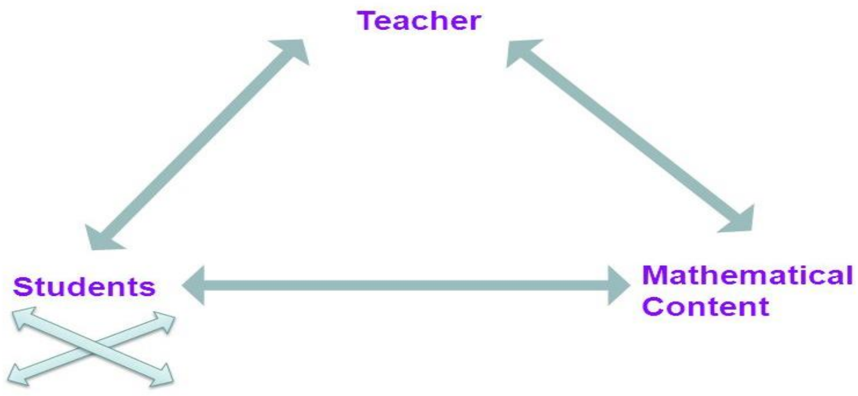


Figure 9: A preadaptation of the original D’Amore triangle

Empirical research on flipped instruction, however, is still in its infancy, with a preponderance of anecdotal work and self-studies (e.g., Bergmann & Sams, 2012; Southmayd, 2014; Tucker, 2012). A common theme among the accounts of flipped mathematics instruction is that teachers flip in the hopes that students develop deeper understandings of mathematics (Bergmann & Sams, 2009; Ford, 2015; Fulton, 2012; Hamdan, McKnight, McKnight, & Arfstrom, 2013; Lage, Platt, & Treglia, 2000; McGivney-Burelle & Xue, 2013; Sickle, 2015). For example, Strayer, Hart, and Bleiler (2015), decided to flip their college pre-calculus courses in order to foster a deeper understanding of the mathematics content with students. In analyzing their implementation of flipped instruction, the instructors did perceive students as developing a greater understanding of content and also the instructors developed greater insight into students’ thinking. Teachers also perceived that flipped instruction can help maintain consistency among multiple sections of a course in terms of pacing and content because teachers of the various sections can send the same video home for students to watch (Strayer et al., 2015). Teachers are also choosing to flip their classrooms in the hopes that students gain more positive attitudes towards mathematics and are more engaged (Chen, Wang, Kinshuk, & Chen, 2014; Moore, Gillett, & Steele, 2014). This increased engagement is possible because students are together as they work on mathematics, allowing for collaboration, and flipped instruction increases the amount of class time available for work. Proponents of flipped instruction even suggest that “different subgroups might benefit from the student-centered support from both the teacher and fellow classmates” (Hamdan et al., 2013, p. 8).

When teaching mathematics, although teachers could use pre-made videos, many choose to make their own videos and some teachers have reported that their students prefer teacher-made videos (Palmer, 2015).

There is growing interest in African higher education in relation to the use of computers to support learning (Bass, 2007; Harrison, 2010). Computer and Internet applications are increasingly making their way into teaching. Research (e.g., Ayub, Mokhtar, Luan, & Tarmizi, 2010; Voogt, 2008) has shown that the use of technology, particularly computers and computer peripherals, in teaching generally improves the quality of teaching. Accordingly, many African countries are encouraging teachers to use computers in their teaching and formulating policies for effective practice (Harrison, 2010). As a result, the use of computers in African education system is increasing, with the aim of improving the quality of education (e.g., Harrison, 2010; Ottevanger, Akker, & Feiter, 2007).

2.5.5 Recent Related Literature

The Zambian education system is based on traditional and physical classroom education which requires that secondary school pupils and undergraduate students attend the school classes physically every single day. This explains why there are boarding schools and college or university hostels just within the institutional premises. This is a normal practice in many countries world-wide (e.g. see Basilaia & Kvavadze, 2020) reported a similar situation. The author of this doctoral thesis has a deep enthusiasm in the advancement and innovative use of Information and Communication Technologies (ICT) as well as social media technologies in Mathematics Education and an awareness of the current and future trends in the use of technology to enhance mathematics teaching and learning. Zambia, like many other countries (e.g. see Mailizar & Fan, 2020), view ICT as a potential tool for enhancing the pedagogy of mathematics in mathematics classrooms. But according to Perienen (2020), he argued that technology integration stretches over other implications and is not limited to using suitable computing digital devices such as PCs, laptops, tablets, phones, and the like to explain, discuss and exemplify mathematical concepts but includes other social media technologies like YouTube, WhatsApp, Zoom, Lifesize and many more to act as relevant platforms for mathematics instructions. Therefore, to appreciate this study, the author thought to examine some other related works in the literature which exclusively focused on online learning and mathematics related activities.

Presently, there is a shortage of studies carried out on the use of social media platforms in mathematics pedagogy. Nonetheless, in the field of Mathematics Education, there is a growing body of relevant literature on the use of social media among mathematics teachers. For instance, a study by Perienen (2020), investigated the factors that significantly contributed to technology usage by mathematics teachers. This study disclosed that mathematics teachers were regular users of technology and participated in online activities more in order to learn well. This study further indicated that students learn mathematics better with effective and appropriate use of technological devices.

Similarly, another recent study revealed that the inclusion of mobile services and social media platforms in mathematics activities improves the quality of teaching mathematics in a digital school, supports professional development as well as professional orientation and self-determination of young people (Soboleva, Chirkina, Kalugina, Shvetsov, Kazinets, & Pokaninova, 2020). Moreover, the aim of their study was centered around the didactic potential of mobile technologies to support Mathematics Education in a digital school while simultaneously preparing specialists of the future. Hence, it is very convenient for the author of the current doctoral thesis to highlight that these additional opportunities tend to motivate the learners to freely participate in lessons without being shy.

Likewise, a study by Campbell (2019), conducted in Cape Town, South Africa, involving high school students and university students established that a “WhatsApp mathematics” tutoring-project was designed to provide fee-free mathematics help anywhere and at anytime to high school students from Cape Town townships. Findings of this study revealed that using mobile phones and WhatsApp is more profitable in specific ways to both tutors and tutees (e.g. school students are more likely to have access to mobile phones than computers and WhatsApp is a universal application). Furthermore, it was disclosed that online tutoring through mathematics “WhatsApp groups” saves travel time and costs, but occasional face-to-face meetings could greatly improve the tutoring process by developing trust relationships between group members and may motivate participants in specific groups to remain actively involved.

With the rapid increase in the use of social networking sites among undergradruate students, in the same vein, a study carried out in the United Kingdom (UK) by Goodband, Solomon, Samuels, Lawson and Bhakta (2012) highlighted on the use of Facebook to facilitate mathematics instructions. In this contextual analysis, Goodband et al., (2012) reported on the utilization of Facebook to support mathematical communications and more collaborative learning activities inside a UK university mathematics department. In general, this contextual analysis discovered that the development of Facebook can add to certain adjustments in the experience of mathematics students. In particular, this study found that students' experiences and impressions of university study – particularly mathematics here - are exceptionally pertinent to the achievement of success of social networking as a way of encouraging new mathematics teaching-learning relationships. As a way of concluding, Facebook did not emerge to be an application for discussion, mathematics students in this study devised a new way of using it to organise their studies.

Furthermore, Albalawi (2017) conducted a study to investigate mathematics teachers' perception of using social media in their teaching. The sample comprised of 142 mathematics teachers teaching at different schools. The said study took place in in Tabuk, Saudi Arabia. Most importantly, this study was closely related to the topic of this doctoral dissertation. Thus, the results of this study revealed that mathematics teachers were moderate users of social media who oftenly used it in their mathematics teaching-learning processes with no particular objective. In terms of which social media app was most used among the responsents, Albalawi's (2017) study findings reported that the most-used social media application among mathematics teachers was WhatsApp. In addition, teachers in this study believed in the significance of using social media in their mathematics teaching and percieved it positively. A significant difference based on gender was also found, and results in this study further disclosed that female mathematics teachers were more actively involved in incorporating social media in mathematics teaching-learning proceses than males teachers. Finally, it was further reported that there was a significant difference based on gender in terms of teachers' perception of the importance of using social media. Likewise, with female teachers ranking it more favorably. Nonetheless, no significant differences were reported based on teachers' experience or level taught in the perception of the importance of using social media.

Meanwhile, Wei and Chen (2006) carried out a study to design an e-book interface for mobile phones which gives students the option to type their comments or suggestions directly onto the text. The results of this study indicated that the e-book interface was extremely relevant for students, particularly, for recording questions, comments and getting feedback. In another study, Genossar, Botzer, and Yerushalmy (2008) indicated that the use of mobile phones in the educational environments developed students' ability to complete their class-exercises in the real contexts. This was highlighted by the students' ability to gain insight of vital mathematical concepts in such contexts.

According to Chernoff (2014), Twitter's co-founder, Jack Dorsey, wanted to provide a platform for the exchange of ideas, dialogue, discussion and interaction. To get a better examine what David Wheeler would tweet, Chernoff (2014) decided to analyse how distinguished members of the Mathematics Education research community use social media. Exploring further into the matter, Chernoff (2014) found that the Mathematics Education research community, as a whole, is very late to the game when it comes to the use of social media. Interestingly, he further noted that certain Mathematics Education organisations have embraced social media platforms: ICMI is on Facebook, NCTM and PME-NA use Twitter, as have a handful of individuals (@joboaler, @mathhombre, @mathedresearch, @rmosvold, @eddiemils and others). To the larger extent, nonetheless, most of mathematics educators has not embraced social media. Based on these research findings, Chernoff (2014) arrived at a new contention: David Wheeler, like the majority of mathematics educators, would not tweet.

Soto and Hargis (2017) in their study, describe how Twitter can be used to engage students in mathematics both inside and outside of the classroom wall. To set up the pace, the two scholars posited that Twitter is one resource students can use to communicate their thoughts [thinking]. Since Twitter enables users to post 30-seconds videos and digital pictures, it is therefore, argued in this study that a teacher may have a classroom Twitter account and post lecture notes (ideas), pictures of events and assignment reminders. This in turn makes Twitter very important for learning. To support this claim, (see e.g. NCTM, 2014), highlights that technology plays an important role in helping students reason, communicate their understanding and make sense of mathematics. One aspect of significance shared in this article is to engage students in thinking about mathematics using Twitter. With the advent of the technological inventions, with ease of social media tools such as Twitter, sharing of ideas and activities as to a greater part become easier and more sustainable. It is argued in this article by the first author that by combining the digital assignment with the capabilities of a sharing tool, such as Twitter, students could be empowered to become more curious, more aware, self-directed in their thinking and engaged in mathematics thinking at anytime.

Another study by Bigirwa, Ndawula and Naluwemba, (2020), conducted in Uganda sought to establish whether school financing role was essential to e-learning adoption, and the salient traits of school financing role to be focused on by midwifery schools. In another study (e.g., Burke, 2020) the authors posited that online learning and teaching require skills that need to be developed, it is argued that globally - we are on a steep learning curve - and from this report, we are doing well. We are being forced to think in different ways, to solve mathematics problems together, to collaborate and to communicate in different ways, to educate and be educated in a different way.

As a matter of fact, this doctoral thesis about mathematics pre-service teachers' use of social media in Mathematics Education was motivated from a broader introspection by Alabdulkareem's study (Alabdulkareem, 2015) which exclusively analysed the use of social media from the context of learning science which was one of the most in-depth studies about teachers' and students' views on social media use in learning. Arguably, pre-service teachers need both digital resources and the use of flipping instructional methods (De Araujo, Otten, & Birisci, 2017) such as assigning instructional videos or multimedia for students to watch as take-home tasks and completing problems or exercise sets in class to effectively teach mathematics in mathematics classrooms.

There has been a rapid increase in recent studies primarily focusing on the use of social media in learning. Although some scholars (e.g. Delegge & Wangler, 2017) were concerned about some social media platforms particularly, Facebook becoming obsolete by the end of 2017, several other scholars (e.g. Sheikh, Sheikh, & Soomro, 2019; Rutherford, Long, & Farkas 2017; Moorthy et al., 2018; Chukwuere & Bonga, 2018; Park, Song, & Hong, 2018; Mahmud, Ramachandiran, & Ismail, 2018) have carried out studies on social media use reporting substantial knowledge required in the context of teaching mathematics.

On the one hand, Lau (2017), examined the effects of social media usage on the academic performance of students, on the other hand, Chun and Lee (2017), explored the effects of views similarities on peoples' willingness to speak out on social media platforms. Hence, it is not surprising to discover that most recent studies reveals that online instructors, tutors and students are using mobile technologies in universities round the world (Snoussi & Kaleel Kaleel, 2019; Valunaite Oleskeviciene & Šliogerienė, 2020; Ifijeh, Ilogho, Iwu-james, Michael-Onuoha (Ohaegbulam), & Osinulu, 2019; Idiedo, 2020). Therefore, based on the incipient body of reviewed literature, this dissertation seeks to find answers to research leading sub-questions located on section 2.6.4 of chapter 2.

Therefore, as already stated on section 1.5.2 of chapter 1 regarding the third and final objective on qualitative analysis, this doctoral thesis will focus on providing a deep insight into the way social media technologies are influencing the teaching and learning of mathematics at the Copperbelt University (CBU) as well as to identify which paths are open (or closed) to take into account in the future to improve both processes. Similar with other previous studies (see e.g. Falcó, Pérez Domínguez, Casaña Granell, Calatayud, & Ezzatvar, 2020; Giannakoulopoulos, Limniati & Konstantinou, 2020; Hennessy, Brown, Pascoe, Holland, Keenan, Meyer, & Royer, 2019; Hennessy, Brown, Pascoe, Keenan, Holland, Meyer, & Royer, 2020), which have looked at classroom innovation with social media in higher education.

Although all the research objectives of the study at the Copperbelt University (CBU) are broadly stated in section 1.5.2 of chapter 1, to rephrase them simply and with a more global coherence, the a first target of this study is to explore the role social media is playing (and might play) in Mathematics Education via social networking among pre-service teachers. A second target of the research is to explore aspects of university pre-service teachers' related online activities that might motivate them to participate in online learning and examine whether there is any effect on the pedagogy of mathematics. Lastly, the authors wish to open a discussion on the question of whether and how the use of social media tools may have an impression on the set of 21st century skills by both learners and teachers.

Not surprisingly, considering its popularity, many recent studies have been conducted on Facebook use (García-Domingo, Aranda, & Fuentes, 2017; Cuesta, Eklund, Rydin, & Witt, 2019; Madge et al., 2009; Kabilan, 2016; Santos & Čuta, 2015;

Gwena, Chinyamurindi, & Marange, 2018) and the use of WhatsApp (García-Domingo, Fuentes, & Aranda, 2018).

In spite of the evidence that much research on social media usage have been done in various fields like Psychology, medical health, medical professions, public sector and cardiovascular imaging (Ayanso & Moyers, 2015; Liyanapathirana, 2019; Parwani, Lee, Khalique & Bucciarelli-Ducci, 2019; Demirtepe-Saygılı, 2020), there is a dearth of research conducted on social media usage by university students focusing on mathematics. However, there is a body of incipient research on this topic (e.g. Campbell, 2019; Cardoso, Kato, & Oliveira, 2014; Chernoff, 2014, Goodband, 2012; Soto & Hargis, 2017; Vohra, 2020) including some closely related to the topic of the dissertation (see Albalawi, 2017).

It is against this background that the current study wants to bridge the gap of knowledge in the field of mathematics in the particular context of Zambia. General findings from these previous studies indicated that social media were used mostly for communication, corroborative discussions, sensitizing patients and research results dissemination. Likewise, the government and other public service agencies use social media platforms as the key channel for communication and service provision.

2.6 Teacher Knowledge Frameworks in Mathematics Education

Whilst the roles for social software technology proposed by Tikhomirov (1981) are key constructs in this research work, it is important to acknowledge other important frameworks in education. Shulman's (1986) constructs of subject matter knowledge and pedagogical content knowledge, and their importance for successful teaching, are considered seminal work in the Mathematics Education research community (and beyond). He drew the attention of teachers and researchers around the world to the "difference between what it means to know and understand something yourself and what it takes to help someone else to come to know and understand" (Shulman, 2000, p. 130). Mathematical content knowledge (MCK) and pedagogical content knowledge (PCK) are essential if teachers are to move learners beyond illusory understanding, described by Shulman as "the appearance of learning, …that is, the problem of people who appear to know something that they don't really know" (2000, p. 131). In the education community, Shulman's framework has been expanded to specifically include technology knowledge, for example, technological pedagogical content knowledge (TPCK), later renamed as the TPACK model (e.g., Koehler & Mishra, 2009). Instrumental orchestration builds on the idea of instrumental genesis whereby a digital tool shifts from a tool to an instrument and "a meaningful relationship exists between the artefacts and the user" (Drijvers & Trouche, 2008, p. 367). In instrumental orchestration, the focus is on how the teacher supports this process. In turn, the framework of Ruthven focuses more finely on how this occurs. The framework includes five structuring features of classroom practices, which influence how digital technologies are integrated. These are the working environment, resource system, activity structure, curriculum script, and time economy (Ruthven, 2014, p. 386).

Thomas and colleagues, in their identification of the progress of teachers' pedagogical integration of hand-held technology into their practice, proposed the construct pedagogical technology knowledge (PTK) (e.g. Thomas & Hong, 2005, 2013). PTK "comprises a teacher's perspective on the technology, their familiarity with it as a teaching tool, and their understanding of mathematics and how to teach with it" (Thomas & Lin, 2013, p. 115). They describe the construct as drawing on PCK and technology knowledge. Thomas, Bosley, de los Santos, Hong, and Loh (2007) argue that teachers with high levels of PTK are more likely to emphasize mathematical concepts, take a multi-representational approach and see the mathematical benefits of using technology. In contrast, a low level of PTK sees a focus by the teacher on operational matters, procedures and skills.

2.6.1 THEORETICAL FRAMEWORKS

In the present study, activity theory and the modified Technology Acceptance Model (TAM) guides the data analysis and interpretation of the study to explore the factors that influence students' participation in online discussions through WEB 2.0 technologies. According to Hasan and Kazlauskas (2014), Activity Theory is grounded in the work of the Russian psychologist Vygotsky and his students, in particular, Leontiev, in the 1920s. Activity Theory provides a lens with which to tease out and to better understand human activity. In the field of online teaching and learning, a community is a group of learners who cooperate and collaborate to participate in course activities (Cross, 1998). The principal objective of this community is to advance the construction and sharing of knowledge between groups through collaborative learning activities (Bielaczyc & Collins, 1999). Individuals who are engaged in a working group believe that their needs can be satisfied through working cooperatively and collaboratively as a community (Rovai, 2002).

Activity theory is a framework that researchers use to design and analyze interactions between members of a group and discover factors influencing their participation in online discussion. Activity theory helps the researcher find factors that influence students' participation in online discussions. Researchers frequently use activity theory to analyze human-computer interactions (Nardi, 1996). Researchers use activity theory as a conceptual framework in the field of computer and mobile technologies for describing and analyzing the structure, development and context of learning activities mediated by computers, mobile technologies, and so on. Activity theory is also used to describe and analyze the factors that influence user participation in online discussions mediated by computers or other devices. Activity theory is a suitable framework through which to design, understand and improve learning through online learning communities. Activity theory can be used to design and understand online learning communities and to evaluate human computer interaction (HCI) activities, Web 2.0 learning communities, mobile learning communities, and many other HCI-based applications.

Engeström (1987), developed an extension of the activity theory model that adds the component of community sharing of the same object. In this suggested model of activity theory, Engestrom added rules that mediate the learning community and the subject and create a division of labor between the community and the object.

Essentially, activity theory aims to describe, analyze and understand the mental capabilities of a single individual. The theory rejects the isolation process applied to individuals, however, such as in the case of individual learning, and considers this isolation to be an insufficient unit of analysis. The theory seeks to analyze the cultural and technical aspects of human action (Bertelsen & Bodker, 2003). Activity theory is based on six related principals:

1. The first principal is the orientedness of the object. The objective of the activity system has social and cultural properties in the system, such as collaborative or cooperative learning in an online course.
2. Subjects are actors engaged in activities. This is considered the individual level of activity theory; students are contextual subjects engaged in collaborative learning.

3. Community or externalization is considered a social context of the system and a community level of activity theory; all actors are involved in the activity system (e.g., a group of students engaged in learning based on social interaction for constructing and sharing of knowledge is an example of a learning community).
4. Tools are considered a technological level of activity theory. In the system, communication between communities is mediated by tools that transmit social knowledge. It includes the artefacts used by actors in the system. Tools influence actor-structure interactions and are influenced by culture.
5. The division of labor is a considered a hierarchical structure of activity or the division of activities among actors in the system.
6. Rules are the conventions and guidelines regulating activities in the system, such as rules of discussion between students in collaborative learning.

Figure 10 shows three levels of activity theory: The technological level, the individual level, and the community level. The three levels are the main factors that influence students' online participation.

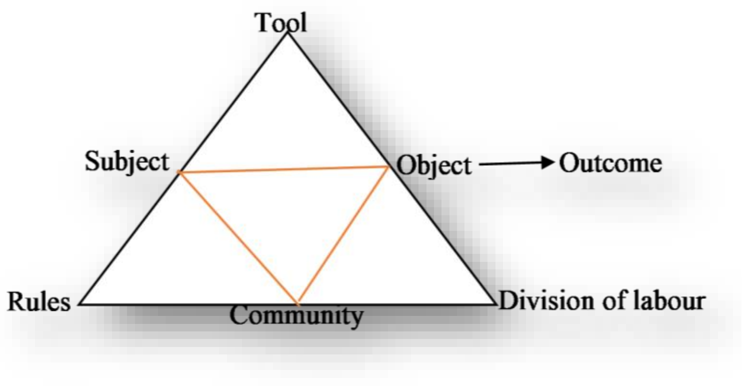


Figure 10: Leontiev's theory of human activity as depicted by Engeström (1987).

Hewitt (2004), used activity theory to evaluate learning communities in online learning environments and to explore the factors that influence students' participation in online communities. The ease of use of the technology exploited in online learning and its usefulness are both pertinent factors that influence students' positive attitudes toward the adoption of online learning communities to construct and share knowledge.

In their research related to learning communities, Strijbos and Fischer (2007), noted that collaborative learning strategies are very useful to construct and share knowledge among students in collaborative and cooperative online courses in the presence of an instructor or tutor. The collaborative and cooperative learning activities achieved by students in the activity system help researchers find the cognitive outcomes of a learning activity and the processes of knowledge creation and sharing during the learning process. Activity theory stimulates professionals to renew knowledge (Tillema & Orland-Barak, 2006).

Mercier and Higgins (2017), examined the adoption of online cooperative and collaborative learning strategies in online communities to support mathematics learning activities and found that a number of factors influencing students' participation in cooperative and collaborative communities. Students are motivated and positively oriented to participate in online communities to share knowledge related to mathematics courses.

Further, we cannot forget the principal role of the instructor in online learning activities. In this context, a recent study by Lu and Churchill (2014), stated that the teacher plays a principal role in guiding students in online lectures. This study showed that the social interaction that helps students construct and share knowledge is achieved through the pertinent role of the instructor; a decrease in the frequency of interactive messages in online communities is triggered when the online tutor or teacher is not present with the group in the online community.

Other researchers in the field of mobile learning have found that online learners are using mobile educational technologies and are integrating it in online learning through learning communities and that the usefulness and ease of use of the mobile technology are the principal factors influencing students' participation and adoption of online interaction (Litchfield et al., 2007). The social presence of students in online communities is a pertinent factor that influences student's participation in online communities (Cheung et al., 2008)

In an article published in Contemporary Educational Technology, Tennyson (2010), noted that in the 1990s, the integration of the media artefact by the tutor or teacher in an e-learning system was the technological factor that improved online social interaction among group members in learning communities. Social online interaction in online learning communities and its analysis became an important domain of research (Tennyson, 2010).

Baran (2010), recommended the integration of auditory and visual representations of knowledge through calculators and audiovisual media, which is considered an effective tool for solving online students' learning difficulties. These technologies may have positive results on teaching and learning.

A study conducted by Yu, Tian, Vogel and Kwok (2010), reported that online discussions between students through social learning communities networked through an artefact, such as mobile learning communities, clearly improved students' social connections, improved their self-esteem and boosted their learning performance.

Preston and his colleagues (2010) found that nearly 70% of students state that they learn just as well in online learning communities such as WhatsApp groups, Facebook communities, Twitter chats and Google+ communities, as they do in lectures that are held in the classroom in the presence of other students.

And lastly, in order to investigate students' views about social media use in this research work and its importance in Mathematics Education, a modified Technology Acceptance Model (TAM) will be used which suggests that external factors, teachers' and students' beliefs about the usefulness and ease of use of a particular technology, are major decisive factors in relation to teachers' actual practice (Davis, 1989). The Technology Acceptance Model (TAM) is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it.

Davis (1989) and Davis, Bagozzi and Warshaw (1989), suggest that users' motivation to utilize technology in the classroom, which in turn leads to their actual practices in the classroom, can be explained by the external variables: perceived usefulness and perceived ease of use of technologies. The following definitions of these concepts are used in the context of this study.

- **Perceived usefulness** - The degree to which a user of a particular technology believes that using a particular technology would enhance teaching performance. This definition suggests that when a technology is perceived as being useful, a teacher or a student will have a more positive attitude toward it, which encourages its subsequent use in practice.

- **Perceived ease of use** - The degree to which a teacher believes that using a particular technology would be easy and free from effort, which encourages its subsequent use for teaching purposes. In this case, perceived ease of use can help to promote a teacher's or student's beliefs about the usefulness of a technology.
- **External factors -** This model also proposes that external factors (e.g., Professional Development and accessibility of technology) affect intentions and actual use through mediated effects of perceived usefulness and ease of use (Davis, 1989).

Additionally, the Technology Acceptance Model (TAM) has explicitly been developed in view of describing and explaining technology adoption and use. The TAM theorizes that an individual's behavioural intention to use technology is basically determined by two beliefs: perceived usefulness, defined as the extent to which a person believes that using the system will enhance job performance, and perceived ease of use, defined as the extent to which a person believes that using the system will be free of effort (Davis, 1989).

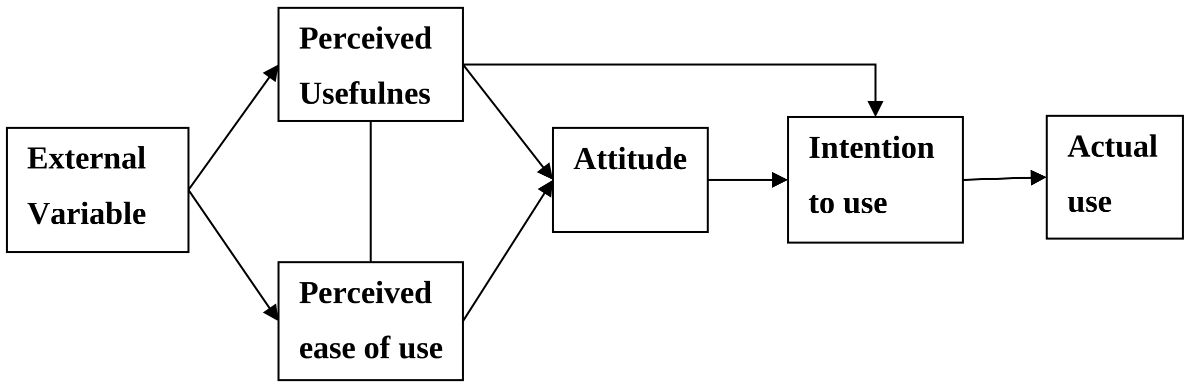


Figure 11: The Technology Acceptance Model (Davis, 1986; 1989).

Perceived usefulness and perceived ease of use are two primary determinants of technology acceptance. Attitude towards technology use is jointly determined by perceived usefulness and perceived ease of use. The latter influences the behavioral intention to use the technology that – in turn – determines the actual adoption and use of technology (Venkatesh & Davis, 2000). External variables for example training on intention to use are mediated by the former internal processes (Venkatesh & Davis, 2000).

This model has been used in so many empirical studies on user technology acceptance and integration as a theoretical basis for example studies done by (Davis, 1989; Davis et al., 1989; Mathieson, 1991; Kumar, 2008; Adedoja, 2013). TAM has become the most commonly and popular used theoretical framework for technology user studies and it is also found to be imperative in explaining instructional use of educational support systems and examining the external factors that influence the usage of these systems. In other words, the research framework adopted in this study uses the constructs of the TAM. Technology acceptance is "an individual's psychological state with regard to his or her voluntary or intended use of a particular technology" (Maslin, 2007). In TAM, it's easy to see that the main dependent factor is the behavioural intention to use and actual system usage while the main independent factors are attitude, perceived usefulness and perceived ease of use.

Therefore, the qualitative data that will be collected will be subsequently and partly analyzed through the lens of Davis' (1989), modified Technology Acceptance Model (TAM). The TAM approach focuses on how the external domain, such as professional development (PD), and accessibility of technology, influences participants' beliefs about the usefulness, and ease of use of technology, which in turn impacts their actual use in teaching (Tekeher, 2013).

2.6.2 RESEARCH QUESTIONS

The study was designed to address two research core questions and three research sub-leading questions which were central to the perception and expectations of students in regard to the use and the impact of social media.

2.6.3 Research core questions of the study

1. Does the official use of social media have a statistically significant impact on teaching and learning of mathematics?
2. Is there a statistically significant difference among students' current social media use?

2.6.4 Research leading sub-questions of the study

1. How do our students currently use social media?
2. How do our students see the impact of social media on Mathematics Education?
3. Do our student teachers believe that the official use of social media can enhance their learning and teaching experience in mathematics?

2.7 HYPOTHESIS

The hypotheses guiding the present study are:

H_1: The official use of social media has a statistically significant impact on teaching and learning of mathematics.

H_2: There is a statistically significant difference among students' current social media use.

Chapter 3: Research Design

This chapter describes the research design adopted by this study to achieve the purpose and significance of the study stated in section 1.4 and 1.5 of Chapter 1. The overall aim of the study was to explore students' use of social media in the context of a "standard" math subject and other mobile applications compared to 100% in-class mathematics learning. The primary the objective of this study sought to investigate pre-service teachers' social media use and its impact on the learning and teaching of mathematics as a scaffolding tool. Section 3.1 describes the methodology and research design used in this study, the phases by which the methodology was implemented and the research design, and the methodological rationale associated with the research design; sections 3.2 and 3.3 discusses the participants in the study; section 3.3.1 describes the sample and sampling techniques used in this study and justifies their use; section 3.4 explains the instrument used in this study as well as its reliability and validation processes; sections 3.4.1 and 3.4.2 gives an account of the type of data collected and data collection methods used; section 3.5 outlines the procedure used and the timeline for completion of each stage of the study; section 3.6 discusses methods of data analysis; finally, section 3.7 discusses the ethical considerations of the research and its [potential] problems and limitations.

3.1 METHODOLOGY AND RESEARCH DESIGN

3.1.1 Methodology

The present study utilized a mixed-methods sequential explanatory design. By definition, a mixed-methods is a procedure for collecting, analyzing, and "mixing" or integrating both quantitative and qualitative data at some stage of the research process within a single study for the purpose of gaining a better understanding of the research problem (Tashakkori & Teddlie 2003; Creswell, 2005). The rationale for mixing both kinds of data within one study is grounded in the fact that neither quantitative nor qualitative methods are sufficient by themselves to capture the trends and details of a situation. The essence of choosing the mixed method research approach in this study is merely to seek for participants´ inputs; this step will provide an all-encompassing and intelligent system for giving a rich description of a circumstance for both the author and those being examined, to build the profundity and expansiveness of the analysts' discoveries.

The research tradition guiding the qualitative data analysis is the case study. Thus, case study research involves the study of an issue explored through one or more cases within a bounded system (i.e., a setting, a context). The results reported in this study represents both quantitative and qualitative analysis. Thus, quantitative analysis was run first which matches a post hoc quasi-experimental design by means of survey technique whereas qualitative content analysis was later used to examine how the special group of students who needed special attention have used different social media platforms in their respective mathematics courses to support their lectures and everyday learning activities.

Parts of the results from this doctoral dissertation have already been published in three different peer-reviewed international journals. However, a comprehensive set of results for both quantitative and qualitative analysis will be published later when the project is finalized. Finally, the stages by which the methodology will be implemented and the discussion of the methodological assumptions are outlined on sections 3.13 and 3.14.

3.1.2 Research Design

3.1.3 Mixed Methods-Sequential Explanatory Design

In recent years, more social and health sciences researchers have been using mixed-methods designs for their studies. By definition, mixed methods is a procedure for collecting, analyzing and "mixing" or integrating both quantitative and qualitative data at some stage of the research process within a single study for the purpose of gaining a better understanding of the research problem (Tashakkori & Teddlie 2003; Creswell, 2005). The rationale for mixing both kinds of data within one study is grounded in the fact that neither quantitative nor qualitative methods are sufficient, by themselves, to capture the trends and details of a situation. When used in combination, quantitative and qualitative methods complement each other and allow for a more robust analysis, taking advantage of the strengths of each (Green, Caracelli, & Graham 1989; Miles & Huberman, 1994; Green & Caracelli, 1997; Tashakkori & Teddlie, 1998).

There are about forty mixed-methods research designs reported in the literature (Tashakkori & Teddlie, 2003). Creswell, Plano Clark, Gutmann and Hanson (2003) identified the six most often used designs, which include three concurrent and three sequential designs. One of those designs, the mixed-methods sequential explanatory design, is highly popular among researchers and implies collecting and analyzing first quantitative data and then qualitative data in two consecutive phases within one study. Its characteristics are well described in the literature (Tashakkori & Teddlie 1998; Creswell 2003, 2005; Creswell et al., 2003), and the design has found application in both social and behavioural sciences research (Kinnick & Kempner, 1988; Ceci, 1991; Klassen & Burnaby, 1993; Janz et al., 1996).

The mixed-methods sequential explanatory design consists of two distinct phases: quantitative followed by qualitative (Creswell et al., 2003). In this design, a researcher first collects and analyzes the quantitative (numeric) data. The qualitative (text) data are collected and analyzed second in the sequence and help explain, or elaborate on, the quantitative results obtained in the first phase. The second, qualitative, phase builds on the first, quantitative, phase, and the two phases are connected in the intermediate stage in the study. The strengths and weaknesses of this mixed-methods design have been widely discussed in the literature (Creswell, Goodchild, & Turner 1996; Green & Caracelli, 1997; Creswell, 2003, 2005; Moghaddam, Walker, & Harre, 2003). Its advantages include straightforwardness and opportunities for the exploration of the quantitative results in more detail. This design can be especially useful when unexpected results arise from a quantitative study (Morse, 1991). The limitations of this design are lengthy time and feasibility of resources to collect and analyze both types of data.

In solving issues to do with which method will be appropriate for the current study, my decision-making process was guided by the purpose of the study and its research questions, as well as the methodological discussions in the literature. The present study will use the sequential explanatory design. This is so because the implementation of the qualitative data will depend on the quantitative findings. Thus, qualitative techniques will be used to explain the findings of quantitative data. Therefore, the qualitative method will only play a less dominant role (embedded) in the study by helping the researcher explain the findings of the main approach (quantitative).

The diagram below summarizes the whole research design.

Figure 12: Sequential Explanatory Design (Adapted from Creswell, 2014).

This study will employ the sequential explanatory research design approach to describe and quantify the data that will be collected by both quantitative and qualitative techniques. The qualitative data will be collected at last and embedded in the quantitative methodology so that it just plays a supplemental role within the overall design. The relevant techniques governed by the positivism paradigm and social constructivism will be used to describe and investigate the use of social media on teaching and learning of mathematics as a scaffolding tool and the impact of that on Mathematics Education students in Zambia.

The Statistical Package of Social Science (SPSS) tool will be employed to analyze quantitative data. Descriptive statistics, cluster analysis, Analysis Of Variance (ANOVA) and multiple regression analysis techniques will be used to describe, summarize and present the data collected by quantitative methods coupled with inferential statistics to draw conclusions. In order to qualify our findings and to describe the qualitative data fully, the researcher will use the standard qualitative content analysis to present, interpret and uncover students' views, opinions and beliefs about social media usage.

In this study, the research tradition guiding the qualitative data analysis is the case study. Thus, case study research involves the study of an issue explored through one or more cases within a bounded system (i.e., a setting, a context). Although Stake (2005) states that case study research is not a methodology but a choice of what is to be studied (i.e., a case within a bounded system), others present it as a strategy of inquiry, a methodology, or a comprehensive research strategy (Denzin & Lincoln, 2005; Merriam, 1998; Yin, 2003). I choose to view it as a methodology, a type of design in qualitative research, or an object of study, as well as a product of the inquiry.

Case study research is a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audio-visual material, documents and reports), and reports a case description and case-based themes. For example, several programs (a multi-site study) or a single program (a within-site study) may be selected for study.

The interesting leading question for this method is;

- *Do our Mathematics Education student teachers believe that the official use of social media can enhance their learning and teaching experience in mathematics?*

Below (see Fig. 13) is the conceptual structure of a Case Study using Stake´s graphical proposal. The main circle shows the case to be studied and the main issue to be explored. Cases under consideration are:

1. The set of Mathematics Education student teachers.
2. The Copperbelt University (CBU)

Around the main circle, there can be seen four semi-circles of minor size, which constitute the contexts in which the case settles down. It is necessary to deepen in the roots of the case, since it is the only way to be able to analyze it in the context in which it arises and it is developed. That is, we would like to develop an in-depth description of the case or multiple cases we are going to look at on the use of social media by university student teachers studying Mathematics Education. It will be amazing if we explore and analyze data through the description of the case and themes of the case as well as cross case themes.

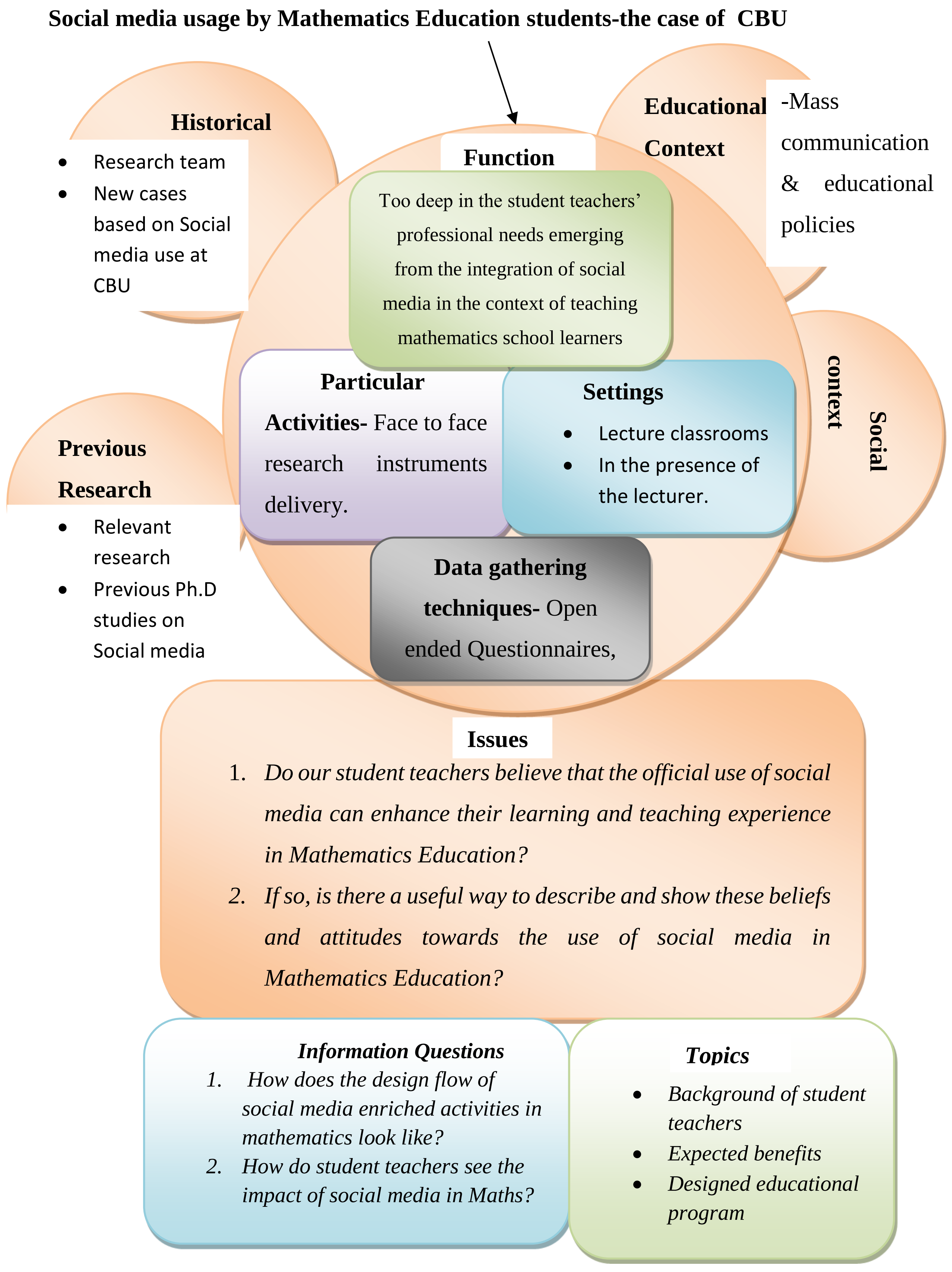


Figure 13: Conceptual structure of a Case Study using Stake´s 1995 graphical proposal

3.1.4 Methodological Rationale of the Mixed Methods Design

The rationale that will be associated with the mixed-methods sequential explanatory design is complementarity**.** In this case, I will use two different methods to address different parts of the same study. Since the current study will involve two different methods, combining two research methods from different philosophical paradigms needs a critical examination of the research problem being addressed, systematic planning of the research design, thoughtful consideration of time and resources needed to conduct the study, and a clear determination of when to integrate both qualitative and quantitative methods. Therefore, in this study, qualitative methods will be used to complement the quantitative findings of the study in order to increase the credibility of my findings.

The rationale for this approach is that the quantitative data and their subsequent analysis provide a general understanding of the research problem. The qualitative data and their analysis refine and explain those statistical results by exploring participants' views in more depth (Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998; Creswell, 2003).

Secondly, the essence of choosing the mixed method research approach in this study is merely to seek for participants´ inputs, this step will provide a holistic and insightful mechanism for providing a rich description of a situation for both the researcher and those being researched, to enrich my findings, to increase the depth and breadth of the researchers´ findings, to test the Activity Theory (AT) which is grounded in the work of the Russian psychologist Vygotsky and his students, in particular, Leontiev, in the 1920s. Activity Theory provides a lens with which to tease out and to better understand human activity. In this research, Activity Theory provides a language and a set of frameworks for making sense of what is discovered about the situation through observation, interviews and other methods. Using the Activity Theory lens for research takes *activity* as the unit of analysis, where *activity* is defined by the 'dialectic relationship between *subject* and *object*', in other words, 'who is doing what for what purpose' (Vygotsky 1978).

Additionally, to test the Technology Acceptance Model (TAM), the study will use an adapted quantitative survey questionnaire and a well-structured qualitative questionnaire to collect data from pre-service mathematics teachers at the Copperbelt University. The data that will be collected will be subsequently analyzed through the lens of Davis' (1989) modified Technology Acceptance Model (TAM). The TAM approach focuses on how the external domain, such as professional development (PD), and accessibility of technology, influences participants' beliefs about the usefulness, and ease of use of technology, which in turn impacts their actual use in teaching. Lastly but not the least, the main essence of this mixed method is to improve the trustworthiness of the results. It is important to reflect back and check if the results of the study best represent the general views or thoughts of the participants´ responses. This in turn will build peoples´ trust and the research community about the research findings.

As in any mixed-methods design, I had to deal with the issues of priority, implementation, and integration of the quantitative and qualitative approaches. Thus, I had to consider which approach, quantitative or qualitative (or both), had more emphasis in my study design; establish the sequence of the quantitative and qualitative data collection and analysis; and decide where mixing or integration of the quantitative and qualitative approaches actually occurred in my study. I also had to find an efficient way to visually represent all the nuances of the study design for my own conceptual purposes and to provide its better comprehension by both the potential readers and reviewers. In solving those issues, my decision-making process was guided by the purpose of the study and its research questions, as well as by the methodological discussions in the literature (Morse, 1991; Morgan, 1998; Tashakkori & Teddlie, 1998; Creswell et al., 2003).

3.1.5 Integrity and credibility of the study

In order to provide the rigor criteria of the research itself in terms of both the internal and external validitity of the more quantitative (positivism) part or those of confirmability, transferability, credibility and consistency of the qualitative (interpretivism) part as defined by Guba repeatedly (e.g. see Guba, 1979; 1981; 1990), or to achieve the integrity and credibility in it, has traditionally been used by other researchers, the paradigm chosen to guide this doctoral thesis is pragmatism which incorporates both positivism and interpretivism. For example, Romero's (2015) doctoral thesis employed strategies that included issues such as validity and reliability and owned the post-positivism tradition approach.

In order to account for all the ontological, epistemological and methodological questions raised in this study, the fundamental set of beliefs (the paradigm or worldview) that I chose to serve as a major foci around which we will analyse this doctoral dissertation titled, “pre-service mathematics teachers’ social media usage and its perceived impact on their personal, academic and teaching careers,” was pragmatic research. Despite the fact that there are numerous types of pragmatism, the focus centered upon results, actions, situations and consequences of discovery instead of the herald or forerunner of the situation. Apart from concentrating on the methodological aspect, the important concern to the author(s) of this doctoral thesis was the problem being studied and the questions asked regarding the problem. The pragmatic paradigm was considered useful for guiding the research design in this study because a single approach or a combination of different approaches is philosophically inconsistent. Thus, the pragmatic paradigm fits well in the methodological design used in this study as it draws upon the mixed-methods approaches and espouses that using different methods to solve a research problem in a single study can be complementary.

Above all, to visualize the methodological coherence and consistency, the study follows a mixed-methods sequential explanatory design. The methodological proposal and design are related to the nature of a clearly pragmatic (positivism-interpretivism) study as the appropriate methodology for effectively answering the research questions of this doctoral dissertation. It is argued that with the addition of the qualitative methods, this study will employ a reinterpretation of qualitative content analysis often for the purpose of ameliorating the problems noted in the opening paragraphs of this chapter. In addition, this study has also included the understanding of the concept of integrity and credibility (trustworthiness) (Guba, 1981; Shenton, 2004), materializing all of the methodological strategies used that give this study rigor.

With regard to the methodology used in this doctoral dissertation, the varied use of different and innovative stages of mixed-methods sequential explanatory research design subjects the study to a rigorous, coherent and well-justified process. The different methods of planning the research process, collecting data and analyzing the data lead to the results and their interpretation being liberated from ambiguities and inconsistencies. Just to give some examples of the strategies and procedures utilized in this study, we highlight the use of Sci2 and CiteSpace in the literature review process, science mapping, specifically the analysis of co-citation and similarity (Gmür, 2003), for the collection of literature (in the search for invisible authors) as well as for the study of the dynamic evolution of the concept of teaching-learning mathematics using social media technologies, quantitative data analysis using SPSS guided by the positivism paradigm and qualitative content data analysis guided by interpretivism paradigm. Quantitative normative methodology is privileged over the insights of creative and divervent thinkers. The call for qualitative inputs is expected to redress this imbalance.

With the goal of providing rigor to this mixed-methods sequential explanatory research, the four lenses of Guba’s proposal (1981) are reviewed in detail: credibility, transferability, dependability and confirmability, own terms of a naturalistic paradigm compared to traditional rationalist terms as criteria of rigor that respond to internal validity, external validity, reliability and objectivity, respectively. Therefore, It was decided that in order to discuss the integrity of the study linked to this doctoral thesis, a brief analysis of the degree of accomplishment of the rigor criteria for both quantitative and qualitative phases based on the pragmatic tradition (combination of both positivism and interpretivism) are examined from the lens of Guba's proposal and Lincoln (1982), which is composed of four fundamental criteria.

- **Credibility**: This study will answer the question of what similarity the results are with reality? (Merriam, 1998). To assess the internal validity, this study will ensure that it measures or evaluates what really is intended to be measured. Thus, the researcher will interrogate the fundamental theories that are there in the field of Mathematics Education.
- **Transferability**: The study will examine if the generated results of the research exercise are applicable to other situations. The researcher is expected to give a detailed description of the phenomenon under study and its implications. Thus, this is intended to illustrate the external validity which must demonstrate that results can be applied to larger populations (generalization) or other contexts.
- **Consistency**: The study will audit the process way to a prototype model of the methodological design or the methodological description in depth. In order to ensure that the findings in this study are reliable or checking for reliability of the whole study: It is expected to demonstrate that if the study is repeated in the same or similar context, with the same methods and the same participants, similar results will be obtained.
- **Confirmability**: Ensuring that the reported results correspond to the repondents’ answers, experiences, and ideas of informants, rather than with the specific features of the researcher. The objective of the study is the use of valid

research instruments that are reliable and do not depend on human perception but have been used and confirmed by other researchers in different contexts. In this study, the author(s) of this doctoral thesis will need to digress the results in terms of the current literature and contributions to the literature by comparing with other previous studies highlighting some interpretational consistencies. That is, to finally compare and contrast with other previous studies to confirm if the findings of this study will converge or diverge.

Finally, the author of this doctoral thesis will recognise the strengths and weaknesses of this methodological approach as well as the assumptions made in the process. All these downsides are expected to be highlighted on the limitations of the study included in the last chapter of this dissertation (see section 6.1) and ethical issues already highlighted on section 3.10.

3.2 PARTICIPANTS-QUANTITATIVE

Convenience sampling method was used to determine the actual sample for this study. Thus, 102 prospective pre-service secondary school mathematics teachers participated in the study. These were students studying at the Copperbelt University in their 3rd and 4th year of their training programmes and were already in the School of Mathematics and Natural Sciences from the beginning of the academic year 2016-2017 up until the end of the academic year 2019-2020 and must complete four years in order to receive a Bachelor's degree in Mathematics Education. Demographic data from table 10 indicates that 42 participants (41.2%) were in 3rd year and 60 participants (58.8%) were in 4th year. Almost 80% of the participants (81) were males (which was quite representative of the gender breakdown at the Copperbelt University as there are more male students enrolled in Mathematics related programmes at CBU) while the remaining 20.6% or 21 participants were females. Majority (71) of the participants were between 22 and 25 years of age, followed by 15 who were between 25 and 28 years of age, 14 were between 18 and 22 years of age and only 2 were between 28 and 31 years of age. In terms of devices used to connect to the Internet, 54 disclosed using Smartphones/mobile phones, 36 use laptops, 2 use desktop/home computers, 5 use iPad/tablet and another 5 use campus computers.

3.3 PARTICIPANTS-QUALITATIVE

Since the impact, experiences and use of social networks by mathematics student teachers was central to understanding the potential for mathematics pedagogy in the classrooms and professional lives of student teachers, the selection of certain participants was integral to this study. In order to ensure that I was selecting participants who actually had experience with Social Media (SM), criterion sampling technique was used in this study. Criterion sampling allowed me as the researcher to guarantee that "all participants have experience with the phenomenon being studied…and works well when all individuals studied represent people who have experienced the phenomenon" (Creswell, 2013, p. 155) which in this case is the requirement that all participants had one or more experience with using social media in their personal and professional lives. It is this experience which informed me to administer the second part of the research instrument to purposively selected student teachers at CBU. This sampling technique was important in acquiring specific insights from this group in order to understand the central phenomenon being studied (Creswell, 2007). From there, the purposeful sample criteria, also known as "judgmental sampling," was implemented by selecting thirty three (33) mathematics student teachers who had already participated in the first survey. This sample consisted of sixteen (16) third year and seventeen (17) fourth year math-student teachers from three clusters. The established criteria ensured that respondents had participated in the first survey. This criterion was useful for establishing "quality assurance" among the participants, as participating in the first survey could guarantee that they had more than one experience to reference in my discussion (Creswell, 2007). The recruitment of thirty-three participants for my sample size garnered a variety of responses that were representative of mathematics teaching as a subject and were purposefully selected since they were "representative or informative about the topic of interest" (McMillan & Schumacher, 2009, p. 138). Finally, natural setting was another important consideration in participant recruitment and my research design. Creswell (2013), posits that "qualitative researchers often collect data in the field at the site where participants experience the issue or problem under study" (p. 45). As a result, the administration of the open-ended questionnaire took place in a pre-booked classroom on campus in the presence of the lecturer, which allowed for convenience and privacy. The following section outlines the method of data collection for this study.

3.3.1 Sample and Sampling Techniques

Purposive sampling technique was used to sample secondary Mathematics Education student teachers at the Copperbelt University (CBU) in Zambia. The population for the study was the pre-service secondary school mathematics teachers studying at the Copperbelt University. Mathematics Education students who were targeted in the study are those undergraduate students studying at CBU. The sample constituted participants from undergraduate school in third and fourth year cohorts. Because the study seeks to investigate the use of social media in teaching and learning of mathematics as a scaffolding tool, it would be wise and amazing to discuss the questions of whether and how social media technologies have influenced the teaching and learning of mathematics in Zambian colleges and universities, and what paths are open (and closed) for future impact. Notwithstanding the fact that, this study seeks to understand the attitudes, perceptions, opinions, experiences, barriers and values of Mathematics Education student teachers concerning social media use and the impact of social media in the learning and teaching of mathematics and the profiles of pre-service secondary school teachers as they progress through a four year degree programme. It was imperative to select a sample that is related to the central issue being studied. As a result, the choice of the third and fourth year students as the sample for this study was based on the fact that the third year students would have gained enough teaching experience at the time of instrument administration and fourth year students would have studied enough mathematical content and methodological courses as at the time of administering the instruments.

3.4 INSTRUMENT

To measure knowledge of the pre-service secondary school teachers' use of social media in their teaching and learning experiences, the researcher administered an adapted and validated research instrument via a quantitative and qualitative survey system. Delivery mode was face-to-face in lecture rooms and in the presence of both the researcher and the lecturer.

Primary data sources were collected through the use of the questionnaire adapted from Moll and Nielson (2017). Furthermore, Moll and Nielson (2017) described the development and validation process of a survey that examined science students' social media learning behaviours. The survey had three main sections. More specifically, the first section included demographics related to age, gender and everyday social media use; social media use in the science subject of interest (i.e. a first year physics course); and social media use in high-school science learning. Below is a brief description of the two groups which participated in the study that established the validity and reliability of the scale used in our current study. A total of 220 pre-service primary teachers in a four-year B.Ed. programme at a university in Australia in 2012 participated in version 1 of the survey. The survey was then inductively validated and revised to generate version 2 according to analysis of the interviews and further analysis of the completed surveys, including statistical analysis. The revised survey was then piloted with a new group of science students in 2013. This participant group included 161 pre-service teachers (131 female, 30 male) who volunteered to complete the survey. Subsequent inter-rater reliabilities were calculated at 90% or higher for each question. The purpose of the Social Media and Science Learning Survey is exploratory; thus the process of development and refinement was largely qualitative. Moll and Nielson (2017) drew from survey results from administering the survey in Australia in 2012 and 2013 to elucidate the process of refining and validating the survey. Refining the survey through two cycles of development and validation interviews, Moll and Nielson (2017) presented a final survey tool that captured how science learners use social media tools to learn science. Results of this study indicated that the responses to the questionnaire had a reliability coefficient that was incredibly high.

3.5 Description of the instrument

In this study, essential data sources were collected quantitatively and qualitatively through the use of an adapted survey-questionnaire from Moll and Nielson (2017). This survey-questionnaire consisted of three sections. In particular, the first section contained demographic information of students associated with their age, educational background (e.g. year of study & level of study), gender, digital devices used, daily time spent on social media, preferred social media sites (communities), barriers identified to using social media and types of social media applications used. The second section obtained data related to (a) Social media practices and mathematics learning in mathematics courses (Mxxx) - This section of the survey was designed to investigate the kinds of social media tools students use to "support their mathematics learning" in Mxxx. Operationally, to "Support their mathematics learning” means that students use these tools to get information or to connect with others to help them complete the expectations for their class (i.e., while doing assignments, studying or working on projects), (b) students’ frequency of social media use for mathematics learning purposes, (c) students’ online mathematics learning behaviours and (d) resources accessed when stuck while doing mathematics tasks. The last section obtained data related to social media practices and mathematics learning in general. This part of the survey contained 10 open ended questions that explored respondents’ practices for social media and mathematics learning more generally. Using a representative sample of pre-service teaching faculty from the Copperbelt University, this part of the survey sought answers related to students’ use of social media, as well as what value they see in including social media sites as part of the instructional process.

More specifically, the first section of the questionnaire contained 4 questions with multiple choice answers, 6 questions with answers in multi-level model and a Likert-type scale from 1 to 4 (with response options as follows: Non-user, Infrequent user, Frequent user, Contributor) to categorise students’ use of various social media technologies in their everyday life for personal purposes. Similarly, the second section used a 4-point Likert-type scale to measure students’ frequency of social media use for mathematics learning (academic) purposes. The response options for the first part were those of Non-user, Infrequent user, Frequent user, Contributor and the last part required students to explain how they have used social media packages in mathematics courses. A 3-point Likert-type scale was also used to measure the frequency of students’ online learning mathematics activities while completing assignments for mathematics. The response options were those of never, sometimes and regularly. The last part of this section measured students most frequently accessed digital resources (technological applications) when doing mathematics activities once stuck. Finally, the last section of the survey-questionnaire extracted information related to social media practices and mathematics learning in general in classroom practices using 10 open ended questions. Students had to report how they typically used software packages or digital tools in their mathematics teaching-learning processes (professional purposes). The survey-questionnaire is shown in the Appendix section.

3.6 Validity and Reliability of the Instrument

For the purpose of this study, an explanation is briefly given how the author(s) took precautions towards threats to validity and reliability of the research instrument. The first phase in the reliability and validation procedure of the survey-questionnaire included face validation. Thus, to make sure that all the questions included in the questionnaire were not misunderstood by the participants, a four-step validation process was undertaken. First, a preliminary run of the survey-questionnaire was conducted with 10 randomly selected respondents from the study population. In view of their answers, minor adjustments concerning the wording of different statements were recorded.

The second step in the development process involved validation interviews with the same sample (n = 10) of survey respondents for the express purpose of obtaining feedback and refining the instrument to fit the intended sample at the Copperbelt University. The interviews were conducted before concluding the term and took about an hour and were audio-recorded. For the sake of confidentiality, the researcher used pseudonyms throughout the transcription process, the purpose of conducting these interviews was to evaluate different aspects of the survey from the views of the 10 respondents based on the feedback interviews. The aim was to seek answers on the 'clarity of items' and 'the structure of the survey-questionnaire'. This process examined wording for instructions, items on the survey-questionnaire, formatting and overall length. Based on interview analysis and further analysis of the survey data, we exclusively attended to two types of changes to inform the next administration of the survey. These were "changes for clarity" and "structural changes". We then adjusted phrasing for instructions or items based on feedback from interview respondents and the need to facilitate the ability to manage the data statistically. Minor adjustments regarding the wording of a few statements were produced. By re-writing and testing the wording in the instructions and questions, we deduced that the participants could precisely and accurately identify the kinds of Web 2.0 tools they used as well as recognise themselves as a type of user for that tool and how they use social media platforms for personal, professional and teaching purposes highlighting the key targets of the survey.

For the purpose of our current study, the third step involved running SPSS with a different data collected from two educational institutions of higher learning (n = 98).

That is, an exploratory factor analysis was performed separately in the software package of SPSS version 24.0 for each section of the questionnaire in order to determine the construct validity of the constructs measured in this questionnaire, internal reliability for each section of the questionnaire was also computed before carrying out any other statistical test (see Table 4 below), the internal reliability of the instrument was assessed using Cronbach's alpha (Cronbach, 1951). Cronbach's alpha is a measure used to assess the reliability, or internal consistency, of a set of scale or test items. In other words, the reliability of any given measurement refers to the extent to which it is a consistent measure of a concept, and Cronbach's alpha is one way of measuring the strength of that consistency. Although the standards for what makes a "good" α coefficient are entirely arbitrary and depend on your theoretical knowledge of the scale in question, many methodologists recommend a minimum α coefficient between 0.65 and 0.8 (or higher in many cases); α coefficients that are less than 0.5 are usually unacceptable, Thus, all the alpha values which were computed showed acceptable levels of Cronbach alpha with the least value being 0.65 showing the internal reliability of our research instrument for our current study.

The survey-questionnaire was finally given to four specialists in Mathematics Education from different universities for face validation assessments and clarification of the items on the questionnaire. Their positive remarks and proposals were recorded. The research scale then underwent cycles of refinement to produce the final version. This was done to ensure that all the questions asked in the survey-questionnaire were obviously comprehended before carrying out the survey with the actual sample (n = 102 in the first phase, out of which n = 33 belonged to the second phase) for this study. Author(s) therefore, concluded that the survey-questionnaire was collecting the intended data.

The tools that were employed when carrying out the study included a computer, camera, field note book, pens and pencils.

3.7 Justification of the research instrument

As discussed earlier, a total of 220 and 161 science students who were studying at an Australian university during the academic year 2012-2013 respectively took part in two surveys which established the validity and reliability of the survey-questionnaire. Subsequently, inside every science learning setting, the author(s) of this doctoral dissertation adjusted the validated survey-questionnaire to fit inside every mathematics learning setting and afterward carried out a complete process of validation before carrying out a survey with the participants of the present study. The major reason for using this survey-questionnaire in this study which was used 3 years ago is that the survey development followed an inductive validation process that dealt with issues of credibility (trustworthiness), reliability and transferability. Through a deliberate procedure, the survey-questionnaire was then revised, piloted with a new group of mathematics students and refined. Although there could be various research instruments that may be used to collect data associated with different aspects of students' use of social media in the field of Mathematics Education, the use of this instrument in the current study to collect data related to all aspects of social media technology integration in the teaching-learning process of mathematics was not only simpler for students to complete because of its length, but it also enabled researchers to obtain complete data concerned with different aspects of students' attitudes toward technological applications, digital tools as well as the use of social media in their academic lives.

3.7.1 Data Collection Phase 1: Quantitative

Thus, within each science learning context (high school or university science), the author(s) of the current document adapted the validated scale within each mathematics learning context. The survey had three main parts. The first part included demographics and everyday social media use; social media use in the mathematics course of interest (i.e. a third year and a fourth-year mathematics course) and social media use in high-school/university mathematics learning. Participants were asked to self-report a level of proficiency with the listed social media tool. The participants were also asked to respond to statements about specific social media behaviours for learning by indicating how frequently (never, sometimes, or regularly) particular behaviours were used. The survey included 7 pages with fill-it-in or tick-box response categories and the final part asked ten open-ended questions. The survey was administered during a regular class day meeting of a mathematics methods class that included the entire cohort of pre-service secondary teachers in a third-year and four-year classes studying Bachelors of Science degree in Mathematics Education at the Copperbelt University ($n = 102$) during the 2019-2020 academic year. Survey completion took at least 30 minutes. This sample took a mandatory mathematics methods course (Mxxx) in the third year and fourth year of the Bachelor of Science programme and students volunteered to participate in the research by completing the survey anonymously. No intervention took place before the survey. The researcher's role, during participants' answering, was restricted to answering their questions in order to clarify the items under study. To ensure that all questions involved in the questionnaire were clearly understood.

3.7.2 Data Collection Phase 2: Qualitative

In order to evaluate the students´ attitudes, perceptions, opinions, experiences, barriers and values concerning social media use and the impact of social media in the learning and teaching of mathematics, the researcher administered a qualitative survey instrument which was a questionnaire designed based on the qualitative research questions of the study, the research problem, the quantitative research findings, the prevalent social media interactions in Zambia and a review of extant literature.

Since my study seeks to uncover the rich experiences of student teachers in the usage of social media and its impact on mathematics pedagogy, the use of a survey (open-ended questionnaire) as an instrument is central in allowing for rich, in-depth information. It also gives me the ability [to] further probe for more thorough responses, when needed, particularly those related to feelings associated with using social networking platforms in the teaching and learning of mathematics. Thus, in order to investigate whether or not student teachers believe that the official use of social media can enhance their learning and teaching experience in Mathematics Education and how the design flow of social media enriched activities in mathematics look like, open-ended questions were posed to each participant in order to evoke their prior experiences with using social media sites from secondary schools to university level. Open-ended questions allowed for the uncovering of rich, in-depth discussions and the sharing of social media usage narratives, opinions, feelings and experiences. In terms of questioning; open ended questions were preferred in this study since it "allow[ed] the participants to contribute as much detailed information as they desire and it also allow[ed] the researcher to ask probing questions as a means of follow-up" (Turner, 2010, p. 756). Questions also sought to investigate the ease or challenge of using social media platforms into the mathematics classroom upon student teachers' return to their teaching experiences and later on full-time deployment. All in all, the follow-up survey (open-ended questionnaire) was ideal in this study and gave me confidence and preparedness as a novice qualitative researcher, but also balanced the need for comfort, credibility and complementarity.

3.8 PROCEDURE AND TIMELINE

The complexity of the mixed-methods designs calls for a visual presentation of the study procedures to ensure better conceptual understanding of such designs by both researchers and intended audiences. Therefore, a visual representation is shown below (see Fig. 14) which summarizes all the steps that will be taken during this research. In the present study, it would be difficult to comprehend the mixed-methods sequential explanatory design used without graphically representing the mixed-methods procedures used in the study. For this reason, a graphical representation of the mixed-methods procedures will help us visualize the sequence of the data collection, the priority of either method, and the connecting and mixing points of the two approaches within a study. It will also help me as a researcher understand where, how, and when to make adjustments and/or seek to augment information. In addition, it will facilitate comprehending a mixed-methods study by interested readers, including prospective funding agencies like the European Commission.

The value of providing a visual model of the procedures has long been expressed in the mixed-methods literature (Morse, 1991; Tashakkori & Teddlie, 1998; Creswell et al., 2003; Creswell, 2005). Other authors (Tashakkori & Teddlie, 1998; Creswell et al., 2003; Hanson, Creswell, Plano Clark, Petska, & Creswell, 2005) provided some visual presentation of major mixed-methods designs. Following the reviewed relevant literature on visual models, I then wish to adapt Creswell's (2014) graphical representation of the mixed-methods sequential explanatory design procedures that will be re-interpreted and used in this study. The model will portray the sequence of the research activities in the study, it will also indicate the priority of the data collection phase. It will also show the connecting points between the quantitative and qualitative phases and the related products, as well as specify the place in the research process where the integration or mixing of the results of both quantitative and qualitative phases occurs.

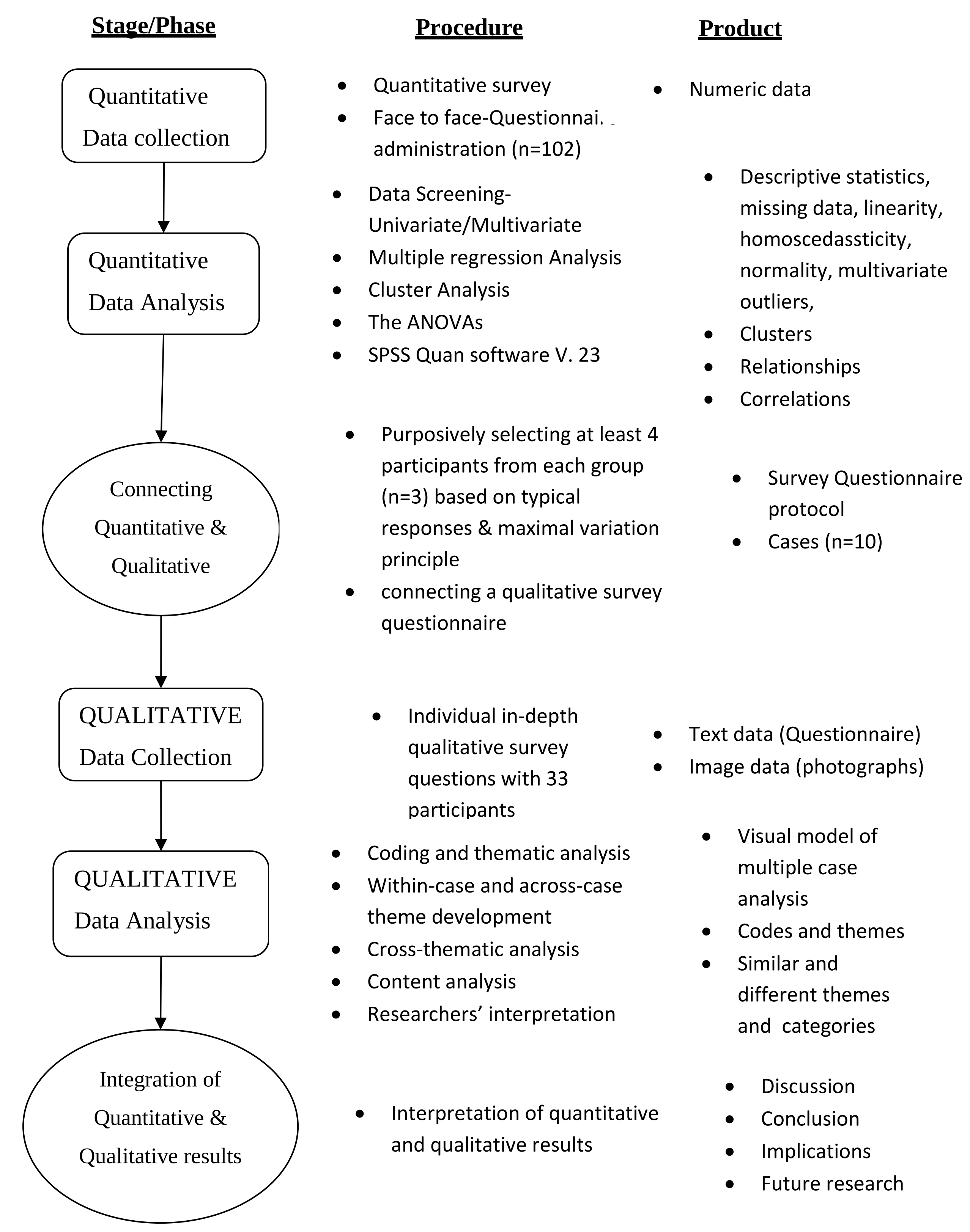


Figure 14: Sequential Explanatory Design Procedures-Visual Model

3.9 ANALYSIS

Data analysis technique takes a two-step sequential approach. First quantitative followed by qualitative. To analyse quantitative data, SPSS 24.0 software was used. Descriptive statistics were used to explore the data. Analysis of variances (ANOVA) was performed to check the mean differences in Zambian mathematics pre-service teachers' attitudes towards the use of social media based on gender and year of study. Multiple linear regression analysis (MA) was used to predict the regression model on social media use in the teaching of mathematics. Again MA was run to examine the relationship between pre-service teachers' use of social media to support their mathematics learning and the various types of social media platforms used to participate in online mathematics discourses and in mathematics classrooms.

Eventually, K-means cluster analysis was used to analyze data by using SPSS version 24.0 again. By definition, cluster analysis is an exploratory analysis technique that tries to identify structures within the data. In this study, our goal was to organize data into clusters such that there is high intra-cluster similarity, low inter-cluster similarity and informally find natural groupings among students on how they use social media technology in the teaching and learning of mathematics. We first wanted to find out how many groups the data will be clustered into and discover the patterns in the data, and which student groups needed special attention in the utilization of social media technology. Second, we wanted to envision the number of students who would participate in online mathematics discourses and in mathematics virtual classrooms. Thus, for each social media application, participants were asked to rate how they have used social media platforms in their mathematics learning at the university by responding to the listed items on a four point Likert Scale (1=Non-user: Never heard of it or never used it, 2=Infrequent User: use it sometimes, 3=Frequent User: use it regularly and 4= Contributor: frequently use this application to both read content and to contribute content) as shown on Table 15 below.

The rationale for combining both quantitative and qualitative type of data within one study is based on idea that non of the two methods is sufficient when used independently. Thus the quantitative research phase is intended to inform the author about the trends and details of the situation under study whereas the "qualitative phase" is intended to measure latent psychological variables like students' attitudes, feelings, emotions, beliefs and values which cannot be fully measured during the quantitative phase. When the two methods collaborate in one study, quantitative and qualitative techniques complement each other and enable for a more complete data analysis, taking advantage of the strengths and weaknesses of each into consideration. Therefore, similar to Fernandes’ (2016), elaborate approach in analyzing qualitative data, this thesis took similar steps during qualitative content data analysis process. The next paragraphs gives a brief but detailed account on the description of the analysis of qualitative data.

Content analysis was used to analyse qualitative data. This phase of the study allowed me to interpret and group the data together in order to make greater meaning of patterns and consistencies. This enabled me to identify the unit of analysis by breaking up the participants’ responses into chunks of data (i.e., words, phrases, sentences and paragraphs) to get a feel of my data. Since I was not using any qualitative data analysis software (QDAS), my initial analysis of the qualitative data (text) involved a rigorous process of multiple reading stages. That is, a simple reading through line by line analysis, followed by a second, third and fourth reading that involved connecting themes and establishing patterns. This was an iterative process.

After I had established familiarity with the data, I started making notes, coding consistent, listing all codes, constant comparison and similar phrases in the data that were shared amongst the thirty-three participants. These codes were then charted to allow for the visualization of themes and their degrees of similarity, connectedness or difference (Fernandes, 2016). At the core of qualitative research analysis, is “reducing the data into meaningful segments and assigning names for the segments, combining codes into broader categories or themes…and making comparisons in the data” (Creswell, 2013, p. 180). For this study, after reading through the response scripts several times, I then identified recurring themes in the respondents’ scripts. Creswell (2013, p. 186) describes these themes as “broad units of information that consist of several codes aggregated to form a common idea” which furthermore become a “family of themes with children, or subthemes, and even grand-children represented by segments of data”.

In the sense of Fernandes (2016, p. 54), she reflectively thought of the “data as a metaphoric family” which allowed her to “think about reducing the data into smaller groups of families in order to best examine the data”, while also reducing the data enough to write my discussion of this case study. I also found it useful to display these shared themes in a table, so as to compare similar or contrasting themes amongst respondents. Woolcott (1994), would posit that this helps in identifying patterns and irregularities in the data. Fernandes (2016, p. 54), would eloquently posit that "…keeping the metaphor of family in mind when breaking down the data, many new themes later emerged as the off-spring of the first set of identified themes" and these will be discussed in the results section.

3.10 ETHICS AND LIMITATIONS

According to the global norm and the University of Valladolid (UVa) standard, written approval had been granted, collected and safeguarded by the author(s). The doctoral school of the University of Valladolid (UVa) through the research ethics academic committee cleared this research-project. Therefore, the author(s) wish to confirm that this study is neither against the public interest nor the release of information permitted by enactment of the Spanish government or the King of Spain. In addition, other ethical considerations, like plagiarism, fraudulent, copy distribution, infringement of copyrights, authorship, conflict of interests and other serious issues regarding ethical integrity when submitting this doctoral dissertation to the university have been carefully considered.

Since the study involved pre-service teachers of mathematics from the Coppebelt University (CBU), signed consent was sought from the School of Postgraduate Studies Coordinator, the Head of Department (HOD) for Mathematics and Science Education and mathematics lecturers before conducting the research at the selected research site. Informed consent was obtained from all research participants. Participants of the study were informed that there were no known risk(s) linked with taking part in this study, and of their right to withdraw from the study at will and at anytime. Participants were also assured of anonymity, that is all their identifying details (e.g. real names, nicknames, mobile phone numbers and identifying images) were replaced with codes to preserve anonymity and no identifiable references would be made in the final doctoral dissertation or part of the published results of this research-project.

In order to address the anticipated threats to the validity of the results, this study used a quantitative-qualitative survey-questionnaire technique to collect data. This is because a survey questionnaire is a research instrument that records data over a huge sample and its goal is to make an interpretation of the research objectives into clear questions and answers. Therefore, for each question asked, participants were expected to provide the data for testing the research hypotheses and attending to all the research objectives of this doctoral dissertation. The upsides of a survey-questionnaire over other different instruments include: data can be gathered from huge samples, no room for predisposition (biasness) since it is administered in paper form and privacy is maintained.

This doctoral dissertation had several limitations. The major one being the unfunded PhD program of study. Doing a self-funded PhD research from a lower middle-income family is very stressful and uncertain. I found this time to be very humiliating. Having no stipend, it was difficult to make ends meet. In addition, I was also unable to have the experiences other PhD students had such as working with renowned scholars on important grant funded university research projects or just ending up being either a research assistant or teaching assistant. As a result of the mentioned reasons above, this doctoral dissertation was limited to only a few resources the author(s) had. Due to lack of external funding, the researcher(s) could not travel to attend as many conferences, workshops and seminars as possible as he would have wanted during the course of study without financial worries.

Parts of the results of this doctoral thesis have been published in international journals. However, in cases where the journal charges the article publication fee, the author(s) had to bear the publication costs on limited resources available. In some instances, fees would prevent the publication of worthy research work. Therefore, I was under pressure both financially and academically more than the other funded UVa graduate students. Other limitations included: some conferences being held in Spanish since Spain is a Spanish speaking country. That limited my understanding because Spanish is not my native language.

Chapter 4: Results and Discussions

Firstly, parts of the results of this chapter have already been published in three different peer-reviewed journal articles (Mulenga & Marbán, 2020a; 2020b; 2020c). In addition, this chapter begins with a discussion of preliminary results from 288 participants from Wusakile Secondary School (section 4.1). That being the case, in the preliminaries of the doctoral studies journey, the author(s) sought to explore on –one hand– the use of social media among secondary school students in the the particular context of a standard ordinary level "mathematics subject" and on the –other hand– the impacts of social media on the teaching and learning of mathematics in Zambian secondary school settings. This is because since time immemorial, a social networking site for new and old students starting their school has never been developed in most secondary schools in Zambia especially in the Departments of Mathematics and computer science laboratories. The first idea was to offer a free-of-charge social website in the context of learning basic ordinary Mathematics at my place of work. This was thought to be an efficient tool to facilitate the beginning of studies in which mathematics topics are arranged in a significant role. However, the prediction failed which caused the author(s) to study secondary school students motivations for social networking site usage in the mathematics teaching-learning context. The broad focus was on finding out students' attitudes to e-learning communities and social networking sites especially Facebook.

Although, all the four research objectives that are attended to at the secondary school are clearly stated on section 1.5.1, to re-iterate them briefly, the target of the preliminary investigation was to explore aspects of students' related social software packages that would motivate them to participate in mathematics learning activities (see objective 2). The reason why this preliminary research was needed is because we wanted to understand how technological applications, digital tools and social media technologies were influencing the lives of secondary school going pupils and their teachers (see objectives 1 and 3) before extending the investigations to higher education. The findings of the preliminary investigation informed us to explore the use and the impact of social media on Mathematics Education in Zambia among university students. Being very keen about the second phase, the author(s) examined students' social media usage during and after mathematics instructions at university level based on three factors, which are: personal, professional and academic life (see the objectives of the study at CBU on section 1.5.2).

Next, this chapter reports all the results and discusses all the research findings of the study for the data collected from 102 participants at the Copperbelt University (CBU) in Zambia (section 4.2). This chapter is therefore, divided into eight (8) sub-sections covering the structural description between quantitative and qualitative findings. In the first stage, It begins with the reporting and discussion of quantitative results first (see section 4.3) with their subsequent analysis techniques – ANOVA, Multiple regression and Cluster analysis – followed by the second stage of the findings drawn from a qualitative sample as analysed through content analysis technique (see section 4.7).

The presented results in this chapter sought to address two research core questions on section 2.6.3 and three research leading sub-questions on section 2.6.4 as stated in Chapter 2. Throughout this chapter, Activity Theory (AT) and Davis' (1989) modified Technology Acceptance Model (TAM) are the lenses used to guide the data analysis and data interpretation to investigate the factors that influence undergraduates' interests in online interactions through Web 2.0 innovations.

4.1 Preliminary results from Wusakile Secondary School Participants

The presence of social media platforms in secondary students' daily life is growing on daily basis but it may appear difficult to know which ones are right for academia particularly among secondary school pupils who are commonly substantial Internet users. In spite of an increasing number of relevant literature on the utilization of web-based social networking sites around the world, there is lack of studies in Zambia on how social media use- especially Facebook use- in the learning of mathematics affects the social life of secondary school pupils.

Thus, regardless of the developing collection of research writings recommending an enduring rise in the number of studies done on the usage of social networks among university undergraduates, there is a lack of research in Zambia on how secondary school pupils use social media platforms, particularly Facebook in the learning of mathematics. It is on these premises that the reason for this research was included in this doctoral thesis. As alluded to earlier on in chapter 1 of this doctoral thesis, the primary objective of the study at Wusakile secondary school is to quantitatively assess the frequency at which the students are social-networking.

Therefore, the first specific objective of this study was to examine the Zambian secondary school pupils' profiles of social media use in mathematics and, especially, the use of Facebook in the learning of mathematics at Wusakile secondary school. The second specific objective of the study at the secondary school was to explore aspects of a secondary school students' related web community that would motivate students to participate in its activity. The third objective tasked the author(s) to examine the role that social media play -especially Facebook- in secondary school settings and on Internet public activities. The particular points of the investigation were to examine the profiles of secondary school pupils' social media usage, to investigate how secondary school pupils used Facebook for academic purposes and to find out the purposes for which secondary school pupils used Facebook.

Finally, the fourth and final specific objective of this study employed the author(s) to finding out how the use of social media platforms, particularly Facebook could help develop the 21st century skills of pupils and secondary school teachers in the teaching and learning of mathematics and by extension explore the impact of Facebook on Mathematics Education in Zambia and the student-teacher Facebook interaction during and after mathematics instructions.

Hence, this research-project was concerned with verifying the hypotheses whether there is a significant difference in Zambian mathematics pupils' Facebook use based on gender and grade level, if there is a significant difference in Zambian mathematics pupils' scores on the social media sub-factors based on gender and grade level, and finally to address the particular question about what is the social network use of Wusakile secondary school pupils.

4.1.1 Instrument

This preliminary study employed the survey model. Essential data sources were collected quantitatively through the use of a questionnaire adapted from Kaya and Bicen (2016). The questionnaire consisted of 51 items. Respondents evaluated their degree of agreement with each item on a 5-point Likert scale (1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree). This study dissects and analyses the process of 51 items. The consequences of this investigation demonstrated that the reactions to the survey utilized had a reliability coefficient (α =0.77) that was sufficiently high for our purposes. All the alpha values which were computed in SPSS for our current study showed also acceptable levels of Cronbach's alpha suggesting a proper reliability of our adjusted scale.

4.1.2 Participants

Convenience sampling technique was utilized in this preliminary study. A questionnaire was administered to 288 pupils who were in Grade 11 and 12 classes respectively from Wusakile secondary school in Kitwe (Zambia), ranging from 14 to 28 years old (mean age = 17.8 and *SD* = 1.8). A total of 127 (44.1%) participants and 161 (55.9%) were in Grade 11 and Grade 12 respectively. Of the 288 participants, 51.7% were females, followed by 48.3% males, 238 participants (82.6%) had Smartphones while the rest had no phones at all, 71.5% had Internet package on their gadgets while the remaining 28.5% did not have. Regarding Facebook use between the Grades, 12 participants from Grade 11 classes and 25 participants from Grade 12 classes declared that they had no Facebook accounts and were excluded from analyses while 115 Grade 11s and 136 Grade 12s owned a Facebook account. Thus, 123 participants were female Facebook users while 128 were male Facebook users. 104 owned Facebook messenger accounts while 184 did not. Concerning the use of other social media platforms, 65 participants owned a YouTube account, followed by 129 WhatsApp, 32 Instagram, 5 Viber, 56 Twitter, 10 Snapchat, 125 Google+, 1 Askfm, 1 Tango, 34 Gmail, 26 Yahoo mail and 4 owned a LinkedIn account respectively. Signed permission was obtained from the School Head teacher. All the data coming from the self-report questionnaires was gathered during a typical working school day in study halls with the assistance of the Deputy Head instructor. All the 288 participants were studying ordinary mathematics as a compulsory subject.

This section discusses the results obtained from the survey by analyzing all the responses of all the participants (n =288) from Wusakile secondary school. In order to observe the effects of social media (Facebook) on students' mathematics activities, only quantitative techniques were employed to explore data, descriptive statistics, t-test and one-way ANOVA was used to analyze data by using IBM SPSS version 24.0. Preliminary results are presented, discussed and interpreted in the next section.

4.1.3 Analysis of results from Wusakile Secondary school

In this segment, we examine the results acquired from the survey by breaking down the reactions of all the 288 respondents. Descriptive statistics and results of the ANOVA Tables are presented and interpreted. The section contains 6 tables of reported statistical data starting from table 4 to table 9.

Below is a frequency Table showing the types of operating systems used by secondary school pupils at the named school.

Table 4: Type of Operating System used

Operating System	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Android	130	45.1	45.1	45.1
iOP	11	3.8	3.8	49.0
Windows	39	13.5	13.5	62.5
None	108	37.5	37.5	100.0
Total	288	100.0	100.0	

Source: Field data (2017).

From Table 4, we see that 130 participants use Android Operating System, 39 use Windows, 11 use iPhone OP and 108 pupils neither use Android, iOP nor Windows operating system. This clearly suggests that 37.5% never owned any Smartphones. Previous studies have revealed that there is a relationship between the types of electronic devices used by students to access social media. Thus, this study has disclosed that the major tool used by the pupils to access social media, in particular facebook is a Smartphone (as 62.5% agree). It is therefore, argued that learners at secondary school are not tool exposed to digital devices and this limits them to the most affordable and accessible too, a phone. Although, previous studies (e.g. see Singh & Gill, 2015; Stanciu et al., 2012), revealed that the major tools that students used to access social media were reported to be laptops followed by desktops and mobile phones.

The Table below displays the results of commonly used social media applications among secondary school pupils in their every day life.

Table 5: Types of social media popularly utilized by pupils

Social media	Number (N)	Percentage (%)
Facebook	251	87.2
WhatsApp	129	44.8
Google+	125	43.4
Facebook Messenger	104	36.1
YouTube	65.0	22.6
Twitter	56.0	19.4
Gmail	34.0	11.8
Instagram	32.0	11.1
Yahoo mail	26.0	9.00
SnapChat	10.0	3.50
Viber	5.00	1.70
LinkedIn	4.00	1.40
ask.fm	1.00	0.30
Tango	1.00	0.30

Source: Field data (2017).

The first primary point of this preliminary investigation was to look at the popular profiles of pupils' social media utilization. From Table 5, it is evident that 100% of participants use social networking sites. The most popular social networks used by the pupils was Facebook (87.2%), followed by WhatsApp (44.8%), Google+ (43.4%), Facebook messenger (36.1%), YouTube (22.6%), Twitter (19.4%), Gmail (11.8%), Instagram (11.1%), Yahoo mail (9.0%) and Snapchat (3.5%). Other social media sub-factors used include Viber (1.7%), LinkedIn (1.4%), Ask.fm (0.3%) and Tango (0.3%). It is contended that high score of Facebook use (251) could be because of the ease of use of the Facebook application. Contrary to our obtained results, Chukwuere and Bonga (2018) found that majority of the respondents used WhatsApp more than any other social networking sites. Precisely, 56.8% of the participants used WhatsApp and only 17.7% used Facebook. Researchers have likewise noticed that since its creation in 2004, Facebook now has in excess of 600 million clients (Facebook, 2012; Pingdom, 2012).

According to Ferrucci and Tandoc (2015), studies have likewise called attention to numerous utilizations and pacifications that inspire individuals to utilizing Facebook, and these endeavours have given rise to a wide range of various motivations. For examples, based on the features of the Facebook application, authors of this paper contend that school pupils may interface with friends, loved ones, family and meet new individuals, set status updates, share photos, videos and their favourite memories. Facebook also helps them to follow the latest news and current events around the world. Additionally, pupils may also wish to subscribe to their favourite pages, such as academic groups, watch live streaming videos of interest, writing on timelines, browsing for people and play games and so on. WhatsApp, Facebook messenger, YouTube, Google+, Twitter and Gmail were also among the most popular used social media networks.

Our results appear to vanquish with the results of Chukwuere and Bonga (2018), that several undergraduate students used social media platforms too much. But low use of LinkedIn (4) is not shocking as school pupils may not be very familiar with this social media platform since it’s a business and professional driven service centred on building one’s professional network. Tango and Askfm are also not common social media platforms used by secondary school pupils. However, the use of these social networks suggests that once pupils become very familiar with all of them, they can be used for further studies in future. It is advised that mathematics teachers should have social interactions with their pupils through schools’ social media platforms. These platforms would encourage both pupils and teachers the habit of having mathematics intellectual discourses on and off the classroom.

Table 6 below displays a set of confidence intervals for the difference between pairs of means based on grade level and gender. The Table uses the confidence intervals to estimate the likely ranges for the differences and to determine whether the differences are practically significant. The results are discussed analysed in the subsequent paragraph.

Table 6: Pupils' Facebook use based on 'grade level' and 'gender'

		N	Mean	Std. D	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
Grade	Grade 11	37	1.68	.475	.078	1.52	1.83
	Grade 12	251	1.44	.499	.032	1.48	1.60
	Total	288	1.56	.497	.029	1.50	1.62
Gender	Male	37	1.57	.502	.083	1.40	1.74
	Female	251	1.56	.501	.032	1.45	1.57
	Total	288	1.52	.501	.029	1.46	1.58

Source: Field data (2017).

In order to fully understand the pupils' use of Facebook, the analysis of variance was conducted to estimate the statistical differences between group means concerning grade level and gender.

Table 7: Pupils' use of Facebook based on grade level and gender

		Sum of Squares	df	Mean Square	F	Sig.
Grade	Between Groups	.578	1	.578	2.346	.000
	Within Groups	70.419	286	.246		
	Total	70.997	287			
Gender	Between Groups	.107	1	.107	.426	.514
	Within Groups	71.806	286	.251		
	Total	71.913	287			

Table 7 shows that at the significance level of 0.05%, there is a statistically significant mean difference [since $p = 0.0001 < 0.05$] based on grade level in the Zambian mathematics secondary school pupils' use of Facebook for Grade 11s and 12s. To determine the actual mean differences in terms of garde level, results [see Table 6 as Grade 11, Mean = 1.68 while Grade 12 Mean = 1.44] indicate that Grade 11 pupils have higher mean values for Facebook use than Grade 12 pupils. Confirming that grade level has an impact on pupils' use of Facebook. Hence, the differences in the use of Facebook could be attributed by grade level. On gender, according to Table 7, the F of .426 shows that there is a non statistically significant difference since $p = 0.514 > 0.05$, this implies that there are no significant mean differences based on gender in the mean scores of pupils across the grades. This result is confirmed by Table 6 as Male Mean = 1.57 while Female Mean = 1.56. These results suggest that gender does not have an effect on Zambian mathematics pupils' use of Facebook. However, this is contrary to the findings of Hamade (2013), Ruleman (2012) and Stainbank and Gurr (2016).

The Table below shows the results of the mean scores of pupils' social media use sub-factors based on grade level.

Table 8: Mean scores of pupils' social media use sub-factors based on grade level.

Social media Sub-factors	**Grade level**	**N**	**Mean**	**Std.D**	**Std. Error**
Facebook	Grade 11	127	.91	.294	.026
	Grade 12	161	.84	.363	.029
FB Messenger	Grade 11	127	.38	.487	.043
	Grade 12	161	.35	.478	.038
YouTube	Grade 11	127	.24	.426	.038
	Grade 12	161	.22	.414	.033
WhatsApp	Grade 11	127	.44	.498	.044
	Grade 12	161	.45	.499	.039
Instagram	Grade 11	127	.09	.294	.026
	Grade 12	161	.12	.331	.026

Viber	Grade 11	127	.02	.152	.014
	Grade 12	161	.01	.111	.009
Twitter	Grade 11	127	.23	.421	.037
	Grade 12	161	.17	.375	.030
Snapchat	Grade 11	127	.03	.175	.016
	Grade 12	161	.04	.190	.015
Google+	Grade 11	127	.49	.502	.045
	Grade 12	161	.39	.490	.039
Askfm	Grade 11	127	.00	.000	.000
	Grade 12	161	.01	.079	.006
Tango	Grade 11	127	.00	.000	.000
	Grade 12	161	.01	.079	.006
Gmail	Grade 11	127	.09	.294	.026
	Grade 12	161	.14	.345	.027
Yahoo mail	Grade 11	127	.12	.324	.029
	Grade 12	161	.07	.253	.020
LinkedIn	Grade 11	127	.02	.152	.014
	Grade 12	161	.01	.079	.006

Source: Field data (2017).

When Table 8 is analysed, we see the pupils' mean scores taken from the sub-factors of social media use differ significantly based on grade level with respect to Facebook [Grade 11s, $\mu = 0.91$ and Grade 12s, $\mu = 0.84$], Instagram [Grade 11s, $\mu = 0.09$ and Grade 12s, $\mu = 0.12$], Twitter [Grade 11s, $\mu = 0.23$ & Grade 12s, $\mu = 0.17$], Google+ [Grade 11s, $\mu = 0.49$ & Grade 12s, $\mu = 0.39$], Gmail [Grade 11s, $\mu = 0.09$ & Grade 12s, $\mu = 0.14$] and Yahoo mail [Grade 11s, $\mu = 0.12$ & Grade 12s, $\mu = 0.07$]. These results suggest that Grade 11 pupils' mean scores for Facebook, Twitter, Google+ and Yahoo mail are more positive than Grade 12 pupils' scores and vice versa for Instagram and Gmail. The results likewise show no significant differences in the pupils' social media scores taken from YouTube, WhatsApp, Viber, Snapchat, Askfm, Tango and LinkedIn sub-factors in relation to grade level.

Table 9 reports findings of the mean scores of pupils' social media usage according to gender.

Table 9: Mean scores of pupils' social media use sub-factors based on gender

Social media Sub-factors	**Gender**	**N**	**Mean**	**Std.D**	**Std.Error**
Facebook	Male	139	.88	.320	.027
	Female	149	.86	.349	.029
FB	Male	139	.40	.492	.042
Messenger	Female	149	.32	.469	.038
YouTube	Male	139	.27	.447	.038
	Female	149	.18	.386	.032
WhatsApp	Male	139	.49	.502	.043
	Female	149	.41	.493	.040
Instagram	Male	139	.12	.320	.027
	Female	149	.11	.311	.025
Viber	Male	139	.02	.146	.012
	Female	149	.01	.115	.009
Twitter	Male	139	.23	.422	.036
	Female	149	.16	.369	.030
Snapchat	Male	139	.05	.219	.019
	Female	149	.02	.141	.012
Google+	Male	139	.43	.497	.042
	Female	149	.44	.498	.041
Askfm	Male	139	.00	.000	.000
	Female	149	.01	.082	.007
Tango	Male	139	.00	.000	.000
	Female	149	.01	.082	.007
Gmail	Male	139	.20	.403	.034
	Female	149	.04	.197	.016
Yahoo	Male	139	.11	.311	.026
mail	Female	149	.07	.262	.021

LinkedIn	Male	139	.02	.146	.012
	Female	149	.01	.082	.007

Source: Field data (2017).

Table 9, shows significant difference in the mean scores of pupils' social media sub-factors based on gender in relation to FB-messenger, YouTube, Twitter, Gmail and Yahoo mail. These findings suggest that male pupils' mean scores of FB-messenger [$\mu = 0.88$], YouTube [$\mu = 0.27$], Twitter [$\mu = 0.23$], Gmail [$\mu = 0.20$] and Yahoo mail [$\mu = 0.11$] are more positive than the female pupils' mean scores of FB-messenger [$\mu = 0.86$], YouTube [$\mu = 0.18$], Twitter [$\mu = 0.16$], Gmail [$\mu = 0.04$] and Yahoo mail [$\mu = 0.07$] respectively. This indicates that the mean scores recorded are more positive among the named social media sub-factors based on gender. Again, results have likewise uncovered that there is no significant difference between male and female school pupils' social media sub-factors of Facebook, WhatsApp, Instagram, Viber, Snapchat, Google+, Askfm, Tango and LinkedIn.

4.1.4 Reasons for which secondary school pupils used Facebook

As regards pupils' activities when logged on Facebook, the second and third aims of our thesis were to find out the purposes for which pupils used Facebook generally and further explore how they used Facebook for academic purposes. Therefore, results show the synthesis of the 51 items below.

Table 10: Pupils' reasons for using Facebook

No.	When using Facebook…..	Mean (μ)	STD
1.	I communicate by Facebook	3.60	1.40
2.	I share pictures on Facebook	3.43	1.44
3.	I use Facebook in order to meet with new people	3.37	1.50
4.	Nice picture comments increase my confidence.	3.32	1.47

5.	I belong to an academic group on Facebook.	3.30	1.54
6.	I check Facebook and I like or comment on posts related to Mathematics.	3.28	1.46
7.	I follow Mathematics pages on Facebook.	3.26	1.42
8.	I follow news on Facebook.	3.25	1.44
9.	My profile picture is up to date.	3.23	1.43
10.	I share news on Facebook.	3.21	1.49
11.	My profile picture is alone.	3.18	1.54
12.	I share mathematics problems with friends on Facebook.	3.17	1.45
13.	I follow specific friends on Facebook.	3.13	1.47
14.	I generate new ideas by Facebook.	3.12	1.49
15	My details are up to date.	2.85	1.40
16.	I use Facebook in order to check mutual friends.	2.79	1.47
17.	My Facebook use increases my confidence.	2.79	1.43
18.	I change my profile picture regularly.	2.74	1.39
19.	I use Facebook just for fun.	2.70	1.44
20.	I check my previous partners' Facebook profile.	2.66	2.19
21.	Negative picture comments depress me.	2.61	1.54
22.	I accept friend request according to the gender.	2.61	1.52
23.	My other social network accounts are connected with Facebook.	2.60	1.42
24.	I use Facebook in order to find out popular places.	2.55	1.43
25.	I change my privacy according to closeness.	2.54	1.33

26. I check in places regularly on Facebook.	2.52	1.37
27. I start up new debates by Facebook.	2.52	1.38
28. I become upset if I do not receive any likes or comments on my status/pictures\ or content that I had share.	2.50	1.54
29. I feel isolated when I cannot login to Facebook.	2.44	1.43
30. I follow specific brands/products on Facebook.	2.41	1.29
31. Content I share changes according to my mood	2.38	1.39
32. I change my profile picture in order to get attention.	2.34	1.34
33. I share songs on Facebook.	2.31	1.43
34. My profile picture is a famous person.	2.28	1.45
35. I follow famous people on Facebook.	2.26	1.37
36. I share trailers on Facebook.	2.25	1.28
37. I use Facebook in order to get attention.	2.22	1.36
38. I accept every friend request.	2.22	1.34
39. I play games on Facebook.	2.22	1.38
40. My privacy settings are public in order to get more likes.	2.18	1.40
41. I update my relationship status instantly in order to get attention.	2.05	1.24
42. I can buy followers on Twitter.	2.01	1.18
43. I can buy Likes on Facebook.	2.01	1.16
44. I fool/deceive people on Facebook.	2.00	1.27
45. I can buy Retweets on Twitter.	1.99	1.13
46. I share videos on Facebook.	1.93	1.13
47. I share my own videos on Facebook.	1.90	2.16
48. I use my friends' Facebook account.	1.89	1.23

49.	I share my Facebook password with my friends.	1.80	1.22
50.	I use Facebook for Politics.	1.72	1.04
51.	I use Facebook in order to gossip.	1.67	1.06

Source: Field data (2017).

The data from Table 10 based on 251 Facebook users, disclosed that pupils who communicate by Facebook ($\mu = 3.60$), share pictures on Facebook ($\mu = 3.43$), use Facebook to meet with new people ($\mu = 3.37$), belong to an academic group on Facebook ($\mu = 3.30$), check Facebook and like or comment on posts related to Mathematics ($\mu = 3.28$), follow Mathematics pages, news and specific friends on Facebook [all $\mu \geq 3$], share mathematics problems with friends on Facebook ($\mu = 3.17$), generate new ideas ($\mu = 3.12$) and share news on Facebook ($\mu = 3.21$) received higher mean scores, from the midpoint (3) in a scale of one to five. As this study further disclosed, a considerable number of pupils gave least mean scores (below the midpoint of 3) for pupils who indicated that: they use Facebook in order to check mutual friends, to increase their confidence and to confirm if their details are up to date received the mean (μ) scores of 2.79, 2.79 and 2.85 respectively, from the midpoint (3) in a scale of one to five.

Steady with Euna, Hae-Deok and Ah (2018), whose study investigated how Facebook use influences student commitment in the classroom hall. Results from their examination disclosed that students with progressively dynamic Facebook use accomplished fundamentally higher scores on student commitment than those with less dynamic Facebook use. Concerning students' mathematics academic performance, research conducted by Lau (2017), revealved that academic performance was unfavourably influenced when social networking sites were utilized to satisfy social and non-scholastic needs only. He further proposed that in order to boost the involvement of the undergraduate students, their fulfilment and performance in a mathematics course, staff must adopt Facebook as an instructional device by creating a Facebook group exclusively for deliberating mathematical content courses outside the classroom walls.

Based on the obtained results, it can be deduced that pupils who follow, comment or like posts related to mathematics have an undeniable opportunity to express their views on any related mathematics topic they failed to express in class due to shyness. By subscribing to mathematics pages, they see posts related to mathematics on news feed and express their opinions on their timelines so that their specific friends and mathematicians they follow could see and criticise. Our findings seem to agree with Malissa, Chandra and Ismail (2018), whose results disclosed that students depend via web-based networking media since they can be depicted diversely and be less bashful.

However, in the absence of Internet bundles or reliable Internet connections, pupils feel isolated when they can't login to Facebook ($\mu = 2.44$). Furthermore, pupils fire up new discussions by utilizing Facebook ($\mu = 2.52$). In any case, they become disturbed on the off chance that they don't get any likes or comments on their Facebook updates, posts they share or pictures they upload ($\mu = 2.50$). A perceptible strategy to decide reactions to one's posts is the number of "likes" or "comments" they get. Likes and comments have become some sort of a cash on Facebook that could mean ubiquity, endorsement, or even sportlight (Ferrucci & Tandoc, 2015). This is discouraging as pupils are too expectant to learn from their Facebook peers, family and friends. Unfortunately, this same expectation of how others might react also demoralises school pupils from posting anything.

The author(s) of this doctoral thesis argue that pupils view acknowledgement as something important. If they update a status on Facebook and get likes or comments from it, it's obviously a good thing because they know that people care about what they are posting. Results show that there are some pupils who feel depressed if they receive negative picture comments ($\mu = 2.61$) and due to this, the content they share changes according to their mood swings ($\mu = 2.38$). This study found out that even if pupils had mathematics content to share on Facebook, a lot become very de-motivated as Facebook users would pay less or no attention at all to issues related to mathematics while online.

Consistent with the discoveries of Ferrucci and Tandoc (2015), who highlighted that Facebook posts that are not funny get derided, subsequently, even friends and loved ones once in a while chuckle at posts that are excessively long and passionate. As such, pupils would rather use Facebook just for fun ($\mu = 2.70$) instead of academics. Due to the negative attitudes of Facebook users concerning use of Facebook for mathematics purposes, pupils have also linked their other 'social media' accounts with Facebook ($\mu = 2.60$) so as to easily navigate between them and interact with their specific friends on common mathematics problems affecting them. At least two pupils on average follow famous people on Facebook ($\mu = 2.26$). It is possible that pupils could be following some renowned mathematicians on Facebook, some famous mathematics teachers in their district and extraordinary mathematics pupils on Facebook.

Among many other uses of Facebook recorded, our findings suggest that pupils rarely share trailers on Facebook ($\mu = 2.25$), use Facebook to get attention ($\mu = 2.22$), accept every friend request ($\mu = 2.22$), play games on Facebook ($\mu = 2.22$), update their relationship status immediately in order to get attention ($\mu = 2.05$), purchase likes on Facebook ($\mu = 2.01$) and trick/beguile individuals on Facebook ($\mu = 2.00$). Unfortunately, our field findings also recoded lower scores in the use of Facebook from item 45 to item 51 (see Table 10).

4.1.5 Discussions and Conclusions arising from the Secondary School results

In this section, results of this preliminary investigation are discussed in line with the research exploration points and research questions. The discussion below is a combination of statistical analyses results obtained and literature that supports or contradicts our results. The research results presented on Table 7 show that there is a statistically significant mean difference based on grade level in the Zambian mathematics pupils' use of Facebook. Grade 11 pupils with (M = 1.68, Std.D= 0.475 and Std error = 0.078) have higher mean values for Facebook use than Grade 12 pupils with (M = 1.44, St.D=0.499 and Std error = 0.032).

Based on the mean scores, Grade 11 pupils had more positive mean scores. Thus, It could be argued that Grade 11 pupils were very active Facebook users as they frequently followed mathematics pages and groups on Facebook so as to consult from their peers on any maths related problems. It is also likely that they create Facebook conversation groups for discussing mathematics related homework, assignments and projects. With this approach, pupils are able to communicate mathematics with fellow pupils and their teachers and eventually use Facebook as a learning platform. This is consistent with Lau (2017), who posited that students have strongly embraced Facebook to support instructional method both inside and outside the classroom.

According to Table 5, the study also found that majority of the participants (87.2%) use Facebook more than any other application. Consitent with Fasae and Adegbilero-Iwari (2016), whose study also found that the majority of the participants (93.5%) use

Facebook. Consistent with Singh and Gill (2015) who disclosed that Facebook was the most popular social media among students (84.7%). This, in any case, is in contrary to the discoveries of Chukwuere and Bonga (2018), who proposed that Facebook is the second social media platform that students use the most. In terms of WhatsApp use, the results obtained agree with Chukwuere and Chukwuere (2017), who also contend that WhatsApp is the second application or social media platform mostly used by students.

Thus, it will suffice to comment that high WhatsApp use (44.8%) is not surprising as WhatsApp messenger is a free messaging application for Android and other Smartphones. Therefore, school pupils could use WhatsApp for making free online calls both local and international to discuss maths related problems at length (Anna, 2019). In addtion, according to Anna (2019), and García-Domingo, Fuentes and Aranda (2018), posited that besides making calls, pupils may wish to send and receive photos related to mathematics, share maths videos, mathematics documents, voice messages and eventually create a WhatsApp group so that they can easily stay in touch with their classmates.

Secondly, there was no statistically significant difference based on gender in the mean scores of secondary school pupils. Nonetheless, extant literature informs us that females are more plausible than males to utilizing social media platforms (Hargittai, 2007; McAndrew & Leong, 2012), however, when males do utilize Facebook, they as often as possible uncover more personal information as opposed to females (Special & LiBarber, 2012).

When social media sub-factors are analysed, results of the mean scores of pupils' social media use sub-factors based on grade level differed significantly in terms of the mean scores in relation to Facebook, Twitter, Google+ and Yahoo mail (see Table 8). Again, these results suggest that Grade 11 pupils' mean scores for Facebook, Twitter, Google+ and Yahoo mail are more positive than Grade 12 pupils' scores and vice versa for Instagram and Gmail. These results indicate a significant positive correlation between grade level and the mentioned social media sub-factors whereas the results also show no significant differences in the secondary school pupils' social media scores taken from YouTube, WhatsApp, Viber, Snapchat, Askfm, Tango and LinkedIn sub-factors in relation to grade level.

Arguably, on one hand, social media platforms have created negative effects on our general public and Zambian cultural values. Unfortunately, Peluchette and Karl (2010) pointed out that a number of students share unbefitting and contemptible (revolting) materials on Facebook in order to get the attention of their friends.

Facebook and other social media platforms are popularly used among secondary school pupils but there is a high probability that these social media platforms can be utilized for communication and mathematics learning provided they are monitored and regulated by the school management. To support this claim, a study by Hilary (2017) in a revised social media policy at St John's College, it is documented that the social media policy is intended to alleviate the dangers related to the utilization of social media by students, academic and non-academic members of the college's staff. Furthermore, the college will maintain guidelines outlining the standards it expects students, academic and non-academic staff to observe when utilizing social media or taking part in any type of online communication, while directly or in an indirect way associated with the college.

Therefore, it was argued that non-academic Internet use, including the use of web 2.0 tools, among secondary school pupils was negatively linked with classroom performance. Social media platforms have brought about a new age for information trading and free articulation of opinion. The connection between social media and social change is noteworthy in the sense that social media has not only brought about extraordinary changes in the field of popular opinion yet in addition play a fundamental role to cultivate social change (Tiance, Chenxi, & Xu, 2017).

Results from to Table 9 revealed that pupils' social media use sub-factors between males and females in relation to FB-messenger, YouTube, Twitter, Gmail and Yahoo mail received higher mean scores of 0.88, 0.27, 0.23, 0.20 and 0.11 respectively. As this preliminary study further revealed, a considerable number of participants gave least mean scores between males and females for some other social software tools, such as Facebook, WhatsApp, Instagram, Viber, Snapchat, Google+, Askfm, Tango and LinkedIn.

The author(s) of this doctoral thesis wanted to find out if pupils' use of Facebook could predict their online mathematics learning involvement. Participants were further asked to rate how they used Facebook based on their social lives by indicating their degree of agreement with each of the fifty-one (51) items on a Likert scale.

Based on Table 10, quantitative analysis results revealed that pupils at Wusakile secondary school who use Facebook for communication received a higher mean score of

3.60 from the midpoint (3) in a scale of one to five. Facebook is the most used application (μ =3.60) consistent with the report from Facebook (2017). This is also consistent with Newham (2012), who argued that many people spend a lot of time communicating on Facebook. Newham (2012), eventually reasoned that for most individuals, Facebook has supplanted face-to-face communication.

Participants were further asked to rate how they used Facebook for academic purposes. Results show there are some pupils who “belong to an academic group on Facebook”, “share mathematics problems with friends on Facebook” and also “generate new ideas on Facebook”. Thus, it is probable that in the absence of mathematics classroom instructions, pupils are also having mathematics discussions outside the classroom, particularly on Facebook. Our research results agree with the findings of Mahmud, Ramachandiran and Ismail (2018), who posited that outside-the-study hall or after school programs are the place Facebook or any other social media platforms are needed to act as a median for lecturers to advise or teach their students.

Taken together, all these findings seem to give a clear picture of other Facebook uses outside-the-classroom where teachers can act as peers or ultimate consultants on Facebook whenever pupils need immediate clarifications on mathematics problems wherever they may be.

Participants were also using Facebook for non-academic reasons such as; for checking in places regularly, finding popular places, checking their previous partners’ Facebook profiles, following specific brands, sharing songs, trailers, news and videos. Surprisingly, others were using Facebook just to get the attention from people, playing games, gossiping, and to deceive people. This is similarly in concurrence with an exploration directed by Hamat, Embi and Hassan (2012), who posited that Facebook is not mostly utilized for formal educating purposes. Thusly, Facebook has made negative impacts on our general public and social customs. In some cases, it even tends to thrive on fantasies by promoting beauty that does not exist.

These results suggest that Facebook use can constitute, to a larger extent a learning environment for mathematics were intellectual discourses can be discussed with different people. In the light of the above discussion, our research aims have been met and all our research questions have been addressed. This study has revealed the impact of social media on pupils’ mathematics engagement with Facebook as the contextual study. It has been shown that there is no statistically significant mean difference in pupils’ use of

Facebook based on gender but grade level does have. The difference could be partly because pupils are motivated differently with regards to using Facebook. Regarding social media sub-factors, the results also show no significant differences in pupils' social media scores taken from YouTube, WhatsApp, Viber, Snapchat, Askfm, Tango and LinkedIn sub-factors in relation to grade level.

In a nutshell, the extant literature on Facebook has highlighted the facets that propel the general use of Facebook and provide an important addition to the existing knowledge. This explains why many researchers have now noted that Facebook is the most interesting topic of research in academia. Its use cuts across age, gender, communication and news sharing as opposed to traditional media. Facebook's popularity goes beyond geographical boundaries, traditions, cultures and decades (e.g. Glynn, Huge, & Hoffman, 2012; Lee & Ma, 2012). Several previous studies have tried to investigate what really motivates users to go on Facebook (e.g. Baek et al., 2011; Peluchette & Karl, 2010; Quan-Haase & Young, 2010; Raacke & Bonds-Raacke, 2008; Ross et al., 2009; Smock, Ellison, Lampe, & Wohn, 2011).

The present results are preliminary findings of the larger ongoing project since we only focused on the use of Facebook among secondary school pupils but we recommend that a similar study should be carried out with university students and as such; some limitations must be highlighted. First, our results are limited to this sample and as such we acknowledge our limitation in making any generalisations from these results. The use of data from a self-report scale could be influenced by reaction predisposition and answer precision. This study is limited to the quantitative research design used. Quantitative methods are not enough to explore and describe the depth and breadth of the observations concerning Facebook use by secondary school pupils. Without these constraints, after-effects of this investigation have suitable potential ramifications for incorporating social media sub-factors especially Facebook into the teaching and learning of secondary school mathematics.

In light of the reported results, a recommendation was made to explore the use of social media tools among university students in Mathematics Education. As there were some indications of Facebook use for personal and academic purposes, the impact of this on pupils' mathematics learning activities motivated the author(s) to consider the use of social media technologies among university students of Mathematics Education for further research.

4.1.6 Contribution of the Study to the Body of Knowledge

This preliminary study contributes to the body of knowledge both in theory and practice. In an attempt to unearth more valuable and deeper conclusions, the methodology adopted in this study involved administering a questionnaire across a wider range of secondary school students in two successive grades, so as to build the generalizability of the results. As disengagement from Facebook leads to poor academic performance among secondary school students, this study is of academic interest as it has further disclosed factors such as contact with mathematics teachers and fellow students outside the classroom walls that lead to an increase in mathematics teaching-learning process. This is similarly true for testing of a possible relationship between the daily lives of secondary school students and social media engagement. Thus, this study proposes that in the absence of mathematics classroom instructions, some secondary school students are also having mathematics interactions outside the classroom by means of social media, particularly on Facebook, although this academic use is still far from being relevant. This preliminary study really helped the author of this doctoral thesis to spell out [identify] the naunces that cannot be captured adequately with a single method (quantitative approach) used in this study. Thus, the major contribution of this study to the rest of the thesis was to lay a foundation for the development of the mixed-methods sequential explanatory design proposed. It is expected that this proposed design will adequately and qualitatively explain the results, models and grand theories used- while also acknowledging that words alone cannot fully paint the whole picture either.

In the context of seeking to bring out supplemental elements that expand the frequency of students' Facebook participation on one hand, and other social media engagement on another hand, recent studies ignored to investigate what according to pupils' perception can be done to decrease the barriers to Facebook use in mathematics activities as well as other social media engagement. For instance, one barrier cited by the pupils in this study is the absence of Internet bundles or reliable Internet connections which makes pupils feel isolated when they can't login to Facebook ($\mu = 2.44$). It is therefore, recommended in this study that this research gap must be addressed in this doctoral thesis later on by administering questionnaires at the individual level over and above quantitative analysis method.

This study has established that the main drivers for pupils' use of Facebook are the number of friends they have, peers they follow, confidence built, comments and likes they receive or motivations from mathematics teachers. Hence, in no uncertain terms, Facebook and other social media platforms are popularly used among secondary school pupils but there is a high chance that these social media platforms could be used for communication and mathematics teaching-learning processes if and only if they are monitored and regulated by the school administration.

This study has established that Facebook is truly an important application for incoming university students – as they get to begin a new life in a new environment, encircled by new social networks. It is with no doubt that Facebook presents a profoundly interactive way to investigate this new space. For this reason, a vital contribution that this study leaves to the field of Mathematics Eduction is the significant personal, academic and social role that Facebook plays in the regular day-to-day lives of current university students has prompted some teachers to position it a noticeable site for student teaching-learning process.

Whilst educationalists may well expect that Facebook advances associations which are identified with formal educational goals, this study has established that students are also likely to use these social media applications for the informal aspects of their education. Notwithstanding, the academic and social challenges, difficulties and setbacks of undertaking a university education in the space of social networks.

This study contributes to the understanding of challenges related to continous professional development (CPD) and resources. Districts and schools need to consider staff preparation and training. Digital platforms and social media applications should be properly re-introduced in schools, in addition to training both teachers and students on how to effectively use them for instructional practice. As a matter of contribution, policy makers in the Zambian government should modify and improve existing pedagogical frameworks - learning from other countries (e.g. United Kingdom and Saudi Arabia) on how to use social media in the teaching-learning process of mathematics.

The reported preliminary results in this study informed the author(s) to appreciate the role social media technologies can (might) play in higher learning institutions considering the aspects identified with technological applications, software [social media] technology, innovative teaching-learning approaches that incorporates social media platforms and high-tech evaluation tools that are progressively reasonable, flexible and efficient. The results of this study motivate new lines of research. For example, this study will now be extended to university students of Mathematics Education to examine on the vision of digitalization of education.

4.2 Analysis of results from the Copperbelt University

In the segments that follow, results of the analysis of variance (ANOVA), multiple linear regression analysis, cluster analysis and qualitative analysis are presented and discussed. That is, all the findings from the Copperbelt University participants ($n = 102$) in relation to the research questions and aims of the study are presented and interpreted. The results obtained from the survey by analyzing all the responses from 102 participants are discussed. The survey was divided into 3 sections to investigate and probe the intended variables like: (a) Demographic characteristics and social media use in everyday life, (b) Social media practices and mathematics learning in mathematics courses (Mxxx), (c) Social media practices and Mathematics learning in general.

4.3 Quantitative Results

As a first step in the analyses process, we wanted to test for the validity and reliability of the research instrument used. This was a necessary condition for us since we wanted to obtain high-quality research results. Thus, Cronbach's alpha tests were performed in SPSS for each of the variables (items) of the questionnaire to test for the internal consistency. The majority of the items on the questionnaire performed well on this test as shown on Table 11 below.

Table 11: Testing for internal consistency- Cronbach's alpha values

Section of the questionnaire	**No. of items**	**Cronbach's alpha (α)**
Social media use in everyday life	12	0.713
Apps to support maths learning in Mxxx	13	0.747
Frequency use of SM in maths learning	17	0.733
online mathematics learning behaviours	9	0.710
Resources accessed	11	0.650

The alpha coefficient for the 13 items is 0.747, followed by 17 items with ($\alpha = 0.733$), 12 items with $\alpha = 0.713$ and 9 items with $\alpha = 0.710$, suggesting that the items have relatively high internal consistency (since a reliability coefficient of 0.70 or higher is considered acceptable in most social science research situations). This shows that nearly all the 62 items are closely related to each other as a group on the scale and fall within the levels of acceptance. A low alpha value ($\alpha = 0.650$) recorded may be due to the low average of the inter-item correlation or low number of items. To measure knowledge in the pre-service secondary school teachers' use of social media in their teaching and learning experiences, the author(s) adapted the validated science research questionnaire by Moll and Nielson (2017). Thus, within each science learning context, the author of the current manuscript adapted the validated scale within each mathematics learning context and then underwent a complete process of validation before administering it to the current study's participants.

Table 12 below illustrates the demographic data of all the participants involved in this quantitative study. One hundred and two questionnaires (102) were distributed to students pursuing a Bachelor of Science in Mathematics Education at the Copperbelt University (CBU). All the 102 questionnaires were returned, giving a response rate of 100%.

Table 12: Demographic characteristics of the participants

Variable	**Description**	**Freq (F)**	**Percent (%)**
Institution	CBU	102	100
Study programme	B.Sc Math Ed	102	100
Year of study	3rd year	42	41.2
	4th year	60	58.8
Gender	Male	81	79.4
	Female	21	20.6

Age	18-22	14	13.7
	22-25	71	69.6
	25-28	15	14.7
	28-31	2	2.0
Devices used	Smartphone	54	52.9
	Laptop	36	35.3
	Home PC	2	2.0
	iPad/Tab	5	4.9
	Campus PCs	5	4.9

Results indicates that about 70% of the students were aged 22-25 years, 14.7% were aged 25-28 years, 13.7% were aged 18-22 years and only 2% were aged 28-31 years. Furthermore, 20.6% of the participants were female while 79.6% were male. Consistent with Wickramanayake and Jika, (2018), the results of the current study disclosed that female enrollment in higher education in Zambia was lower compared with males. This gender variation could be caused by different phenomena, such as pass rate, sponsorship, ethnicity, devotional, geographical location, cultural, traditional beliefs and tribal issues.

Higher education institutions in Zambia do not have enrollment age limits for students, which encourages more qualified older persons to register in Bachelors degree programs. However, the overall results confirmed that Zambian students usually enroll in universities immediately after they complete their Senior Secondary General Certificate Examination at the age of 18. Majority (58.8%) of the participants were 4th years and 41.2% were 3rd years. The main reason for selecting third year students was that they were already done with their teaching practices and fourth years were almost ready to graduate and to take teaching positions in government or private schools throughout the country.

Slightly above half (52.9%) owned Smartphones and 35.3% owned personal laptops. A small number of students were also using home computers (2%), iPads/tablets (4.9%) and 4.9% of the respondents access campus computers. This is consistent with previous studies (e.g. see Lenhart, 2015; Singh & Gill, 2015; Stanciu et al., 2012), which revealed that the major tools that students use to access social media platforms were reported to be laptops followed by desktops and mobile phones.

The reported results in this doctoral thesis seem to powerfully agree with the results in the study conducted by Wickramanayake and Jika, (2018) who also found that the slight majority of the respondents used mobile phones and laptops to access social media. Furthermore, respondents used Smartphones more to access social media. Home PCs use of students to access social media was very low (2%) compared with Smartphones, laptops and other digital devices, such as tablets, Campus PCs and iPads. Table 12 illustrates all the demographic characteristics.

The primary aim of this study was to assess the frequency at which the students were social networking per day, and whether it had any effect on their academic performance. Therefore, the sub-leading aim of the study was to find out the amount of time students spent on social media per day. The Table below reports all the findings.

Table 13: Time spent on social media per day

Duration	**Number**	**Percent (%)**
Do not access them daily	10	9.8
$\leq$ 30 min	8	7.8
31-60 min	30	29.6
61-120 min	20	19.6
$>$ 120 min	34	33.3
Total	102	100

Table 13 shows that 9.8% of the respondents do not access social media daily, 7.8% of the respondents spend 30 minutes or less per day on social media; 29.6% of the respondents spend around an hour per day on social media, agreeing with Singh and Gill (2015), 19.6% of the respondents spend around 2 hours per day on social media and the majority (33.3%) spend more than 2 hours per day on social media. Hong et al., (2014) found that the average time that university students spent on social media (e.g. Facebook) was more than 4.5 hours per day. This is not surprising as Worldwide, digital consumers are now spending an average of 1 hour and 58 minutes per day on social networks and messaging (Akakandelwa & Walubita, 2018). The current study also found that the majority of sampled students spent over 2 hours per day on social media.

The current study depicts that the majority of students were average users of social media. The results in the present study seem to somehow agree with other studies investigating social media use among university students which revealed that students spend between 30 and 60 minutes of social networking (Jacobsen & Forste, 2010; Pempek, Yermolayeva, & Calvert, 2009). The present findings are confirmed by Jelenchick, Eickhoff and Moreno (2013), who posited that the estimated median time spent on social media on daily basis by older students was nearly 30 minutes. According to O'Keeffe and Clarke-Pearson (2011), the American Academy of Paediatrics (AAP) classify time spent on social networking sites (SNS) into three categories as high use (more than 2 hours), average use (30 minutes to 2 hours) and low use (less than 30 minutes).

There are several reasons why it is expected to find that the student estimated daily average time spent on social media is above half an hour. University students have reached a stage in their lives once they spend most of their leisure time alone, free from parental control and independently explore the planet which provides them an opportunity to form media choices which are not constrained by others (Larson, 1990).

The Table below shows grouped statistics in terms of frequencies on how students use social media platform for personal purposes.

Table 14: Statics of response for item A10.

Use of social media for personal purposes	Frequency	Percent
Daily	76	74.5
Weekly	22	21.6
Monthly	4	3.9
Total	102	100.0

Student teachers were asked how often they used social media sites for personal purposes. That is, for non-teaching and learning activities (e.g for fun). Findings from Table 14 suggest that majority (74.5%) of the respondents (76) use social media sites for personal purposes daily, 21.6% use social media sites for personal purposes weekly and barely 3.9% use social media sites for personal purposes monthly.

The findings reported in this thesis are consistent with what Sharma and Shukla (2016) found in Indian undergraduate students that social media was used as a cheaper online medium for chatting with friends, keeping in-tuned with family and for sharing pictures, documents and videos. It is therefore argued in this study that CBU students with lower levels of life satisfaction could seek to participate in online networks to increase their personal well-being, to keep in touch with old friends and to strengthen bonds with colleagues, to maintain and increase their social networks (Ellison et al., 2007).

The first key sub-leading question of this thesis was to investigate how students currently use social media platforms. There are so many social media communities that students prefer while online. Table 15 below displays students' choices.

Table 15: Students' preferred social media communities.

Preferred social media communities	No.	Percent (%)
Educational	26	25.5
Entertainment/recreation	39	38.2
Informational	30	29.4

Resource sharing	5	4.9
Any other	2	2.0
Total	102	100

Results from Table 15 shows that majority (39) of the respondents (38.2%) use social media for entertainment/recreation, 29.4% of the respondents use it for accessing information and about 26% of the respondents use it for educational purposes. Respondents are also using social media for resource sharing (4.9%) and any other (2%) related activities such as politics, religious, motivation and so on. However, researchers noted that very few respondents declared interest in using more than one social media community simultaneously. These results seem to contradict the findings of Wickramanayake and Jika (2018) who reported that majority of the Nigerian students preferred educational communities, followed by informational, entertainment or recreational, and resource sharing.

It is important to understand some of the students' motivations for using social media. Some go on social media for politics, news, entertainment or education. It has been revealed in this study that majority of Zambian students are highly fixated on entertainment communities. In this vein, some students would actively participate in social media to experience connectedness and happiness (Valkenburg, Peter, & Schouten, 2006) while others use social media for flirting online, for sexual exploration or for watching fan vedios. For instance, one study disclosed that although students did not intentionally go to seek sexual materials such as sex clips and nude pictures from porn web-sites, they unintentionally encountered these contents mostly through social media platforms (Adu-Kumi, 2016).

However, a reasonable number of students in the present study use social media for educational purposes such as sharing of information, discussing mathematics study material or topics, and networking to complete mathematics assignments or term/semester projects. Thus, it is evident that social media platforms also provides convenient methods of peer-to-peer exchange of arithmetical knowledge and collaboration (Eid & Al-Jabri, 2016) among university students.

Participants were further asked to select some barriers they have identified in using social media by ticking all that applies to their everyday life. Table 16 below illustrates this information.

Table 16: Students' barriers to using social media

Barriers to using Social media platforms	No.	Percent (%)
Unstable security and privacy concerns	16	15.7
Technology is not user friendly/difficult to use	3	2.9
Internet connection costs too much	33	32.4
Internet connection is unreliable	17	16.7
Unstable electricity connection	3	2.9
Too Busy/Don't have time	7	6.9
Lack of support at my institution	18	17.6
Integrity of student submissions	5	4.9
Total	102	100

Based on Table 16, our results have highlighted that among many other barriers students face when using social media, majority (33) of the respondents (32.4%) indicated that Internet connection costs too much. This is understandable as most students do not work or have part-time jobs to facilitate for their basic needs such as buying phone credits/data bundles. Nearly 17% of the respondents expressed concern that "Internet connection is unreliable" and 17.6% of the respondents "lack institutional support" from the Copperbelt University. It is therefore argued in this study that the university authorities do not monitor or regulate students' social media related activities. Thus, 15.7% were worried about "unstable security and privacy concerns". This finding is consistent with Mohamed and Sumitha (2011) who also found that some students were afraid of the mis-use of private information and lack of security and privacy issues. Additionally, Hamade (2013) reported that some students had no knowledge related to security and privacy issues when using social media. Unfortunately, 4.9% exercised concern about the “integrity of students’ submissions” while 6.9% of the respondents indicated that they were “too busy/don’t have much time” for social media. In supporting this, Lim et al., (2014), posited that social media creates distractions and loss of focus in students’ studies. About 3% of the respondents each declared that “Technology is not user friendly/difficult to use” and “electricity connections are unstable”. This is not a big barrier at CBU as most students are exposed to technology early enough from their homes to get acquainted with technological devices.

Furthermore, despite the whole Zambia experiencing the power crisis at the time of data collection, CBU remained unaffected and hence electricity connections remained stable to sustain the learning. The barriers to the social media usage of students were exclusively illustrated in several recent studies. Our results are somehow similar in context in a study by Singh and Gill (2015) in relation to the general barriers encountered by students. This study has also observed that when asked to tick all that applies, students identified at least three barriers or a combination of all at the same time when using social media platforms.

For each social media application, respondents were further asked to rate what kind of users they were in their everyday life by responding to 12 listed items on a four point Likert Scale (1=Non-user (**NU**): Never heard of it or never used it, 2=Infrequent User (**IU**): I use it sometimes, 3=Frequent User (**FU**): I use it regularly and 4=Contributor (**Contri**): I frequently use this application to both read content and to contribute content). The aggregate score (aggregate) in the Table represents the sum of agreement for pre-service teachers who either ‘sometimes’ or ‘regularly’ use social media to support their every life activities.

It was imperative to find out how univeristy students were using social media applications in their daily lives (outside the classroom). The responses of students were recoreded and reported in Table 16 below.

Table 17: What kind of Social Media user are you in your everyday life?

Social Media Application	**NU**	**IU**	**FU**	**Contri**	Aggregate
Social networking(e.g., Facebook)	1.0%	36.3%	51%	11.8%	99.1%
Communication(e.g., MSN chat, email, text messaging)	3.9%	41.2%	45.1%	9.8%	96.1%
Blogs (e.g., Tumblr)	71.6%	25.5%	2.9%	0.0%	28.4%
Microblogging (e.g., Twitter)	71.6%	23.5%	3.9%	1.0%	28.4%
Document managing and editing tools (e.g., Google documents, Dropbox)	29.4%	45.1%	24.5%	1.0%	70.6%
Social bookmarking(e.g., Delicious)	76.5%	15.7%	7.8%	0.0%	23.5%
Social news (e.g., Reddit)	40.2%	38.2%	21.6%	0.0%	59.8%
Wikis (e.g., Wikipedia, Wikispaces)	18.6%	38.2%	43.1%	0.0%	81.3%
Video sharing (e.g., YouTube)	21.6%	30.4%	45.1%	2.9%	78.4%

Live casting (e.g., Skype, life size)	61.8%	28.4%	9.8%	0.0%	38.2%
Photography sharing (e.g., Flickr)	57.9%	28.4%	12.7%	1.0%	42.1%
Discussion Forums (e.g., Yahoo answers, ask.com)	40.2%	45.1%	13.7%	1.0%	59.8%

The results indicate that majority (99.1%) of the respondents found themselves either sometimes or regularly or frequently contributing to social networking (e.g., Facebook); interestingly, 96.1% of the respondents use social media applications for Communication (e.g., MSN chat, email, text messaging) and 78.4% found themselves either sometimes or regularly or frequently sharing videos (e.g,. on YouTube). Consistent with research conducted by Mingle and Adams (2015) and confirmed by Ogaji, Okoyeukwu, Wanjiku, Osiro and Ogutu (2017) and Ahad and Lim (2014), the present study found that the majority of the prospective teachers used social networking (e.g., Facebook) because it is the most generally used social media platform followed by Communication platforms (e.g., WhatsApp, email, text messaging apps, etc) and sharing videos (e.g,. on YouTube).

Ahad and Lim (2014) are among those that provide the rationale why students use WhatsApp. Similar to using YouTube, the two researchers argue that built as an alternative to short messaging service (SMS), WhatsApp offers real-time texting or communication, including the ease of sharing information (e.g. contact list) or media content (e.g. audio, video files, images, location data). While it is argued that students may use these same platforms in their every day life to form different types of relationships with other people ranging from business, intimacy, professional and spiritual.

Furthermore, Lenhart, Smith and Anderson (2015) posited that social media platforms may allow various relationships of different calibres to unfold, simultaneous, such as one-to-many, many-to-many, and many-to-one communication via text, photographs, instant message, direct messages and videos. Chukwuere and

Bonga (2018) in their study found that participants use social media platforms for different purposes, including hooking up and maintaining family, friends, couple, and boy/girl-friend relationships.

All in all, Ante-Contreras (2016), concluded his report by highlighting that social media has different impacts and influences on students in their daily activities; some of these impacts are in favour of students'social lives and studies. Therefore, it is worth noting that students have favourable perceptions about using social media in their daily lives. Furthermore, the study revealved different variations in terms of students' daily usage of social media.

The study found that 81.3% were either sometimes or regularly using Wikis (e.g., Wikipedia, Wikispaces); 59.8% would either sometimes or regularly or frequently have discussion forums and another 59.8% found themselves either sometimes or regularly checking social news (e.g., Reddit); exactly 70.6% of the respondents would either sometimes or regularly use document managing and editing tools (e.g., Google documents, Dropbox); 42.1% use social media for Photography sharing (e.g., Flickr); 38.2% use social media for Live casting (e.g., Skype, life size); 28.4% go on Blogs (e.g., Tumblr); 28.4% use social media for Micro-blogging (e.g., Twitter) and 23.5% use social media applications for Social bookmarking(e.g., Delicious). To support these findings, Quadri and Adebayo Idowu (2016), also found that students were using social media platforms like Twitter, LinkedIn, Facebook and many others for sharing information.

4.3.1 Social media practices and mathematics learning

This section of the study is designed to investigate what kinds of social media tools mathematics students at the Copperbelt University (CBU) use to support their mathematics learning in their respective mathematics course(s). In this study, 'to support their mathematics learning' means that students use these tools to get information or to connect with others to help them complete the expectations for their class (i.e., while doing assignments, studying or working on projects).

Table 18 below shows participants' rate of agreement with three items on a 5-point Likert scale (1 = agree, 2 = strongly agree, 3 = moderately agree, 4 = disagree, 5 = strongly disagree).

Table 18: Grouped statistics of responses (%).

Item	**2a**	**2b**	**2c**
1	35.5	6.9	45.1
2	27.5	3.9	44.1
3	28.4	48.0	8.80
4	4.9	28.4	1.00
5	3.9	12.7	1.00
Aggregate	91.5	58.8	91.2

2a*-I use social media in teaching mathematics,* ***2b****-social media is more distracting than helpful to students for academic work and* ***2c****-social media have a place in my mathematics teaching subject.*

This section highlights the findings of students' social media use in their teaching and learning activities. Majority (91.2%) of the student teachers agree that social media platforms have a place in their mathematics teaching subject (item 2c). They also agree to the statement that "as a mathematics student teacher, I see myself using any of the relevant social media applications in teaching mathematics in my teaching career" (35.5% agree, 27.5% strongly agree and 28.4% moderately agree). Results seem to suggest that prospective teachers utilize social media in their mathematics teaching careers. This probably happens even during their teaching practice. The current results are confirmed by Mahnoor, Rana and Fatima (2018), whose quantitative study on the Impact of Social Media on Academics disclosed that 96 participants utilized social media sites for studies.

Not surprisingly, throughout the existence, social networking sites among students have become very famous. It is argued in this study that media technology has become an approach for students to make associations in schools, colleges, universities or outside the walls of the universities. However, 58.8% of students agree to the statement that "Online and mobile technologies are more distracting than helpful to students for academic work" (6.9% agree, 3.9% strongly agree and 48% moderately agree). This finding is consistent with a study conducted in Taiwan by Yen, Tang, Yen, Lin, Huang, Liu and Ko (2009) who perceived an association between mobile-phone usage and students and reported that students' usage of the mobile-phone hindered their studies. Similarly, Hong, F., Y., S., I., and Hong, D., H., (2012) argued that daily usage of mobile phones were linked to the self-reporting of study complexity among Taiwanese university students.

Nonetheless, this study does not report on any connection between how much time students spend on social media platforms and study performance. But most of the guardians are anxious that students use more Facebook and other social media platforms and don't pay attention to their studies. Consistent with Mailizar and Fan (2020), whose study aimed at investigating Indonesian secondary school teachers' knowledge in the use of ICT in secondary mathematics classrooms, based on this study's findings, the author of the current doctoral thesis argues that it is crucial to improve student teachers' knowledge of using social media technology in mathematics classrooms, and more training courses for students' knowledge development in this area are needed. This will help students not to see social media platforms as tools of distractions to their own academic work.

When used appropriately, web 2.0 tools can be helpful in mathematics transactions. As a matter of fact, Lau, Lui and Chu, (2016) pointed out that social media platforms may expand students' ability to generate and stimulate their interests in academic subjects and communicate with professionals easily. Cox and McLeod (2014) posited that online networks advance correspondence with instructors, undergraduates, guardians and help encourage proficient learning networks.

Students were further asked to list any three of their most favourite social media applications they usually make use of to support their mathematics learning. Table 19 displays the frequencies of students' statistics of their responses.

Table 19: Students' statistics response

Students' favourite Apps used	Frequency	Percent
WhatsApp, Facebook & Wikipedia	20	19.6
YouTube, Google & LinkedIn	18	17.6
WhatsApp, Facebook & YouTube	40	39.2
Instagram, Twitter & Facebook	8	7.8
Facebook, WhatsApp & Messenger	16	15.7

Total	**102**	**100**
I use social media to support my maths career	**N**	**%**
Use	73	71.6
Do not use	29	28.4
Total	102	100

Results from Table 19 above reveals that majority (39.2%) of the respondents (40) use WhatsApp, Facebook and YouTube, while 19.6% use WhatsApp, Facebook and Wikipedia, 17.6% use YouTube, Google and LinkedIn, 15.7% use Facebook, WhatsApp and Messenger and about 8% use Instagram, Twitter and Facebook. Although the actual Figures are not replicated, our findings are similar to those found in a study by Mahnoor et al., (2018) which disclosed that students' most loved social media applications were Facebook, followed by WhatsApp and Twitter. This study has argued that the main reason for students' preferred favourite social media Apps, could be because they are user friendly. In addition, students can easily navigate to other social media platforms while using just one of the three favourite apps.

According to Facebook (2015), Facebook is the world's largest social media platform which boasts of more than 1.31 billion mobile active users and 1.49 billion monthly active users. Not only does Facebook take the top spot, its other subsidiaries (WhatsApp and Instagram) have an impressive penatration for social engagement and take the 2nd and 3rd spots respectively. The findnings in the current study are confirmed in a recent study which was done at the University of Florida, United States of America by Jung and Moon (2017) who posited that social media platforms such as Facebook, Instagram, YouTube, Twitter, etc can be used by students and lecturers in institutions of higher learning to communicate with their intended audience. Further analysis revealed that majority (71.6%) of the respondents (73) use social media sites (e.g. LinkedIn, Facebook, etc) to support their mathematics professional careers while 28.4% do not use it in similar manner.

Table 20 shows respondents' rate of agreement with 17 items on a 3-point Likert scale (1 = never, 2 = sometimes and 3 = regularly) on how frequently they use social media to support their mathematics learning in mathematics courses. The aggregate score (aggr) represents the sum of agreement for pre-service teachers who either 'sometimes' or 'regularly' use social media to support their mathematics learning.

Table 20: How frequently do you use social media to support your mathematics learning?

Item	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k	3l	3m	3n	3o	3p	3q
1	20.6	38.2	5.9	31.4	91.2	33.3	55.9	45.1	2.9	11.8	49.0	35.3	74.5	73.5	72.5	19.6	40.2
2	56.9	48.0	23.5	46.1	6.9	40.2	33.3	35.3	18.6	34.3	41.2	52.9	18.6	19.6	22.5	33.3	39.2
3	22.5	13.7	70.6	22.5	2.0	26.5	10.8	19.6	78.4	53.9	9.80	11.8	6.9	6.9	4.9	47.1	20.6
Aggr:	79.4	61.7	94.1	68.6	8.9	66.7	44.1	54.9	97.0	88.2	51.0	64.7	25.5	26.5	27.4	80.4	59.8

3a-Use Facebook chat (or MSN or texting) to contact a friend to get help with a class assignment, 3b-Use e-mails more effectively in communicating with my mathematics lecturers than in my class, 3c-Use WhatsApp to get help with mathematics assignments/home works/ research works etc, 3d- Use e-learning mathematics materials available via social media to learn maths, 3e- Use Skype (or some kind of live casting service) to connect with a friend or a group to work on a class assignment, 3f- Ask a mathematics question on an online forum such as Ask.com, 3g- Collaborate with a classmate on an online document using Google docs (or something similar), 3h- Create or join a Facebook group with classmates to share homework, links, and to discuss class content, 3i- Search YouTube for a video to learn about a mathematics concept, 3j- Access Wikipedia to read about a mathematics concept, 3k- Answer or comment on a mathematics related topic on a forum such as Ask.com, 3l- Read a mathematics related blog or news items, 3m- Follow mathematicians or maths related feeds on Twitter, 3n- Save and share maths related bookmarks on Delicious (or some other social bookmarking service), 3o- Post mathematics related content on a blog, 3p- Store apps on my Smartphone that are useful for learning mathematics and 3q- I share and/or post videos related to my mathematics learning.

Once again, based on the theoretical framework of this study, it was very easy for us to analyse and understand the results reported on Table 20. Activity Theory enabled us to describe and analyse the structure, development and context of learning activities mediated by mobile technologies and so on. Using AT as our lens, results from Table 20 showed that the most popular social media platforms used in mathematics activities was YouTube (97%). That is, majority of the participants (on item 3i) found themselves either sometimes (18.6%) or regularly (78.4%) searching YouTube for a video to learn about a mathematics concept, representing a sum total of 97%, followed by 94.1% of the respondents found themselves either sometimes (23.5%) or regularly (70.6%) using WhatsApp to get help with mathematics assignments/home works/ research works etc (item 3c), 88.2% would either sometimes or regularly access Wikipedia to read about a mathematics concept (item 3j) and by the foregoing, we see that 79.4% use Facebook (item 3a), 68.6% use e-learning platforms (item 3d), 66.7% use Ask.com (item 3f) and 61.7% use Gmail (item 3b).

On the other hand, pre-service teachers had deep concerns of possible unfamiliarity with other social media technologies like Tumblr, Twitter, Delicious, Zoom, Life-size, Flickr and Reddit and recorded low scores. For instance, 74.5% of the participants never follow mathematicians or mathematics related feeds on Twitter (item 3m), 73.5% never save and share mathematics related bookmarks on Delicious (item 3n) and 72.5% never post mathematics related content on a blog.

High use of YouTube is not surprising as the application is user friendly. Anna (2019, p. 7) posited that "...YouTube is one of the most important applications downloaded by pre-service teachers on their Smartphones. Pre-service teachers use YouTube, in addition to being an entertainment medium, as a source of information to search for lecture material, pre-service teachers use YouTube to find tutorial videos related to lecture material..."

Pre-service teachers also use WhatsApp, Facebook, Gmail and other e-learning platforms whenever they need to access assignments from lecturers, upload assignments, and obtain information associated with lectures (Anna, 2019). This is quite encouraging as pre-service teachers at CBU do not only use social media for social purposes but majority of them see it as a tool for teaching and learning mathematics. Consistent with Wickramanayake and Jika (2018), social media tools functions through different platforms to provide various services to their members. The participants' choices of platforms and their use in mathematics teaching and learning are summarized in Tables 20 and 21.

Students were also asked how frequently they engaged in online mathematics learning behaviours while completing assignments for mathematics and other mathematics teaching methods course(s). Respondents rated their level of agreement on a 3-point Likert scale (1 = never, 2 = sometimes and 3 = regularly). Table 21 shows students' responses involving mathematics online learning activities.

Table 21: Statistics of students' online mathematics learning activities

Item	4a	4b	4c	4d	4e	4f	4g	4h	4i
1	43.1	6.90	10.8	0.00	0.00	7.8	24.5	24.5	56.9
2	47.1	33.3	48.0	19.6	27.5	34.3	43.1	62.7	32.4
3	9.80	59.8	41.2	80.4	72.5	57.8	32.4	12.7	10.8
Aggregate:	56.9	93.1	89.2	100	100	92.1	75.5	75.4	43.2

4a- When completing Mxxx assignments I work in front of my computer so that I can chat online with my friends when I am stuck, 4b- When completing Mxxx assignments I work in front of my computer so that I can search the Internet and/or Google, 4c- I search the Internet for the answers to particular assignment questions. When I find the answer I stop looking, 4d- I search the Internet for information that will help me to understand mathematics concepts better, 4e- I actively search the Internet for resources (links, videos, websites) that will help my mathematics learning, 4f- When I find a good mathematics online resource I bookmark it or save it somewhere so that I can access it later, 4g- I use collaborative tools such as Google documents or a wiki to work with my friends on class work and projects for Mxxx, 4h- I share online resources (links, documents) for learning mathematics with my classmates and 4i- I have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and students.

Results from Table 21 reveals that 100% of the respondents indicated that they either sometimes or regularly search the Internet for information that will help them understand mathematics concepts better and another 100% of the respondents found themselves either sometimes or regularly actively searching the Internet for resources (links, videos, websites) that will help their mathematics learning. Exactly 93.1% of the respondents either sometimes or regularly agreed to the statement that "When completing Mxxx assignments I work in front of my computer so that I can search the Internet and/or Google"; 92.1% also sometimes or regularly agreed to the statement that "When I find a good mathematics online resource I bookmark it or save it somewhere so that I can access it later"; 89.2% found themselves either sometimes or regularly searching the Internet for the answers to particular assignment questions and when they find the answers they stop looking: 75.5% would sometimes or regularly use collaborative tools such as Google documents or a wiki to work with their friends on class work and projects for a mathematics course; exactly 75.4% found themselves either sometimes or regularly sharing online resources (links, documents) for learning mathematics with their classmates, and about 57% indicated that when completing Mathematics assignments they work in front of the computer so that they can chat online with their friends when they are stuck. Surprisingly, nearly 57% of the respondents never have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and/or fellow students.

For each social media application, participants were again asked to rate how they have used social media platforms in their mathematics learning at the university by responding to 12 listed items on a four point Likert Scale (1=Non-user (NU): Never heard of it or never used it, 2= Infrequent User (IU): I use it sometimes, 3= Frequent User (FU): I use it regularly and 4= Contributor (Contri): I frequently use this application to both read content and to contribute content) as shown on Table 22 below. The aggregate score (aggregate) represents the sum of agreement for pre-service teachers who either ‘sometimes’ or ‘regularly’ use social media to support their mathematics learning.

Furthermore, participants were also asked to qualitatively explain how they have used any chosen social media tools in their mathematics courses during and after mathematics instructions. Their explanations from A to M are given in the subsequent section.

Table 22: Students’ responses to social media usage in Mathematics learning

Social Media Application	**NU**	**IU**	**FU**	**Contri**	Explain how you’ve used it in Maths.
Social networking (e.g., Facebook)	21.6%	33.3%	37.3%	7.8%	**A**
Communication (e.g., MSN chat, email, text messaging)	22.5%	28.4%	42.2%	6.9%	**B**
Blogs (e.g., Tumblr)	85.3%	12.7%	2.0%	0.0%	**C**
Micro-blogging (e.g., Twitter)	82.4%	14.7%	2.9%	0.0%	**D**

Document managing/editing tools (e.g., Google documents, Dropbox)	39.2%	25.5%	34.3%	1.0%	**E**
Social bookmarking (e.g., Delicious)	89.2%	6.9%	3.9%	0.0%	**F**
Social news (e.g., Reddit)	67.6%	19.6%	12.7%	0.0%	**G**
Wikis (e.g., Wikipedia, Wikispaces)	22.5%	30.4%	45.1%	2.0%	**H**
Video sharing (e.g., YouTube)	22.5%	19.6%	55.9%	2.0%	**I**
Live casting (e.g., Skype, Life size)	84.3%	10.8%	3.9%	1.0%	**J**
Photography sharing (e.g., Flickr)	77.5%	12.7%	8.8%	1.0%	**K**
Discussion Forums (e.g., Yahoo answers, ask.com)	52.0%	27.5%	18.6%	2.0%	**L**

UoW Learning management system (SMP)	94.1%	3.9%	2.0%	0.0%	**M**

Results from Table 22 show respondents' choices of social media platforms used to support their mathematics discourses. Based on the Activity Theory of this study, results indicated that Social Networking (e.g., Facebook) had the highest preference (78.4%), followed by Communication (e.g., MSN chat, email, text messaging) (77.5%), Wikis (e.g., Wikipedia, Wikispaces) (77.5%), Video sharing (e.g., YouTube) (77.5%), Document managing and editing tools (e.g., Google documents, Dropbox) (60.8%), Discussion Forums (e.g., Yahoo answers, ask.com) (48%) and Social News (e.g. Reddit) (32.4%). These results agree with Tsai, Galyen, Xie and Laffey (2010), who also used Activity Theory to examine social interaction of students' online learning and the digital tools they employed. The current findings are similarly reported in a study by Sharma and Shukla (2016) who disclosed that among Indian college students, social media was used as a cheaper online medium for chatting with friends, keeping in touch with family and for sharing pictures, documents and videos.

Consistent with Anna (2019), the current results seem to suggest that mathematics pre-service teachers at CBU were primarily using social media platforms like YouTube to watch, download or upload mathematics videos related to their classroom lectures. It is also argued in the current study that the use of social media in mathematics learning processes would reduce the learner-teacher dependency syndrome as pre-service teachers can learn on their own through online interactions.

However, pre-service teachers had deep concerns of possible unfamiliarity with other social media platforms like Life-size. Thus, it is not surprisingly that 94.1% of the participants never use "Learning management system (SMP)", 85.3% of the participants never use "blogs (e.g., Tumblr)", 82.4% of the participants were non users of "Micro-blogging (e.g., Twitter)", 89.2% of the mathematics students never use "Social bookmarking (e.g., Delicious)", 84.3% never use "Live casting (e.g., Skype, Life size, Zoom)" to discuss mathematics courses and 77.5% of the participants never use "photography sharing (e.g., Flickr)" in their mathematics learning. Based on TAM model, pre-service mathematics teachers do not necessarily percieve these technonlogical applications ease of use and consequently useful in the teaching and learning of mathematics.

4.4 Qualitative Findings

In this section, I draw on findings from a qualitative study to examine how CBU students have used different social media platforms in their respective mathematics courses to support student lectures, everyday learning activities such as supporting hobbies, simplifying life and many others. In order to access the respondents' true feelings and their understanding on the usage of 13 social media platforms in mathematics courses, the researcher distributed questionnaires where students filled out an open-ended question to further explore the data. The results of the collected data are then filtered and processed in Table 22 from A to M for further analysis.

Most respondents were still at least somewhat interested in using social media applications in their mathematics courses due to their convenience while others use them because the situation dictates. The most widely used social media applications are those which enable respondents to share and store information, save documents online, communicate, and collaborate with classmates.

General explanations of how students have used social media applications in Mathematics.

Overall, for the current analysis, I developed a preliminary set of codes based on impressions from the open-ended question in terms of students' reasons for selecting a particular social media tool. Consistent with Shanna (2014), after coding a small set of transcripts, the codes were slightly refined and expanded. After all transcripts were coded, I organized the final set of codes according to the larger thematic areas laid out in the next section. Quotes included in the next section are presented verbatim. Respondents provided several general explanations to using social media Apps in mathematics. In subsequent sections, I first discuss general reasons why students use a particular social media platform and how it has benefited them to support their mathematics lectures. More details are given below:

4.4.1 Social networking (e.g., Facebook)

Students cited several broad reasons for using social networking sites (e.g., Facebook). First, almost all the students appreciated the features found on the Facebook application. Participants fell into three clear categories: (1) approximately three quarters of students use it for communication, (2) slightly above half use it for sharing information and (3) the rest use it for collaboration. The researcher summarized their responses as detailed in subsequent paragraphs.

Some frequently felt that Facebook allows them to share mathematics problems, solutions, data, pictures, videos and links. In addition to these structural reasons, a few students use Facebook for exchanging mathematics related information, such as frequently sending assignments to classmates to compare solutions with others in M310, asking for notes from other classmates who have them, for online mathematics group discussions, subscribing to Facebook mathematics groups/pages, posting questions and answers in mathematics groups, getting information on certain topics from Facebook math groups, consulting friends on how to solve some difficult questions, for class updates such as finding out if there is an M370 class or not, seeking help from math colleagues/tutors by asking them about a difficult concept, visiting pages that share materials related to students' mathematics courses, communicate with fellow teachers who have more experience and just for chatting with friends.

While other students specifically mentioned using Facebook for contribution purposes such as creating a group for mathematics on Facebook where questions and answers are posted, discussing mathematics problems raised online such as sharing ideas about questions, helping in answering quiz questions, posting answers in the group for people to see the solutions, sharing a video from YouTube, sending and receiving photos of some mathematical content, explaining the solutions to some problems and answering questions for other mathematics students. One student said:

> "I capture questions in M320 that are difficult for me to answer and send them to my Facebook friends so that I get answers from people who know."

As one other student also said:

> "I frequently read information on mathematical Facebook pages and sometimes search for solutions to mathematics problems."

Suffice to say that outside the many advantages that Facebook offers, it allows students to stay connected with their friends, share updates and photos, engage with friends and mathematics pages and stay connected to communities important to them. Facebook allows students watch live streaming mathematics videos and get caught up in the latest happenings. Facebook also helps them keep up with the latest news and current events around the world.

4.4.2 Communication (e.g., MSN chat, email, text messaging)

Slightly above three quarters of students use social media platforms for communication (e.g., MSN chat, email, text messaging) at CBU. The students' responses were then grouped and summarized as follows.

Several students preferred Gmail and WhatsApp applications for communication. Generally, findings seem to highlight that on these two platforms, most students are either frequently sharing data such as books, lecture notes, class schedules, place changes, pdfs, assignments' solutions, articles, math problems, class projects, class updates or contributing significantly to clarifying solutions, offering academic advice to fellow students or seeking help and making consultations from their supervisors.

Several other students, particularly younger ones, noted that they tended to create mathematics WhatsApp groups for discussions, sharing YouTube math videos, subscribing to educational programs, solving and sharing mathematics questions, texting friends for help, using WhatsApp to capture questions and solutions and share in a group, receiving handouts, exchanging data, sharing ideas on the topic, discussing tutorial sheets, comparing assignment solutions to challenging questions, sending mathematical theorems, lemmas and proofs and frequently asking and sharing mathematical concepts with classmates.

Nearly half of the students alluded to the beauty of using Gmail. Respondents noted that Gmail can be used to send big files as opposed to WhatsApp. A sample of students use Gmail as their mail platform, they either create or join Gmail groups to support their mathematics learning process. Students are either frequently mailing mathematics questions, projects to lecturers or receiving mails containing answers, books of their courses or subscribe to communities which send news letters or sites that mail maths related information. As one student noted:

> "I frequently receive mails from sites that are related to mathematics, I receive notes and books of my course via emails from my lecturers."

Another group of 4 students respectively said:

> "…I frequently mail people I know that have the information am looking for…, I frequently email Universities about my program for inquiry…, I email questions to my lecturers that I don't know and I infrequently send emails of the project to my supervisor…"

The use of e-mail is considered more effective if it is used to send large and more flexible files because students type their assignments through laptops and can be sent directly via e-mail, whereas WhatsApp is widely used to send small files or forward files to friends. This helps majority of students with easier access towards lecture materials, either through e-mail or WhatsApp messages (Anna, 2019).

4.4.3 Blogs (e.g., Tumblr)

According to Rebecca (2000), a blog (a truncation of "weblog") is a discussion or informational website published on the World Wide Web consisting of discrete, often informal diary-style text entries (posts). Tumblr is both a blogging platform and a social network. One can use it strictly for blogging or strictly for social networking with other users or one can use it as both. Most importantly, users can navigate to Tumblr.com in a browser. Interestingly, users can connect their Tumblr account to their Facebook account so that they automatically get posted on Facebook too. Similarly, users can connect their Tumblr account to their Twitter account so that they automatically get posted on Twitter too. Unfortunately, only a handful of Zambian students seemed to use this social network for mathematics learning at CBU. May be this is due to lack of familiarity with the social network. Among a few students' responses, students are either infrequently using this platform for class updates, asking questions to experts, for assignment purposes or for class discussions and debates on various topics. As one student said:

> "I read about some different research in M320".

Another student said:

> "I sometimes check notes on the class blog, download them and share with my classmates; I also just go on the blog to check on the treading mathematics concepts".

4.4.4 Micro-blogging (e.g., Twitter)

Several studies claim that there are over 100 micro-blogging sites in different countries. Among the most notable services includes- Twitter, Tumblr, FriendFeed, Plurk, Jaiku and many more. Different versions of services and software with micro-blogging features have been developed (Wikipedia contributors, 2019). Plurk has a timeline view that integrates video and picture sharing. Flipter uses micro-blogging as a platform for people to post topics and gather audience's opinions. PingGadget is a location-based micro-blogging service. Pownce, developed by Digg founder Kevin Rose among others, integrated micro-blogging with file sharing and event invitations (Wikipedia contributors, 2019). Pownce was merged into SixApart in December 2008 (Wikipedia contributors, 2020). Several studies, most notably by the Harvard Business School and by Sysomos, have tried to analyze user behavior on micro-blogging services (Harvard Business School, 2009; Sysomos, 2009).

Several of these studies show that for services such as Twitter a small group of active users contributes to most of the activity (TechCrunch, 2009). Sysomos' Inside Twitter (Sysomos, 2009) survey, based on more than 11 million users, shows that 10% of Twitter users account for 86% of all activity.

Consistent with our findings at the Copperbelt University, only a handful of Zambian students seem to discuss questions on Twitter and check tweets about mathematics. To be specific, three Zambian micro-blog users most often pursue content created by friends, experts in mathematics or related mathematics tweets. Two other students explicitly said that they use Twitter just for chatting, for Internet news and for sharing information. One explained that "I use Twitter for asking questions to my fellow mathematicians" while the second said "I use Twitter for mathematics tweets/questions and checking for treading mathematics concepts".

4.4.5 Document managing/editing tools (e.g., Google documents, Dropbox)

Based on our quantitative results, 54 respondents are in possession of Smartphones with different brands while 36 respondents are in possession of laptops. These gadgets store various applications and software such as PDF element, Microsoft Office, Dropbox, Google Docs/Sheets/Slides/Forms, Evernote, Acrobat DC, apple pages/numbers/Keynote, Apache OpenOffice, etc… as document editing tools to execute tasks in the most effective way. Quite often, students do a lot of editing with these documents to achieve perfection. Thus, smartphones and laptops with in-built or installed applications or software have become mandatory equipment for students to support educational activities.

Participants were asked to qualitatively self-report how they have used document managing/editing tools (e.g., Google documents, Dropbox) in their mathematics courses during and after mathematics instructions. About half of the students said that they usually use these tools for storing or saving documents online, creating slides for presentations, accessing soft copy data such as maths books, pdfs, articles, write educational material, taking photos of documents, sharing information, researching, googling maths questions, editing questions for practice, downloading or uploading maths books, articles, etc to Dropbox, gathering of all mathematics documents in one place, creating a data folder and mostly used when doing assignments. One student specifically mentioned that:

> "Sometimes I use Dropbox to save important documents like handouts, books, pdfs files online". The second student said: "I sometimes use Google documents to validate my knowledge" while another one said: "I find useful PDF books that make my understanding in M320 clearer, I also search for lecture notes for challenging topics in M310" and the last student said that "I use them for saving recommended books and reading information am researching on".

4.4.6 Social bookmarking (e.g Delicious)

Unfortunately, none of the students explained anything on using social bookmarking in their mathematics courses. This somehow suggests that students were very unfamiliar with the social network. Thus, respondents may never have used it before for academic purposes. This is not very surprising since quantitatively, 89.2% of the mathematics students never use social bookmarking (e.g., Delicious) as found earlier.

4.4.7 Social news (e.g., Reddit)

When asked to explain how students have used Social news (e.g., Reddit) platform in mathematics, students cited several broad reasons which the author summarized. Only a handful of students said that they have used it for reading information and checking world news, for being updated with educational information, for learning (new concepts and new teaching methods), for checking the updates about the curriculum, for reading the current affairs and for reading mathematics articles (checking for new math discoveries). In the light of this, one student said that:

> "I use it to know what and how the education system has improved by following new developments" while another one said: "I use it to check the level of understanding especially after publishing the Grade 12 results".

4.4.8 Wikis (e.g., Wikipedia, Wikispaces)

In accordance with Wikipedia contributors (2019), Wikispaces was founded in 2005 and has since been used by educators, companies and individuals across the globe. Unfortunately, in January 2018, Tes announced the first cite closure. After exploring all the possible options for keeping Wikispaces running, the Tes Global had to conclude that it was no longer viable to continue running the service in the long term. Sadly, the site was closed down. Due to cost issues, classroom and free-level Wikispaces closed on July 31, 2018, while private Wikispaces closed on January 31, 2019 (Wikispaces, 2019).

Wikis was another social networking site that was widely used by both students and lecturers to support the learning process during lectures. Fortunately for us, at the time of the data collection, the wikis site was still running and when students were asked to explain how they have used it in their mathematics courses, they cited various broad reasons which were then summarized by the researcher in the next paragraph.

Based on frequencies of responses to the open ended question, majority of the students (77.5%) frequently used wikis for different activities ranging from either reading information related to M310, M370 and M320 for easy understanding of mathematical concepts, mathematics research activities, sharing information (such as class projects, maths assignments, solutions, etc), searching for mathematical definitions, research related works, finding meaningful solutions to problematic questions, searching for answers to tutorial sheet questions, downloading of pdf class tutorial sheets from the site, posting/ uploading of math questions, contributing to the site to downloading pdf files that have clearer math explanations.

Another considerable group of students felt that: "doing a lot of reading about concepts in M320, understanding how concepts are explained, searching for some history about a certain topic, getting clarity on different issues, searching for answers to questions, especially with assignment deadlines and reading on mathematicians' biographies" were the necessary academic activities they did on wikis.

Three other students expressed how important the wikis site is in facilitating access to mathematics lecture materials, making it easy to find information/references and in getting related information. As one student said "I use it to search and ask a question and later discuss with other people". The second one said "I frequently use it to search for definitions and valid formulae and I also use it to learn more about double integration". The last student commented that "I frequently use it to search for the meaning of some words in M330; I also use it for searching the news and opinions about topics".

4.4.9 Video sharing (e.g., YouTube)

Based on the students' response statistics to the closed ended question on Table 22, majority of the students (77.5%) either infrequently or frequently use "Video sharing (e.g., YouTube)" to learn mathematics content with only 2% contributing maths content on such platforms. But to what extent are the students using this social media platform? In part, this is not surprising as qualitative findings seem to highlight more on how students have used this platform to better their mathematics lectures and probably answer the above leading question.

Based on frequencies of responses to the open-ended question, the top six uses of video sharing (e.g., YouTube) by students were watching mathematics tutorial videos, watching mathematics lecture videos, downloading/uploading mathematics videos, having online (YouTube) mathematics discussions, having online mathematics lectures and sharing mathematics related information on the site. Echoing on the relevance of watching YouTube math videos, one student in the same study said, “When I watch YouTube math videos, I learn mathematics concepts from other tutors in M310” and another one said, “Watching tutorials on YouTube helps my understanding of topics that are challenging”.

The students expressed the need for “watching videos to learn more about mathematics topics they did not understand in class, viewing various examples and worked out problems and seeing how others have solved a question”. This comment was made by students enrolled in several mathematics courses at CBU. These findings are supported by Amador, Keehr, Wallin and Chilton (2020), who argued that a video is a common tool used to support student-teacher learning because it is said to provide an opportunity for reflection on teaching practices. In addition, in a study conducted by Klobas, Moghavvemi and Paramanathan, (2018), participants where compelled to rely on YouTube videos for meaningful learning.

A considerable group of students felt that one of the benefits of this platform (video sharing) in supporting mathematics lectures is: “the ability to share information between students through YouTube video links, sending and asking mathematics questions, chatting with mathematics colleagues and getting proper explanations about concepts”. Three other students explicitly said the following: One student commented, “I post videos of M320 on YouTube and download videos on a certain topic in M310… I also frequently use YouTube to learn more about calculus”. The second student said, “I sometimes use it to find out how to find the point estimate”. The third one said, “I sometimes watch a video on how to do a mathematics computation”.

4.4.10 Live casting (e.g., Skype, Life size)

In order to compliment quantitative results which suggest that only 15.7% of the students use live casting in their mathematics courses, it is not surprising that qualitative findings unearthed only a few responses from a small number of students. Based on frequencies of responses to the open-ended question on Table 22, only a handful of students expressed using live casting (e.g., Skype, Life size) in their mathematics courses.

The top five uses of live casting (e.g., Skype, Life size) among mathematics students includes: live video chatting with maths colleagues, having online lectures/discussions, chatting and sharing answers with others, connecting with distant friends and sharing information with classmates. Thus, it is no surprising that that videos provide a good framework of learning for instructors, researchers, teachers, lecturers and students in teacher education (Amador et al., 2020).

4.4.11 Photography sharing (e.g., Flickr)

Quantitative results seem to highlight that only 22.5% of the students use photography sharing (e.g., Instagram, Picasa, Flickr, etc). Only a few students realized that photography sharing (e.g.., Flickr) is the best platform to share photos with friends, classmates, family, relatives and co-workers. For example, Flickr is an image sharing website where people upload their images and add in a license. Millions of public photos can be uploaded per month to Flickr. One can also connect his/her other social networking accounts such as Instagram, twitter, Facebook, or Tumblr to Flickr. Connecting an account not only lets you share your photos on your Tumblr blog or Twitter feed by clicking a single button, it also allows Flickr to automatically share your new photo uploads to your Facebook Timeline.

Despite the user friendliness and good services photography sharing offers, unfortunately, it appears that only a few students are familiar with this social networking site. Thus, when students were asked to self-report (explain) how they have used photography sharing (e.g.., Flickr) in their mathematics courses, complimenting with quantitative results, only a handful (8 to be specific) of students said that they use it for sharing photos of mathematics questions and solutions.

As one student said: “I use it for either sending or receiving maths pictures containing either mathematics questions or solutions”. “I share tutorial sheet questions with the class using Flickr”, another student commented.

The small number of students who use photography sharing (e.g.., Flickr) is understandable since mathematics content is largely dependent on symbols and numbers as opposed to pictures.

4.4.12 Discussion Forums (e.g., Yahoo answers, ask.com)

Quantitative results highlight that 46% of the students either infrequently or frequently use discussion forums (e.g., Yahoo answers, ask.com) with only 2% contributing to such forums. In order to understand the actual ways in which students have used discussion forums in their mathematics courses, students were also asked to fill in a mandatory section of the questionnaire to explain how they have used discussion forums (e.g., Yahoo, ask.com) to support mathematics transactions.

Nearly half a dozen of students provided eight general reasons why they used such a platform to aid their mathematics discourses: the top eight general explanations are: (1) searching for solutions, (2)-posting assignments, (3)-posting solutions, (4)-verifying solutions, (5)-discussing mathematics concepts, (6)-discussing solutions for M320, (7)-collaborating on challenging questions and (8)-learning or obtaining concepts in M310 from other classmates.

First, several students implied that it was important for them to use discussion forums (e.g, Yahoo answers, ask.com) in mathematics in order for them to look for solutions or provide solutions to questions, frequently discussing assignments, asking questions, checking answers that others have posted, accessing variety of information and for further research. A few other students articulated their satisfaction through seeking help and clarity whenever possible, browsing how some questions are solved, reading other members' explanations about concepts, viewing other peoples' opinions about topics and finding information related to projects.

One student noted that he simply felt that this networking site could be used for confirmation: "when am trying to confirm on something in M310." Another student felt that being on this platform gives access to rich information shared in mathematics: "I find answers to difficult math questions. I have also joined WhatsApp groups for mathematics in Zambia. Useful information is shared." For others, the importance of this platform is found in the contributions they make such as- asking hard tutorial sheet questions and providing solutions. As two other students said: "I ask questions that seem very challenging for me" and another one said: "I provide solutions in M320."

Respondents generally explained that they ask the online community on how to solve questions and also help in answering math questions they are familiar with.

Sometimes they just visit the forum to verify their solutions to assignments and tutorial sheets. As one student said "I use it to ask questions about things I am not sure of." A considerable group of students said "when we have questions, we discuss and work them out together with other fellow students." As one student echoed this theme with one underlying fact "I find answers to my assignments and information related to my project."

4.4.13 Learning management system (SMP)

Since from the results obtained earlier, 94.1% of the participants never use "Learning management system (SMP)" in their mathematics learning and either 3.9% or 2% infrequently or frequently use (SMP). When asked to explain how students have used Learning Management System (LMS) in their mathematics courses, It was not surprising that none of the students explained anything about using this social platform. The researchers' conclusions are that students were very unfamiliar with the technological networking platform. This may be due to lack of exposure to such learning systems by their lecturers.

The Copperbelt University administration has never integrated the Learning Management System (LMS) into the university's teaching and learning process. Thus, lecturers have never created online classrooms or virtual campuses for sharing the learning materials in advance for downloading and viewing by students. Additionally, besides saving time, money and effective delivery of instructions, LMS has a wide range of products and services which can cater to the needs of 21st century's learners and instructors. Despite the popularity of LMS among the universities being very high worldwide, it is still yet a dream farfetched to be realized at the Copperbelt University to move from traditional educational learning environments to online or virtual educational learning environments.

4.5 Analysis of Variance (ANOVA)

Before carrying out the ANOVA test, all the assumptions of the ANOVA distribution were taken into consideration to check if any of them were violated. All the assumptions were tested in SPSS and the results below indicated that the errors were independent of each other, the errors had equal variances and the errors were also normally and randomly distributed.

Table 23: Levene's Test of Equality of Error Variances[a]

F	df 1	df 2	Sig.
1.289	12	89	.239

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Design: Intercept + Gender + Year + Age + Gender * Year + Gender * Age + Year * Age + Gender * Year * Age

Since $p = 0.239 > 0.05$, Levene's test of equal variances were found tenable. Thus, the null hypothesis of equal variances is retained and it is concluded that there is no difference between the variances in the population.

Post Hoc comparisons were conducted to estimate pairwise differences between group means. For this reason, the Tukey test (Table 24) was performed.

Table 24: Tukey's Multiple Pairwise Comparisons of mean differences

(I) Year	(J) Year	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
3rd Year	4th Year	-.489[a,b]	.483	.314	-1.449	.471
4th Year	3rd Year	.489[a,b]	.483	.314	-.471	1.449
(I)Gender	(J)Gender	(I-J)	Std. Error	Sig.[c]	Lower Bound	Upper Bound
Male	Female	.433[a]	.507	.395	-.574	1.441
Female	Male	-.433[b]	.507	.395	-1.441	.574
Dependent Variable:	Overall use of social media in mathematics					

Post Hoc Tests revealed non significant differences between the mean scores of student teachers who are in third year and fourth year of study ($p = 0.314 > 0.05$). Tests also revealed that there are non significant differences between the mean scores of male and female student teachers ($p = 0.395 > 0.05$).

The current section explored a number of factors such as whether the integration of social media in the teaching and learning of mathematics depends on gender, age or year of study. Statistical analyses using both two-way and one-way analysis of variance were conducted to test the null hypotheses. In addition to the analysis of the research questions, interactions between variables were considered, to determine any effect on each other. Thus, the researchers conducted the two tests as follows:

Null hypotheses

1. **Ho:** Gender has no significant impact on student teachers' use of social media in the teaching and learning of mathematics.
2. **Ho:** Year of study has no significant impact on student teachers' use of social media in the teaching and learning of mathematics.

Choice of significance level = 0.05

The Table below shows descriptive statistics of a (2x2) Year * Gender Cross-tabulation. The information in the Table will be used in subsequent sections to quickly determine whether the mean difference between any pair of groups is statistically significant.

2(Gender: Male vs. Female) x 2(Year of study: 3rd Year: & 4th year)

Table 25: (2x2) Year * Gender Cross-tabulation

		Gender		
		Male	Female	Total
Year	3rd Year	38	4	42
	4th Year	43	17	60
	Total	81	21	102

Results in Table 26 below displays a set of confidence intervals for the difference between pairs of means according to gender and year of study.

Table 26: Analysis of student teachers' use of social media based on gender and year of study

				95% Confidence Interval	
Gender	Year	Mean	Std. Error	Lower Bound	Upper Bound
Male	3rd Year	3.122	.382	2.362	3.881
	4th Year	3.345	.453	2.445	4.244
Female	3rd Year	3.167	.717	.741	3.592
	4th Year	3.222	.492	2.245	4.199

When the Post Hoc comparisons were conducted to determine the pairwise differences between group means, results on Table 24 revealed non significant differences between the mean scores of student teachers who are in third year and fourth year of study ($p = 0.314 > 0.05$).

In order to confirm and determine whether the mean differences are practically significant, a one-way analysis of variance (ANOVA) was conducted. Results disclosed that at a 95% confidence level, the mean scores did not differ significantly based on year of study of pre-service teachers for males and females [3rd year male Mean = 3.122 2, 3rd year female Mean = 3.167, 4th year male Mean = 3.345 and 4th year female Mean = 3.222]. In verifying the hypothesis, the overall results revealed that the use of social media in mathematics pedagogy did not depend on either gender or year of study.

Comparing with previous studies in relation to gender, although in the context of Facebook use only as a social media platform, other studies have found quite the opposite. For instance, García-Domingo et al., (2017), discovered a different pattern of utilizing Facebook between males and females. In their study, females seemed to be more active than males. On the other hand, the findings in this study did not specifically give any reference. On average, both males and females irrespective of their year of study moderately used social media platforms in mathematics activities.

Based on activity theory of this study, we see that both male and female pre-service teachers are motivated and positively oriented to participate in online communities to share knowledge related to mathematics courses. This is consistent with Murphy and Littlejohn (2019), who similarly used activity theory to analyse the social networking of participants.

The ANOVA Table below tests whether the independent variables have an effect on the dependent variable. To observe the interaction effect of the independent variables, the ANOVA will also test for significance using the available F-tests.

Table 27: ANOVA Table-Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.325[a]	12	2.610	1.691	.082
Intercept	154.358	1	154.358	99.998	.000
Gender	1.987	1	1.987	1.287	.260
Year	5.105	1	5.105	3.307	.072
Age	8.216	3	2.739	1.774	.158
Gender * Year	8.410	1	8.410	5.449	.022
Gender * Age	1.836	2	.918	.595	.554
Year * Age	15.532	3	5.177	3.354	.022
Gender * Year * Age	.657	1	.657	.426	.516
Error	137.381	89	1.544		
Total	1482.000	102			
Corrected Total	168.706	101			

a. R Squared = .186 (Adjusted R Squared = .076)

Based on table 27, on gender, the F of 1.287 shows that there is a non statistically significant difference since ($p = 0.260 > 0.05$). Then moving down to the year of study, there is a non statistically significant difference since the F of 3.307 indicates a ($p = 0.072 > 0.05$). The F of 1.774 also shows that there is a non statistically significant difference based on the age of students since $p = 0.158 > 0.05$. Therefore, at the significance level of 0.05 and confidence interval of 95%, we can conclude that since all the three p-values are greater than 0.05, there are no significant mean differences in the use of social media in the teaching and learning of mathematics by university students based on gender, year and age of students. We thus, accept the stated null hypotheses and conclude that it makes no difference whether the students are in third year or fourth year or whether they are male or female.

On the contrary, the interaction effect of "Gender * Year" together with "Year * Age" of student teachers shows that there is a statistically significant difference since ($p = 0.022 < 0.05$) but there is a non statistically significant difference based on the interaction effect between "Gender * Age" ($p = 0.554 \geq 0.05$), and "Gender * Year * Age" ($p = 0.516 \geq 0.05$). The overall results seem to suggest that the use of social media in mathematical practices by students does not depend on either gender, year or age of students.

The Table below shows the results of students' use of social media in mathematics learning activities based on gender.

Table 28: Analysis of students' use of social media in Mathematics by gender

					95% Confidence Interval for Mean	
		Mean	Std.D	Std. Error	Lower Bound	Upper Bound
Number of times I use Social Media per day.	Male	3.63	1.249	.139	3.35	3.91
	Female	3.43	1.469	.321	2.76	4.10
	Total	3.59	1.292	.128	3.33	3.84
Social media tools have a place in my mathematics teaching subject	Male	1.63	.682	.076	1.47	1.78
	Female	1.90	.995	.217	1.45	2.36
	Total	1.68	.761	.076	1.53	1.83
Online and mobile technologies are more distracting than helpful to students for academic work	Male	3.40	.958	.106	3.18	3.61
	Female	3.24	1.136	.248	2.72	3.76
	Total	3.36	.993	.098	3.17	3.56
I Use social media to support my professional career	Male	1.28	.454	.050	1.18	1.38
	Female	1.29	.463	.101	1.08	1.50
	Total	1.28	.453	.045	1.20	1.37
I use Social media in teaching maths	Male	2.12	1.077	.120	1.89	2.36
	Female	2.24	1.136	.248	1.72	2.76
	Total	2.15	1.085	.107	1.93	2.36

According to Table 27, we found a non statistically significant difference based on gender in the use of social media among pre-service teachers in the teaching-learning process of mathematics $(F(1) = 1.287,\ p = 0.260 > 0.05)$ and by year $(F(1) = 3.307,\ p = 0.072 > 0.05)$, although the interaction between these two terms was significant. When a one-way ANOVA was conducted, we see from Table 28 that there are no significant differences in the mean scores of students' use of social media in mathematics by gender between specific pairs of groups. For example, in the number of times they use social media per day (male=3.63; female=3.43), social media tools have a place in my mathematics teaching subject (male=1.63; female=1.90), online and mobile technologies are more distracting than helpful to students for academic work (male=3.40; female=3.24), I use social media to support my professional career (male=1.28; female=1.29) and I use social media in teaching maths scored (male=2.12; female=2.24). These differences are not practically significant. Similarly, Table 29 shows that there are no significant differences in the mean scores of students' use of social media in mathematics by year of study with respect to all the five dependant variables mentioned earlier. For example, fourth year student teachers' mean score of 3.72 about the number of times they use social media per day does not differ significantly than third year students mean score of 3.40 and so on. These results seem to suggest that there is no significant difference in students' use of social media in mathematics based on either gender or year of study.

The Table below reports data on how pre-service mathematics teachers use social media in the mathematics teaching-learning processes as they progress from third year to fourth year of study.

Table 29: Analysis of students' use of social media in Mathematics by year

		Mean	Std.D	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
Number of times I use Social Media per day	3rd Year	3.40	1.170	.181	3.04	3.77
	4th Year	3.72	1.367	.176	3.36	4.07
	Total	3.59	1.292	.128	3.33	3.84
Social media tools have a place in my mathematics teaching subject	3rd Year	1.67	.612	.094	1.48	1.86
	4th Year	1.69	.856	.111	1.47	1.92
	Total	1.68	.761	.076	1.53	1.83
Online and mobile technologies are more distracting than helpful to students for academic work	3rd Year	3.52	.943	.146	3.23	3.82
	4th Year	3.25	1.019	.132	2.99	3.51
	Total	3.36	.993	.098	3.17	3.56
I Use social media to support my professional career	3rd Year	1.33	.477	.074	1.18	1.48
	4th Year	1.25	.437	.056	1.14	1.36
	Total	1.28	.453	.045	1.20	1.37
I use Social media in teaching maths	3rd Year	1.90	1.031	.159	1.58	2.23
	4th Year	2.32	1.097	.142	2.03	2.60
	Total	2.15	1.085	.107	1.93	2.36

A one-way analysis of variance (ANOVA) was performed to explore the mean differences between and within groups just in case we committed a Type II error. The independent variables (see Table 29), gender and year of study included two groups each: [male (81) and female (21); 3rd year (42) and 4th year (60)] respectively. According to Table 26, the ANOVA was not significant (since F =1.287, $p = 0.260$ for gender and F=3.307, $p = 0.720$ for year). Thus, there was insufficient evidence to reject the null hypotheses and conclude that gender and year of study had no significant mean differences on student teachers' use of social media in the teaching and learning of mathematics. However, when a one-way analysis of variance (ANOVA) was conducted, the actual differences in mean scores between groups was quite small based on Cohen's (1998) conventions for interpreting effect size (see Table 28 and 29 on the means).

4.6 Multiple Regression Analysis

Step-wise multiple regression estimates for predicting student teachers' attitudes towards the use of social media in mathematics teaching and learning.

For the purpose of examining the effect of year of study on the longitudinal evolution of student teachers' social media usage in mathematics instructions based on gender, impact of social media in Mathematics Education, this section sought answers to the following questions;

1. Is there any significant relationship between student teachers' attitudes towards social media use and year of study?
2. What is the evolution of student teachers' profiles of social media use in the teaching of mathematics from 3rd year till 4th year of their training program?

The author(s) performed a multiple linear regression analysis in SPSS to test the inter-play of relationships between student teachers' attitudes towards the use of social media and year of study, evolution of social media math profiles and gender, social media use skills and classroom integration, social media use and mathematics pedagogy, profiles of social media use in mathematics and future classroom social media integration. Thus, this statistical test was used to find out if there was any evidence to show whether positive correlations existed or not. Assumptions underlying the multiple regression analysis were checked. The assumptions of independence, homoscedasticity (constant variance), non multi-collinearity and normality were checked and found tenable.

Figure 16 shows a visual comparison of the mean differences of student teachers' overall social media use in mathematics teaching. We can see from the graph comparison that third year student teachers had the lowest profiles of social media use in mathematics teaching while fourth year had the highest profiles of social media use in mathematics teaching. It is therefore, logical to conclude that social media tools have a place in students' mathematics teaching subject as they progress through their training program of study. This is due to the fact that as student teachers progress from third year to fourth year, they are exposed to more technological tools (social media platforms) during lectures and they use some of these technologies during their own learning. This implies that by the end of their Bachelors degree programme, the new graduates are more likely to integrate social media in their classrooms.

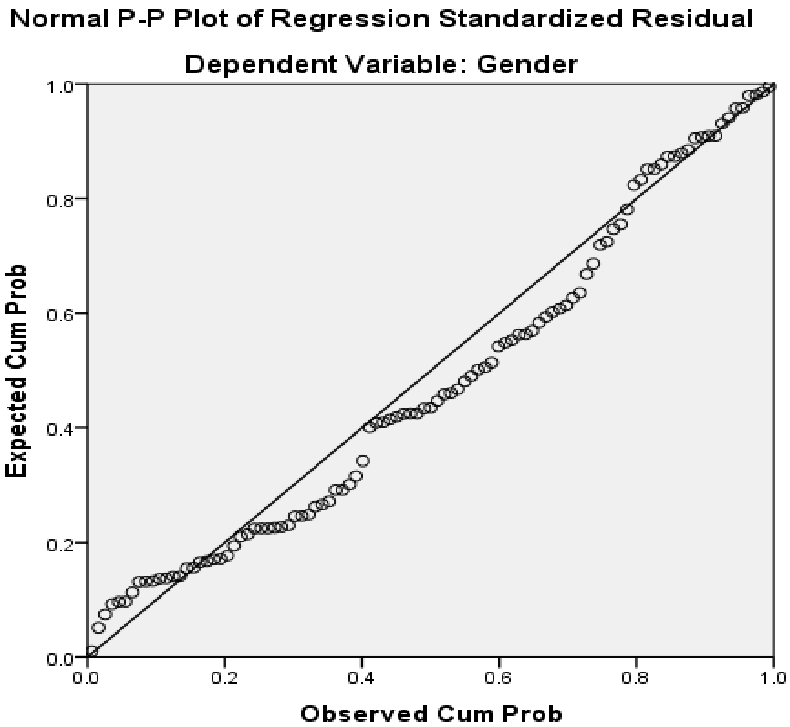


Figure 15: Graph of linearity of the model-diagnostics based on gender.

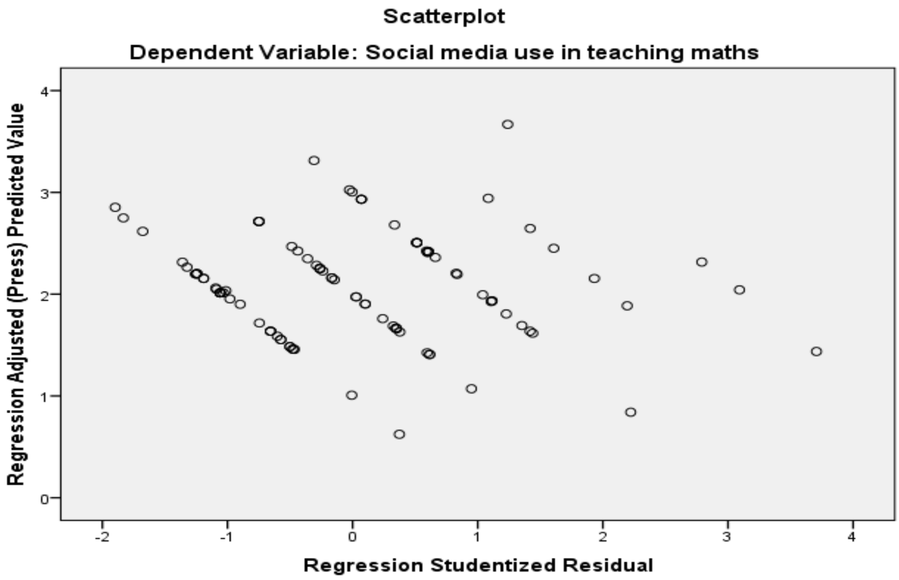


Figure 16: Random distribution of students' Social media use in teaching maths.

Excluding the outliers, Fig. 19, 20 and 21 indicates that the distribution of student teachers' attitudes towards the use of social media in mathematics was fairly normal. The regression line (see Fig. 15) represents the relationship between the independent variables and the dependent variable. The dots from the P-P plot were generally following the diagonal line and this clearly indicated that the residuals were normally distributed. Again the assumption of normality was not violated.

The *F*-ratio in the ANOVA Table below tests whether the overall regression model is a good fit for the data.

Table 30: ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	1.518	1	1.518	4.265	.042[b]
Residual	35.234	99	.356		
Total	36.752	100			

a. Dependent Variable: Age
b. Predictors: (Constant), Social networking (e.g..,Facebook)

Results on Table 30 shows that the independent variables statistically significantly predict the dependent variable, F (1, 99) = 4.265, p < 0.05 (i.e., the regression model is a good fit for the data). Thus, there is a relationship between the age of students and the use of social networking sites such as Facebook, WhatsApp, etc.

The F-ratios in the ANOVA Table below with the associated sig. values tests whether the overall regression model is a good fit for the data.

Table 31: Analysis of students' social media use in teaching mathematics.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.364	1	6.364	6.015	.016[b]
	Residual	102.626	97	1.058		
	Total	108.990	98			
2	Regression	12.486	2	6.243	6.211	.003[c]
	Residual	96.504	96	1.005		
	Total	108.990	98			
3	Regression	18.407	3	6.136	6.435	.001[d]
	Residual	90.583	95	.954		
	Total	108.990	98			
4	Regression	22.680	4	5.670	6.175	.000[e]
	Residual	86.310	94	.918		
	Total	108.990	98			
5	Regression	27.103	5	5.421	6.156	.000[f]
	Residual	81.886	93	.880		
	Total	108.990	98			

Dependent Variable: Social media use in teaching maths

Predictors: (Constant), Social media tools have a place in my mathematics teaching subject, Year, I share online resources (links, documents) for learning mathematics with my classmates., Frequency use of social media for personal purposes, Look for a video to teach me about the mathematics concept

Results indicates that the variables added statistically significantly to the prediction of pre-service teachers' use of social media platforms in the teaching of mathematics. That is; F (1, 97) = 6.015, $p = 0.016 < 0.05$, R^2 = .058, $F(2, 96) =$ 6.211, $p = 0.003 < 0.05$, R^2 = .115, $F(3, 95) = 6.435$, $p = 0.001 < 0.05$, $R^2 =$

$.169$, $F(4, 94) = 6.175$, $p = 0.0001 < 0.05$, $R^2 = .208$ and $F(5, 93) = 6.156$, $p = 0.0001 < 0.05$, $R^2 = .249$. (i.e., the regression model is a good fit for the data). All the five variables added statistically significantly to the prediction, $p = 0.05$.

Table 31 disclosed that positive correlations existed between pre-service teachers' attitudes towards the use of social media and year of study, gender and social media use skills, classroom integration and mathematics pedagogy, profiles of social media use in mathematics and future classroom social media integration. By implication, pre-service teachers have a strong desire to incorporate social media tools in the teaching and learning of mathematics in future. These results seem to agree powerfully with the findings of Acarli and Sağlam (2015) whose study participants were also eager to use social media in their professional lives. This is interesting as activity theory examines online interactions beyond personal benefits. At professional level, we see pre-service teachers working cooperatively and collaboratively as a community (see e.g. Mills, 2017) to learn and integrate social media in mathematics classrooms.

Furthermore, multiple regression analysis was run to determine if there was any relationship between students' use of social media in the teaching of mathematics as explained by five independent predictor variables.

Table 32: Model Summary of the analysis of Social media use in maths.

Model	R	R Squared	Adjusted R Squared	Std. Error of the Estimate	Durbin-Watson
1	.242[a]	.058	.049	1.029	
2	.338[b]	.115	.096	1.003	
3	.411[c]	.169	.143	.976	
4	.456[d]	.208	.174	.958	
5	.499[e]	.249	.208	.938	2.048

Predictors: (Constant), ***a****-Social media tools have a place in my mathematics teaching subject,* ***b****-Year,* ***c****-I share online resources (links, documents) for learning mathematics with my classmates.,* ***d****-Frequency use of social media for personal purposes,* ***e****-Look for a video to teach me about the mathematics concept*

Dependent Variable: ***Social media use in teaching mathematics.***

The mean scores for social media use in teaching-learning of mathematics for each level of gender were normally distributed. Homogeneity of variances was not violated, as assessed by Levene's Test for Equality of Variances ($p = 0.239 > 0.05$) and there were no outliers in the data as assessed by Figure 16. The errors in regression are independent as assessed by the Durbin-Watson statistic which is 2.048. This assumption can be met if the Durbin-Watson statistic is around 2 (and between 1 and 3).

Results from Table 31 show the variability in the pre-service teachers' use of social media in the teaching of mathematics as explained by five statistically significant predictors (also see Table 32). The adjusted R square adjusts for the number of terms in the model. As it can be seen it increases from model 1 to 5 meaning that the new terms added improve the model fit more than expected by chance alone. It is therefore logical to conclude that social media tools have a place in pre-service teachers' mathematics teaching subject as they progress from 3rd year to 4th year through their training program of study.

At the time students enroll as first years at CBU, most of them are already exposed to social media technologies and have registered accounts which they use for personal and professional lives. When the average R-values of the respondents were analyzed, one could also conclude that at the end of their Bachelor's degree programme, the new graduates are very enthusiastic to use social media in their own mathematics classrooms. These results agree strongly with the results reported in the study conducted by Yusuf and Bolaji (2018) in which most of their participants wished to be inclusive of all social media applications for mobile learning and desired that their lecturers could give them tasks which could be solved through the use of social media in a mobile learning platform. In a sense, pre-service teachers in the current study adopted and accepted the use of social media platforms to engage in academic activities.

The general form of the equation to predict "Social media use in the teaching of mathematics" is given by;

$$\boldsymbol{y = 0.242a + 0.338b + 0.411c + 0.456d + 0.499e}$$

The estimated model coefficients show a positive prediction of pre-service teachers' future integration of social media in the teaching and learning of mathematics. The findings in the current study seem to strongly agree with the findings of Akakandelwa and Walubita (2018) at the University of Zambia who reported that most of the sampled students used social media to get new information, stay in contact with friends and for school work.

In order to understand the impact of one or several independent variables (from b to j) on the hypothesized dependent variable (**a-**year of study), the author(s) of this thesis sought to explore the evolution of student teachers' profiles of social media use from 3rd year till 4th year of their training program. A multiple regression was performed to predict year of study from nine independent variables. Therefore, our aim is to test for the statistical significance of each of the independent variables. Table 33 shows the ANOVA testing the statistical significance of the model at each step.

Table 33: Evolution of students' use of social media in Mathematics (Further Analysis of the regression model).

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.004	1	2.004	8.850	.004[b]
	Residual	22.186	98	.226		
	Total	24.190	99			
2	Regression	4.237	2	2.119	10.300	.000[c]
	Residual	19.953	97	.206		
	Total	24.190	99			
3	Regression	5.469	3	1.823	9.349	.000[d]
	Residual	18.721	96	.195		
	Total	24.190	99			
4	Regression	6.689	4	1.672	9.078	.000[e]
	Residual	17.501	95	.184		
	Total	24.190	99			
5	Regression	7.569	5	1.514	8.562	.000[f]
	Residual	16.621	94	.177		
	Total	24.190	99			

6	Regression	8.303	6	1.384	8.101	.000[g]
	Residual	15.887	93	.171		
	Total	24.190	99			
7	Regression	9.162	7	1.309	8.012	.000[h]
	Residual	15.028	92	.163		
	Total	24.190	99			
8	Regression	9.786	8	1.223	7.728	.000[i]
	Residual	14.404	91	.158		
	Total	24.190	99			
9	Regression	10.425	9	1.158	7.573	.000[j]
	Residual	13.765	90	.153		
	Total	24.190	99			

a. *Dependent Variable: Year of study*

Predictors: (Constant), ***b****-Use e-mails more effectively in communicating with my mathematics lecturers than in my class,* ***c****-I share and/or post videos related to my mathematics learning.,* ***d****-Discussion forums (e.g., Yahoo answers, ask.com),* ***e****-Communities,* ***f****-Devices used,* ***g****-Social networking (e.g..,Facebook),* ***h****-Use Facebook chat to contact a friend to get help with a class assignment.,* ***i****-Gender,* ***j****-Age.*

Again, it was discovered that these variables statistically significantly predicted year of study F (1, 98) = 8.850, $p = 0.004 < 0.05$, $R^2 = .083$. All the nine variables contributed statistically significantly to the prediction since ($p = 0.000 < 0.05$) in all the nine cases. This shows that the overall regression model is a good fit for the data.

Results from Table 34 below show the variability in the students' year of study as explained by nine statistically significant independent predictors. In order to assess the overall regression model fit in supporting the research hypotheses, the adjusted R squared was used again to see the percentage of total variance of the dependent variables explained by the regression model.

Table 34: Analysis of relationship between students' attitudes towards social media use and year of study in regression model summary

Model	R	R Squared	Adjusted R Squared	Std. Error of the Estimate	Durbin-Watson
1	.288[a]	.083	.073	.476	
2	.419[b]	.175	.158	.454	
3	.476[c]	.226	.202	.442	
4	.526[d]	.277	.246	.429	

5	.559[e]	.313	.276	.420	
6	.586[f]	.343	.301	.413	
7	.615[g]	.379	.331	.404	
8	.636[h]	.405	.352	.398	
9	.656[i]	.431	.374	.391	.897

*Predictors: (Constant), **a**-Use e-mails more effectively in communicating with my mathematics lecturers than in my class, **b**-I share and/or post videos related to my mathematics learning., **c**-Discussion forums (e.g., Yahoo answers, ask.com), **d**-Communities, **e**-Devices used, **f**-Social networking (e.g..,Facebook), **g**-Use Facebook chat to contact a friend to get help with a class assignment., **h**-Gender, **i**-Age.*
***J**-Dependent Variable: Year of study.*

The adjusted R squared column indicates that 73% of the total variance in the dependent variable (DV) has been explained by how students use emails effectively in communicating with their mathematics lecturers (a); building on the first predictor variable, nearly 16% of the total variance in the DV accounts for how students share or post videos related to their mathematics learning (a and b); 20.2% is explained by three IVs **a**-Use e-mails more effectively in communicating with my mathematics lecturers than in my class, **b**-I share and/or post videos related to my mathematics learning., **c**-Discussion forums (e.g., Yahoo answers, ask.com) (a, b and c); 24.6% is explained by four IVs (a, b, c and d); 27.6% is explained by five IVs (a, b, c, d and e) and so on. This means that the more inclusion of the predictor variables in the model, the model was becoming less and less significant. As a result, the model terminated at 9 showing a statistical significance of the models with a $p < 0.05$.

These nine variables showed a strong ability of prediction of incorporating social media in the teaching of mathematics based on year of study. The general linear regression equation is given by

$$\boldsymbol{y = .288a + .419b + .476c + .526d + .559e + .586f + .615g + .636h + .656i.}$$

However, the improvement of the model above can be assessed at each stage of the analysis by looking at changes in "R squared" and assessing the significance of such change. The value of R squared tends to increase as we include additional predictors in the model.

4.7 Cluster Analysis

Cluster analysis is an exploratory analysis that tries to identify structures within the data. In this section, the goal is to organize data into clusters such that there is high intra-cluster similarity, low inter-cluster similarity and informally find natural groupings among students on how they use social media in the teaching and learning of mathematics. Thus, the author of this doctoral thesis wanted to find out how many groups the data will be clustered into and discover the patterns in the data. However, in hierarchical cluster analysis, we have already conclude that the data was grouped into 3 clusters $(\text{in this case}, \mathrm{k} = 3)$. For this reason, the *k*-means algorithm will be used to partition the input data set into *k*-partitions (clusters).

Thus, a k-means algorithm was run in SPSS multiple times with different starting conditions. The algorithm converged on iteration number 4, proving that on data that does have a clustering structure, the number of iterations until convergence is often small, and results only improve slightly after the first dozen iterations.

To describe the different patterns in the data, the researchers used the guide by Hartigan (1979) and Christopher (2008) suggesting the running process of the k-means algorithm as:

- $n -$ is the number of d $-$dimensional vectors (to be clustered)
- $k -$ the number of clusters
- $i -$ the number of iterations needed until convergence.

The Table below shows how each case in the data was grouped into one of the 3 formed clusters. The first cluster has 27 cases, second cluster has 46 major cases and third cluster has 29 cases (see Table 35, $k = 3$, $i = 4$ and n =102).

Table 35: Number of Cases in each Cluster

Cluster	1	27.000
	2	46.000
	3	29.000
Total		102.000
Missing		.000

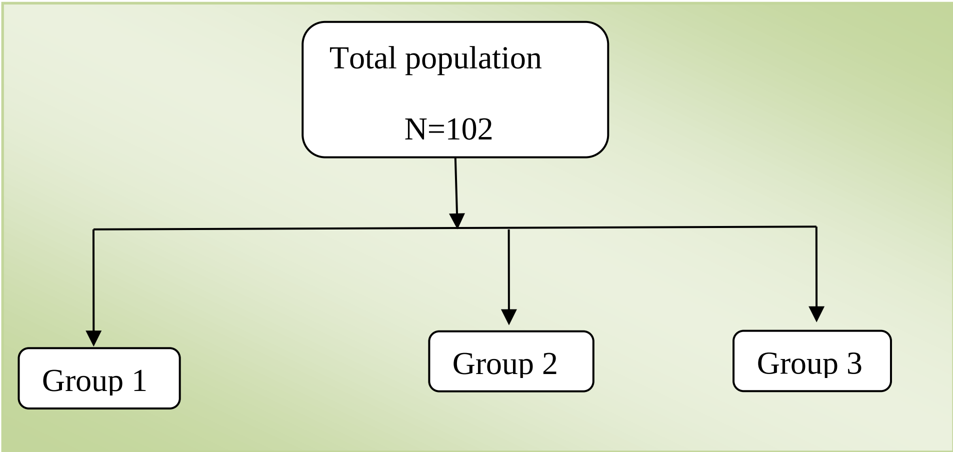


Figure 17: Organized data into groups

Research leading questions:

1. What homogeneous clusters of students emerge based on social media usage scores in Mathematics Education?
2. What is the internal structure of the data based on different groups/variables?
3. What are student groups that need special attention?

These research leading questions intended to explore the structures within the data, organize variables (items) into groups whose members are similar in some way and recognize pattern in terms of students' social media integration in the teaching and learning of mathematics when there is no dependent variable involved. Hence, the 3 questions above helped us to generate logical groups that were the basis for our qualitative investigations.

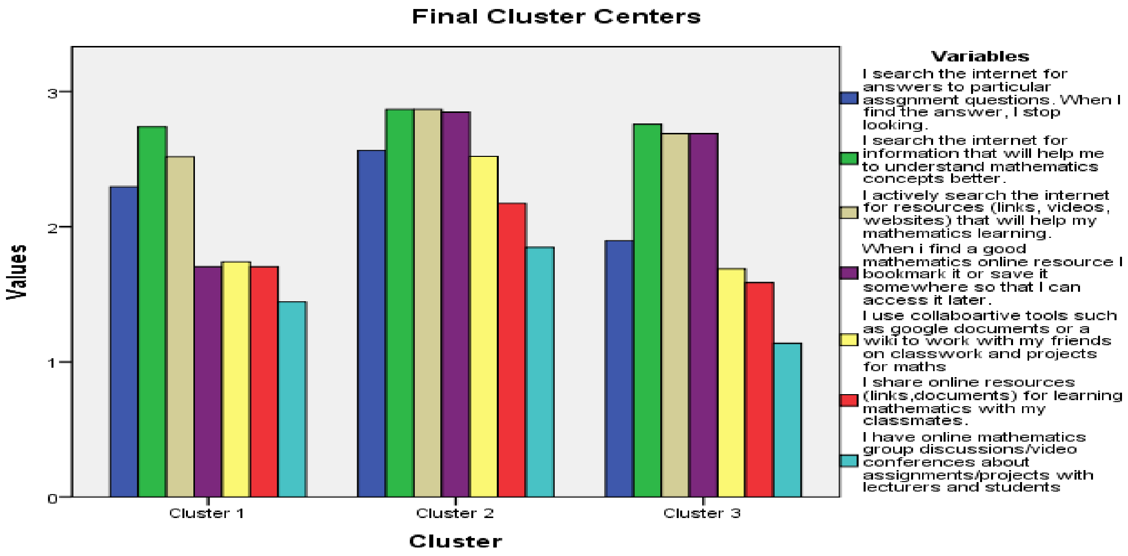


Figure 18: Final Clusters generated

The visual representation of clusters depicted the largest values in Cluster 2, followed by cluster 3 with a relatively small difference recorded in Cluster 1.

Difference between the extent of student teachers' online mathematics behaviours and the 9 investigated variables.

Research Question: Is there a significant difference between the extent of student teachers' online mathematics behaviours in the teaching and learning of mathematics activities and each of the following 9 variables?

1. When completing Math assignments I work in front of my computer so that I can chat online with my friends when I am stuck.
2. When completing Math assignments I work in front of my computer so that I can search the Internet and/or Google.
3. I search the Internet for the answers to particular assignment questions. When I find the answer I stop looking.
4. I search the Internet for information that will help me to understand mathematics concepts better.
5. I actively search the Internet for resources (links, videos, and websites) that will help my mathematics learning.

6. When I find a good mathematics online resource I bookmark it or save it somewhere so that I can access it later.
7. I use collaborative tools such as Google documents or a wiki to work with my friends on class work and projects for Math.
8. I share online resources (links, documents) for learning mathematics with my classmates.
9. I have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and students.

This research question intended to determine the difference of each cluster between variables. Therefore, it called to test the null hypothesis which stated:

> Ho: There is no significant difference between the extent of student teachers' online mathematics behaviours in the teaching and learning activities and the stated 9 variables.

In testing the hypothesis, the researchers employed k-means cluster analysis with a one-way ANOVA to determine whether there were any significant mean differences between two or more clusters on 9 dependent variables. The independent variable, cluster membership, included 3 clusters: ($n = 102$, see Table 36).

Table 36: Auto-clustering of prospective teachers in ANOVA

DV	Cluster Mean Square	Cluster df	Error Mean Square	Error df	F	Sig.
1.	5.823	2	.313	99	18.585	.000
2.	4.521	2	.307	99	14.739	.000
3.	3.977	2	.360	99	11.053	.000
4.	.183	2	.159	99	1.151	.320
5.	1.074	2	.183	99	5.855	.004
6.	11.864	2	.180	99	66.094	.000
7.	8.251	2	.413	99	19.987	.000
8.	3.658	2	.296	99	12.370	.000
9.	4.647	2	.384	99	12.090	.000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Table 36 above shows statistical significant mean differences of each cluster in terms of the 8 out of 9 variables that were computed. Since $p \leq 0.05$, in all cases except for variable 4 with ($p > 0.05$), all the other 8 variables have significant mean differences in clustering. Thus, we reject the null hypothesis and conclude that there is a significant mean difference between the extent of student teachers' online mathematics behaviours in the teaching and learning of mathematics activities and the stated 8 variables while there is no statistical significant mean difference in terms of the way students search the Internet for information that will help them understand mathematics concepts better.

Although there was a performance difference between the three clusters, examining the results, we see that the general extent of student teachers' online mathematics behaviours in the teaching and learning activities were very high on variable 4, 5 and 6 (see Fig. 21) across the clusters with cluster 2 positing the best performance and the least being variable 9 in cluster 3. It can also be argued that cluster 1 and 2 comprised of student teachers with relatively low scores on students' mathematics related activities while online (Fig. 21). On comparison, specifically variable 7, 8 and 9 recorded lower scores in both clusters.

A follow up Post Hoc test was conducted to determine where the actual mean differences lie between the specific clusters. For this purpose, the Tukey HSD test (see Table 37) was performed.

Table 37: Tukey HSD's Multiple Comparisons of mean differences

(I) Cluster Number of Case	(J) Cluster Number of Case	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	.137	.136	.573	-.19	.46
	3	.825*	.150	.000	.47	1.18
2	1	-.137	.136	.573	-.46	.19
	3	.688*	.133	.000	.37	1.00
3	1	-.825*	.150	.000	-1.18	-.47
	2	-.688*	.133	.000	-1.00	-.37
1	2	-.477*	.134	.002	-.80	-.16
	3	.198	.148	.379	-.15	.55
2	1	.477*	.134	.002	.16	.80
	3	.675*	.131	.000	.36	.99

3	1	-.198	.148	.379	-.55	.15
	2	-.675*	.131	.000	-.99	-.36
1	2	-.269	.145	.159	-.61	.08
	3	.400*	.160	.038	.02	.78
2	1	.269	.145	.159	-.08	.61
	3	.669*	.142	.000	.33	1.01
3	1	-.400*	.160	.038	-.78	-.02
	2	-.669*	.142	.000	-1.01	-.33
1	2	-.129	.097	.380	-.36	.10
	3	-.018	.107	.985	-.27	.24
2	1	.129	.097	.380	-.10	.36
	3	.111	.094	.471	-.11	.34
3	1	.018	.107	.985	-.24	.27
	2	-.111	.094	.471	-.34	.11
1	2	-.351*	.104	.003	-.60	-.10
	3	-.171	.115	.298	-.44	.10
2	1	.351*	.104	.003	.10	.60
	3	.180	.102	.185	-.06	.42
3	1	.171	.115	.298	-.10	.44
	2	-.180	.102	.185	-.42	.06
1	2	-1.144*	.103	.000	-1.39	-.90
	3	-.986*	.113	.000	-1.26	-.72
2	1	1.144*	.103	.000	.90	1.39
	3	.158	.100	.261	-.08	.40
3	1	.986*	.113	.000	.72	1.26
	2	-.158	.100	.261	-.40	.08
1	2	-.781*	.156	.000	-1.15	-.41
	3	.051	.172	.952	-.36	.46
2	1	.781*	.156	.000	.41	1.15
	3	.832*	.152	.000	.47	1.19
3	1	-.051	.172	.952	-.46	.36
	2	-.832*	.152	.000	-1.19	-.47
1	2	-.470*	.132	.002	-.78	-.16
	3	.117	.145	.699	-.23	.46
2	1	.470*	.132	.002	.16	.78
	3	.588*	.129	.000	.28	.89
3	1	-.117	.145	.699	-.46	.23
	2	-.588*	.129	.000	-.89	-.28
1	2	-.403*	.150	.023	-.76	-.05
	3	.307	.166	.159	-.09	.70
2	1	.403*	.150	.023	.05	.76
	3	.710*	.147	.000	.36	1.06

3	1	-.307	.166	.159	-.70	.09
	2	-.710*	.147	.000	-1.06	-.36

Dependent Variable: Overall online mathematics learning behaviours

*. *The mean difference is significant at the 0.05 level.*

Results revealed that in terms of item 1 (When completing Math assignments, I work in front of my computer so that I can chat online with my friends when I am stuck), tests revealed that there are significant pairwise differences between the mean scores of student teachers in cluster 1 and cluster 3, cluster 2 and cluster 3 ($p < 0.05$) while cluster 2 does not differ significantly from cluster 1.

Moving down to variable 2 (When completing Math assignments, I work in front of my computer so that I can search the Internet and/or Google), significant pairwise differences between the mean scores of student teachers in cluster 1 and 2, cluster 2 and 1 and finally 2 and 3 existed ($p < 0.05$) but not between the pairs of cluster (1 and 3) and (3 and 1).

Variable 3 (I search the Internet for the answers to particular assignment questions. When I find the answer, I stop looking), shows that the mean scores of students between the pair of clusters (1 and 2) and (2 and 1) are not statistically significant while (1 and 3), (2 and 3) and vice-versa are significant ($p < 0.05$).

Variable 4 (I search the Internet for information that will help me to understand mathematics concepts better), indicates that the pairwise differences between the mean scores of students among the three clusters are not significant ($p > 0.05$). This is consistent with the results on the ANOVA Table on the dependent variable 4 ($p > 0.05$).

Variable 5 (I actively search the Internet for resources (links, videos, and websites) that will help my mathematics learning) shows significant pairwise differences between the mean scores of student teachers in cluster 1 and 2 or 2 and 1 while there are no significant differences in the combination of the remaining clusters as $p > 0.05$.

Variable 6 (When I find a good mathematics online resource I bookmark it or save it somewhere so that I can access it later), shows that there is no significant pairwise differences between the mean scores of student teachers in cluster 2 and 3 or

3 and 2 while they differ significantly between different arrangements of cluster (1 and 2), (2 and 1), (1 and 3) and (3 and 1) since $p < 0.05$ respectively.

Variable 7 (I use collaborative tools such as Google documents or a wiki to work with my friends on class work and projects for Math), indicates significant pairwise differences between the mean scores of students who are in cluster 1 and 2 and cluster 2 and 3. Students in cluster 1 and 3 do not differ significantly from the other two groups $p > 0.05$.

Variable 8 (I share online resources (links, documents) for learning mathematics with my classmates), shows significant pairwise differences between the mean scores of student teachers in cluster (1 and 2) and (2 and 3) as $p < 0.05$ while cluster 1 does not differ significantly from cluster 3.

Finally, variable 9 (I have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and students) highlights significant pairwise differences between the mean scores of students who are in cluster (1 and 2) and (2 and 3) since $p < 0.05$, showing that our findings are significant while students in cluster 1 do not differ significantly from those in cluster 3.

In the next section, we explore the extent of student teachers' social media use in Mathematics based on Clusters. Results are presented in the Tables that follow.

Table 38: Iteration History

Iteration	Change in Cluster Centers		
	1	2	3
1	1.267	1.232	1.060
2	.299	.136	.215
3	.244	.119	.188
4	.134	.040	.129
5	.091	.053	.156
6	.070	.000	.067
7	.000	.000	.000

Convergence achieved due to no or small change in cluster centers. The maximum absolute coordinate change for any center is .000. The current iteration is 7. The minimum distance between initial centers is 2.646.

Again, a k-means algorithm was conducted multiple times with 11 different variables under different starting conditions in order to check which variable belonged to which cluster. The algorithm produced 7 iterations from the 10 selected and converged on iteration number 7. Like before, 3 clusters were formed based on the relative distances $(d = 2.646)$ from each other and their centre of action from the eleven different resources student teachers access whenever they are stuck while doing their mathematics tasks. Table 38 and Figure 19 illustrates this information.

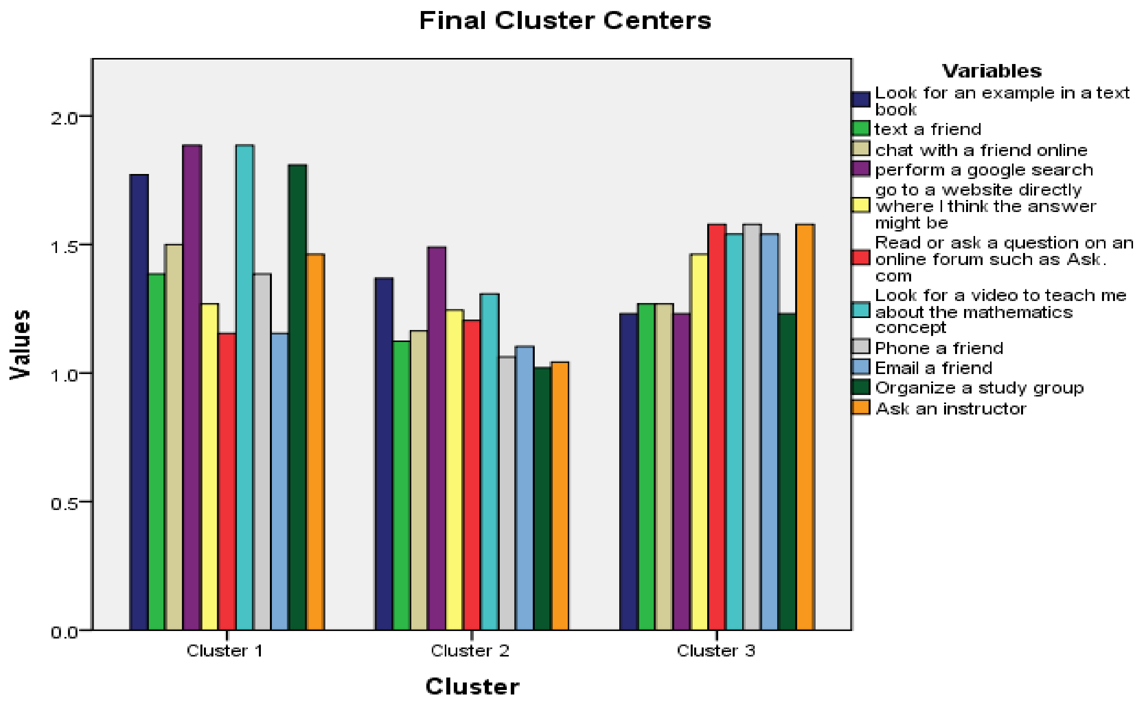


Figure 19: Resources accessed when doing mathematics tasks

As can be seen from Figure 19, the visual representation of clusters depicted the largest values in cluster 1, followed by cluster 3 and the least values in cluster 2. For instance, the bar graph showed the highest values of student teachers "perform a Google search", "look for a video to teach them about the mathematics concept" or "organize a study group" in cluster 1. In cluster 2, a group of students "perform a Google search" more than any other activity, hence recording the highest value of 1.5 while the other 10 activities are relatively low and different.

Lastly, within cluster 3, most of the resources students accesses in order to do a mathematics task are relatively similar within the cluster but dissimilar from other clusters. For example, when stuck doing a mathematics task, students "read or ask a question on an online forum such as Ask.com", "phone a friend" and "ask an instructor" recorded highest values in cluster 3 but relatively low in cluster 1 and 2 respectively. This shows the degree of similarity within clusters and dissimilarity across clusters thereby, allowing us to discover the internal structure of the data based on different groups/variables.

All the cases are grouped into one of the 3 clusters, which is the specialty of k-means cluster analysis. However, we don't know the difference between each cluster in terms of the 11 stated variables. Therefore, this section sought to find answers to the following question:

- What is the difference between each cluster in terms of the 11 variables under investigation?

A one-way analysis of variance (ANOVA) was performed (Table 39) to evaluate the null hypothesis that there is no significant difference between each cluster in terms of the 11 variables of student teachers' most frequently accessed resources when stuck while doing mathematics tasks. The independent variable 'cluster membership' comprised of three clusters (cluster $1 = 26,$ cluster $2 = 49$ & $cluster\ 3 = 26$).

Table 39: Between groups ANOVA

Resources accessed		Sum of Squares	df	Mean Square	F	Sig.
Look for an example in a text book	Between Groups	4.213	2	2.107	10.013	.000
	Within Groups	20.619	98	.210		
	Total	24.832	100			
Text a friend	Between Groups	1.228	2	.614	3.639	.030
	Within Groups	16.535	98	.169		
	Total	17.762	100			

Chat with a friend online	Between Groups	1.928	2	.964	5.161	.007
	Within Groups	18.309	98	.187		
	Total	20.238	100			
perform a Google search	Between Groups	5.674	2	2.837	14.247	.000
	Within Groups	19.514	98	.199		
	Total	25.188	100			
Go to a website directly where I think the answer might be	Between Groups	.847	2	.424	2.011	.009
	Within Groups	20.638	98	.211		
	Total	21.485	100			
Read or ask a question on an online forum such as Ask.com	Between Groups	2.983	2	1.492	8.264	.000
	Within Groups	17.690	98	.181		
	Total	20.673	100			
Look for a video to teach me about the mathematics concept	Between Groups	5.704	2	2.852	14.316	.000
	Within Groups	19.524	98	.199		
	Total	25.228	100			
Phone a friend	Between Groups	4.921	2	2.461	15.744	.000
	Within Groups	15.316	98	.156		
	Total	20.238	100			
Email a friend	Between Groups	3.426	2	1.713	11.711	.000
	Within Groups	14.336	98	.146		
	Total	17.762	100			
Organize a study group	Between Groups	10.604	2	5.302	53.938	.000
	Within Groups	9.633	98	.098		
	Total	20.238	100			

Ask an instructor	Between Groups	5.947	2	2.974	19.789	.000
	Within Groups	14.726	98	.150		
	Total	20.673	100			

Since all the normality assumptions were already tested in SPSS and found tenable, results from Table 39 indicates that the ANOVA was significant since by the foregoing, F (2, 98) = 10.103, $p = 0.000 < 0.05$, $F(2, 98) = 3.639$, $p = 0.030 < 0.05$, $F(2, 98) = 5.161$, $p = 0.007 < 0.05$, F (2, 98) = 11.71 up to $F(2, 98) = 19.789$, $p = 0.000 < 0.05$. In all cases, all the 11 variables have significant mean differences in clustering. Thus, there is enough evidence to reject the null hypothesis and conclude that there is a significant difference between each cluster in terms of the 11 variables of student teachers' most frequently accessed resources when stuck while doing mathematics tasks. It will suffice to say that homogeneous clusters of students emerge based on student teachers' most frequently accessed resources when stuck while doing mathematics assignments. It is from these natural groupings found among students that would inform our selection of the sample for qualitative investigations.

Exploring the structures within the data

Finally, this stage of the k-means analysis process allowed us to organize and group the data together in order to make greater meaning of patterns and consistencies in the data. Additionally, to answer our last research question which states:

- What are student groups that need special attention?

A simple model below (Fig. 20) was constructed on how to measure similar characteristics within a group and dissimilar ones across the groups. Based on these characteristics, a representative sample ($n = 33$) was chosen from the formed clusters for qualitative techniques.

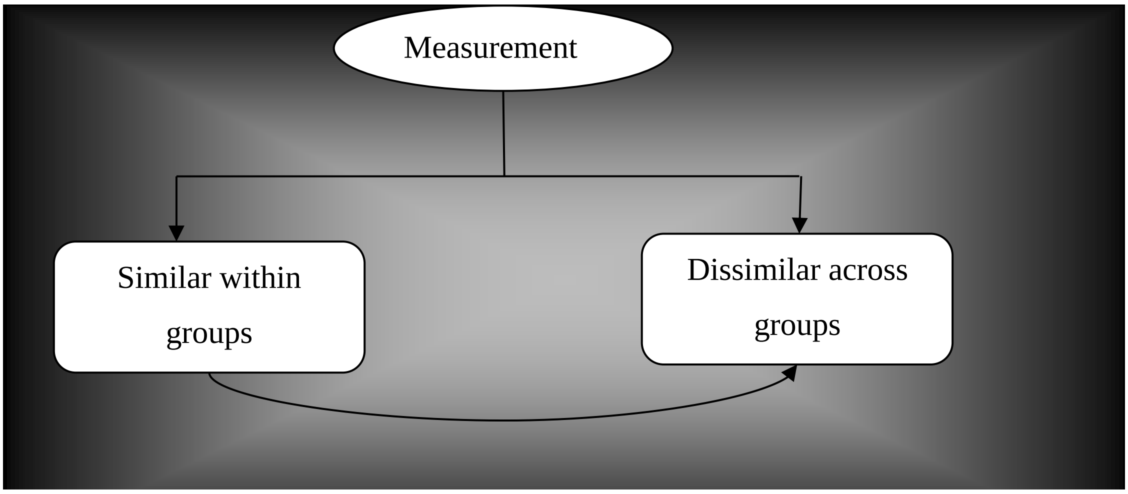


Figure 20: Homogeneous within, Heterogeneous across based on characteristics

Lastly, a k-means algorithm was run with 17 different variables of social media applications (tools) in order to check how university students were using social media platforms to support their mathematics learning and group them into clusters based on their usage characteristics.

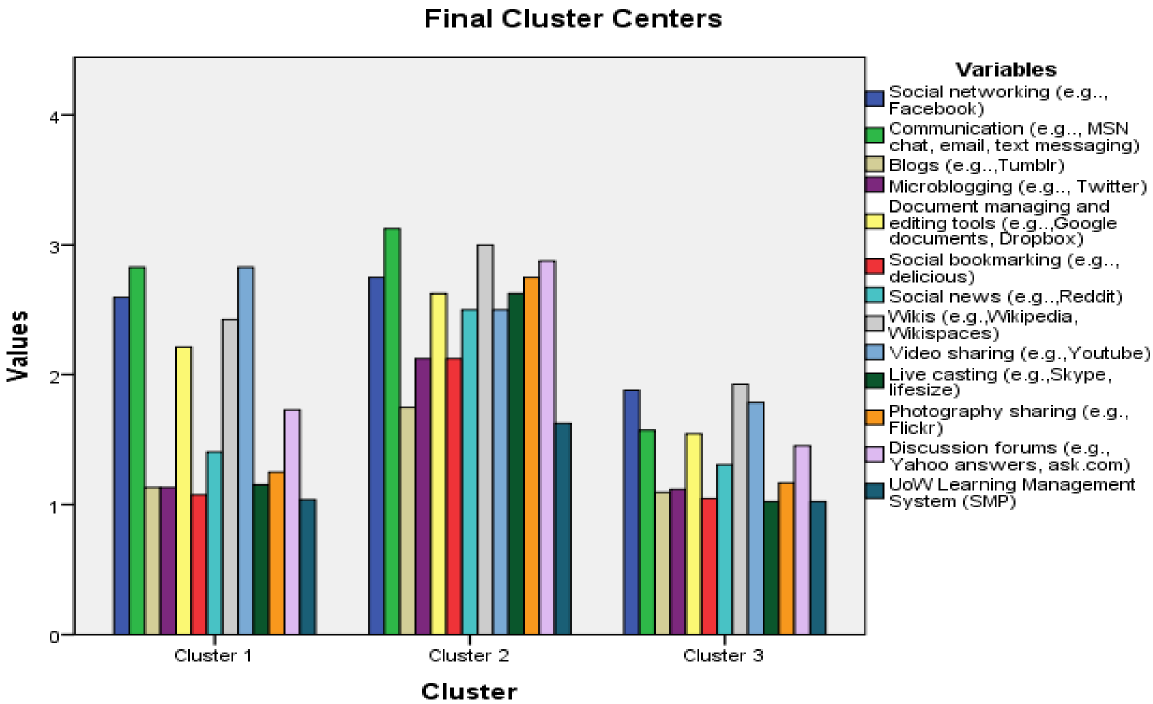


Figure 21: Homogeneous within, Heterogeneous across based on social media platforms used.

A visual representation of the three clusters on Figure 21 shows these clusters naturally grouped based on how student teachers use social media platforms to support their mathematics learning. By inspection, the Figure also shows that students with similar characteristics (homogeneous within) in cluster 2 had the highest mean score values but very dissimilar (heterogeneous across) with the other two clusters. That is, based on the input variables (13 variables on different social media platforms used by students in mathematics teaching and learning); the observation of the response of any student in cluster 1 is very dissimilar to any student in cluster 2 and cluster 3 respectively. Suffice to say that these observed grouped responses of students need special attention.

Figure 21 shows the general performance of pre-service mathematics teachers over a maximum score of 4 according to their responses to the questions comprising the quantitative survey-questionnaire used in this study. Analysing the results, we see that Cluster 1 and 3 recorded the lower scores respectively while Cluster 2 hard the highest scores. In order to fully understand the composition of these Clusters, the profile of the participants has been identified that make up each of them. Results further show that among the 102 participants, 8 out of the 13 social media platforms in Cluster 1 were under utilized and scored below the value of 2 while all the students in Cluster 3 exhibited extremely low or no interest at all or probably a lack of skill of using social media to support their mathematics learning as all the 13 social media platforms scored between 1 and 2 which represents a very poor performance for social media engagement. Yet just 2 out of the 13 social media platforms scored below the value of 2 (both of them belonging to Cluster 2), which represents a good performance of social media usage among pre-service teachers in this Cluster.

Although it can be seen that pre-service mathematics teachers in Cluster 2 performed better than their counterparts in Cluster 1 and 3 respectively, general performance with relative to social media engagement in mathematics discourses was very low in terms of Blogs (e.g., Tumblr), Microblogging (e.g., Twitter), Social bookmarking(e.g., Delicious), Social news (e.g., Reddit), Live casting (e.g., Skype, life size), Photography sharing (e.g., Flickr), Discussion Forums (e.g., Yahoo answers, ask.com) and UoW Learning management system (SMP) with the best performance of the score of 3 in Communication (e.g., MSN chat, email, text messaging) as recorded by participants in Cluster 2 and the least score being 1 in Social bookmarking(e.g., Delicious) from both Cluster 1 and 3 in this case.

Based on the Technology Acceptance Model (TAM) used in this study, one can argue that pre-service teachers in both low ranked Clusters do not perceive that the mentioned social media technologies could be useful to support their teaching-learning process of mathematics. Further, they do not necessarily percieve these technological applications to ease of use. Hence, the perceived difficulty in terms of use of social media technologies to support mathematics learning may have probably contributed to pre-service teachers' negative beliefs about the usefulness of a technology. As a result, these two Clusters characterize participants in terms of exhibiting low technonlogical skills, lack of familiarity and with a negative attitude towards the use of social media in mathematics learning. Because of this, qualitative techniques may later on endeavour to determine the possible intervention measures of each one of these participants in both Cluster 1 and 3.

Table 40 shows the ANOVA testing the statistical significance of the input variables at each step of clustering.

Table 40: Analysis of students' use of social media platforms in mathematics activities

	Cluster		Error			
Input Variables	μ-square	df	μ-square	df	F	Sig.
Social networking (e.g..,Facebook)	6.768	2	.691	99	9.793	.000
Communication (e.g.., MSN chat, email, text messaging)	21.032	2	.410	99	51.281	.000
Blogs (e.g..,Tumblr)	1.495	2	.153	99	9.752	.000
Microblogging (e.g.., Twitter)	3.670	2	.155	99	23.686	.000

Document managing and editing tools (e.g.., Google documents, Dropbox)	6.979	2	.656	99	10.638	.000
Social bookmarking (e.g.., delicious)	4.161	2	.126	99	33.029	.000
Social news (e.g.., Reddit)	4.880	2	.419	99	11.642	.000
Wikis (e.g., Wikipedia, Wikispaces)	5.187	2	.601	99	8.634	.000
Video sharing (e.g, YouTube)	12.665	2	.490	99	25.844	.000
Live casting (e.g, Skype, Lifesize)	8.817	2	.138	99	64.088	.000
Photography sharing (e.g., Flickr)	8.792	2	.294	99	29.927	.000
Discussion forums (e.g., Yahoo answers, ask.com)	6.833	2	.581	99	11.762	.000
UoW Learning Management System (SMP)	1.299	2	.089	99	14.658	.000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Based on Table 40, since $p \leq 0.05$ in all cases for every F-value associated with the input variable, all the variables have significant mean differences in clustering. It was discovered that these 17 variables statistically significantly predicted student groups that need special attention in understanding their feelings, opinions and attitudes on the different types of social media technologies which students use to support their mathematics learning in doing mathematics tasks.

The Table below shows the results of how pre-service mathematics teachers were automatically clustered based on their social media usage in mathematics related activities. Table 41 shows the minimum and maximum scores for each social media application used by each cluster. Three clusters were formed after multiple iterations.

Table 41: Results of the auto-clustering for pre-service mathematics teachers by cluster for each test factor

Test Factors	Cluster	N	Mean	Std	Min	Max
Social networking (e.g..,Facebook)	1	52	2.60	.846	1	4
	2	8	2.75	.886	1	4
	3	42	1.88	.803	1	4
	Total	102	2.31	.901	1	4
Communication (e.g.., MSN chat, email, text messaging)	1	52	2.83	.585	2	4
	2	8	3.13	.641	2	4
	3	42	1.57	.703	1	3
	Total	102	2.33	.905	1	4
Blogs (e.g..,Tumblr)	1	52	1.13	.397	1	3
	2	8	1.75	.463	1	2
	3	42	1.10	.370	1	3
	Total	102	1.17	.424	1	3
Microblogging (e.g.., Twitter)	1	52	1.13	.345	1	2
	2	8	2.13	.641	1	3
	3	42	1.12	.395	1	3
	Total	102	1.21	.474	1	3
	1	52	2.21	.825	1	3

Document managing and editing tools (e.g..,Google documents, Dropbox)	2	8	2.63	.518	2	3
	3	42	1.55	.832	1	4
	Total	102	1.97	.884	1	4
Social bookmarking (e.g.., delicious)	1	52	1.08	.269	1	2
	2	8	2.13	.835	1	3
	3	42	1.05	.309	1	3
	Total	102	1.15	.454	1	3
Social news (e.g..,Reddit)	1	52	1.40	.664	1	3
	2	8	2.50	.756	1	3
	3	42	1.31	.604	1	3
	Total	102	1.45	.712	1	3
Wikis (e.g.,Wikipedia,Wikispaces)	1	52	2.42	.750	1	4
	2	8	3.00	.000	3	3
	3	42	1.93	.867	1	4
	Total	102	2.26	.832	1	4
Video sharing (e.g.,Youtube)	1	52	2.83	.513	1	4
	2	8	2.50	.926	1	4
	3	42	1.79	.842	1	3
	Total	102	2.37	.855	1	4
Live casting (e.g.,Skype,lifesize)	1	52	1.15	.364	1	2
	2	8	2.63	.916	1	4
	3	42	1.02	.154	1	2
	Total	102	1.22	.556	1	4
Photography sharing (e.g., Flickr)	1	52	1.25	.556	1	3
	2	8	2.75	.463	2	3
	3	42	1.17	.537	1	4
	Total	102	1.33	.680	1	4
Discussion forums (e.g., Yahoo answers, ask.com)	1	52	1.73	.795	1	3
	2	8	2.88	.641	2	4
	3	42	1.45	.739	1	4
	Total	102	1.71	.839	1	4
	1	52	1.04	.194	1	2

UoW Learning Management	2	8	1.63	.916	1	3
System (SMP)	3	42	1.02	.154	1	2
	Total	102	1.08	.336	1	3

Results revealed that Cluster 1 had 52 cases, cluster 2 had 8 cases and cluster 3 had 42 cases respectively. The minimum Social networking (e.g..,Facebook) score was 1(Cluster 1, 2 and 3) while the maximum Social networking (e.g..,Facebook) score was 4 (Cluster 1, 2 and 3). As for Communication (e.g.., MSN chat, email, text messaging), Cluster 1and 2 posted the minimum score of 2 while 4 was the maximum score for Cluster 1 and 2. The minimum Video sharing (e.g.,Youtube) score was 1 (Cluster 1 and 2) while the maximum Video sharing (e.g.,Youtube) score was 4 (Cluster 1 and 2). Generally, the minumum score across the clusters for all the test factors was 1 and the muximum was 4.

Based on the technology acceptance model and the activity theory of this study, it can be seen by the forgoing mean scores from the table above that the level of social networking proficiency for pre-service teachers in cluster 2 is higher than those in both cluster 1 and 3 while those in cluster 1 scored higher mean scores than those in cluster 3. This implies that pre-service teachers in Cluster 3 are more likely to exhibit low skill levels in the use of mobile technology and the adoption of social media in relation to mathematics pedagogy. They are also likely to exhibit a negative attitude towards the use of social media platforms in mathematics. This could be because they do not perceive this ‘social software technology’ user friendly or ease of use and consequently do not perceive social media technology to be useful in mathematics classrooms. Such gaps in knowledge of perceived usefulness and ease of use are a worrying factor that might easily affect their future intention to integrate social media technologies into the teaching of secondary school mathematics.

Based once more on the theoretical frameworks of this study, it can be argued that both cluster 1 and 2 comprised of participants who had some challenges in the actual use of social media technology in mathematics transactions. Overall, both clusters perfomed well. Participants in both cluster 1 and 2 realized the need for the online community to cooperate and collaborate to participate in course activities (Cross, 1998). However, the participants' intention to use social media technologies based on each cluster could be affected by external factors such as professional development and accessibility of technological tools.

The Table below displays F-tests tesing the statistical significance values associated with each F-value according to year, gender and age.

Table 42: Clustering students in terms of year, gender and age of students

	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
Year	10.824	2	.031	99	350.308	000
Gender	.802	2	.152	99	5.265	007
Age	11.981	2	.129	99	92.719	000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Based on Table 42, the ANOVA was significant; F (2, 99) = 350.308, $p = 0.000 < 0.05$, $F(2, 99) = 5.265$, $p = 0.007 < 0.05$ and $F(2, 99) = 92.719$, $p = 0.000 < 0.05$. Therefore, year, gender and age have a statistical significant impact in clustering students in terms of social media usage in Mathematics Education. Thus, there is sufficient evidence to reject the null hypothesis and conclude that there is a significant difference between each cluster in terms of how students use social media platforms to support their mathematics learning activities. The overall findings seem to detect the pattern in the data.

The quantitative results seem to suggest that a group of students from these clusters with different and worrying characteristics need special attention to readdress specific concerns emerging from the way they utilize these social media platforms in mathematics classrooms. The specific clusters of concern includes; cluster 2 on Figure

19, cluster 1 and 3 on Figures 18 and 21 respectively. Based on the teacher knowledge frameworks used in the current study, one could easily argue that the low scores could be attributed to participants' perceptions of technology and their lack of familiarity with it as a teaching device. This special group of prospective teachers in these clusters displayed the least scores in the utilization of social media technologies in mathematics activities. This multi-representational approach to teaching to see the mathematical benefit or lack of it in using social software technology is discussed in detail in qualitative findings in the next section.

4.8 Qualitative Findings

This section begins by drawing on findings from a qualitative study to analyze how the Copperbelt University (CBU) students have used social media to support their learning in their respective mathematics courses. Just to reinforce the purpose of the study, the author of this doctoral thesis began this work to explore the use of social media in higher education because he wanted to understand how these new technologies were impacting the lives of mathematics university students. As a result, this section will explore and describe the use of social media by university students for personal, professional, and teaching purposes.

Using a representative sample ($n = 33$) of teaching faculty from the Copperbelt University, the study will probe respondents' use of social media, as well as what value they have seen in including social media sites as part of the mathematics instructional process. The study will require the narratives of thirty-three participants-student teachers' written thoughts, feelings, opinions, comments and suggestions. Using Activity Theory (AT) as a framework for my qualitative analysis, the following areas of Information Systems or Human Computer Interactions (HCI) were identified: subject, tool and object, where the subject is the person being studied, in this case the participant, the object is the intended activity, and the tool is the mediating device by which the action is executed, in this case, the "social media tools". Additionally, activity theory will further "…offer a holistic and contextual method" (Hashim & Jones, 2014, p. 3) of exploring the impact of social media tools to enrich student teachers "…in the following areas: curriculum (what they teach), pedagogy (how they teach), and enriched student-teacher relationships" (Fernandes, 2016, p. 59).

Lastly, this section concludes with the real supposition that not all respondents experience or use social media platforms in mathematics lectures and that there are challenges and obstacles when trying to use social networks for personal, professional or teaching purposes. Thus, the findings are discussed in subsequent sections that follow.

General reasons of the impact of social media on Mathematics Pedagogy

Overall, participants provided many general reasons regarding the impact of social media on the pedagogy of mathematics, discussed in more details below. As expected, based on the stream of existing unearthed literature, in addition to the acquisition of 21st century skills [such as flexibility, researching, learning, collaboration, convenience, time efficiency, etc], pedagogy, curriculum, student-teacher relationships, and reflective teacher practice were the other key reasons commonly shared by the participants.

In the next sections, content analysis of the answers provided by the participants from the clusters are presented to help us understand better what is behind some of the general Figures provided in the Tables of quantitative results. For this purpose, some excerpts containing questions and anwers from thirty-three students are presented in this study to show how the thirty three participants utilized social media in mathematics activities. All the responses of the participants in the open and semi-structured interview used in the qualitative phase have been incorporated in the Appendix section (see Appendix E) in order to facilitate for quick reference and traceability of the qualitative research exercise.

4.8.1 21st century skills

The question in Figure 22, which was extracted from the survey used for data collection in this study, was aimed at assessing whether or not there are benefits to having access to the Internet for learning mathematics. Excerpts from two students are presented on Figure 22 and 23 respectively to show how the two participants benefited from accessing Internet for learning mathematics. The most commonly discussed areas were shared in the area of developing [acquiring] a set of 21st century skills. In this regard, students provided eleven general reasons they felt were the biggest benefits of accessing Internet for learning mathematics. I found it useful to display these shared similar reasons amongst respondents in Table 43 below.

Table 43: Benefits of accessing Internet for learning mathematics

Benefits of accessing Internet for learning mathematics
Makes it easy for collaboration [team work]
Makes it easy for researching
Makes it easy to learn mathematics concepts [topics]
Facilitates better [broad, more, full] understanding.
Helps in saving time
Makes it easy for one to explore
Makes it easy to find assignment material (solutions)
Provides relevant resources (e.g, YouTube tutorial videos, online lectures, etc)
Makes it easy to share [access] related information
Provides a wider knowledge base for mathematics
Platform for questions and answers

One of the benefits of having access to Internet in supporting mathematics lectures is to make it easier to find colleagues through browsers that are available on laptops and Smartphones to collaborate with on mathematics projects. As one student said:

> "It is easier to connect with fellow colleagues of similar interest and quickly get a desired response as well as expanding ones knowledge about a concept".

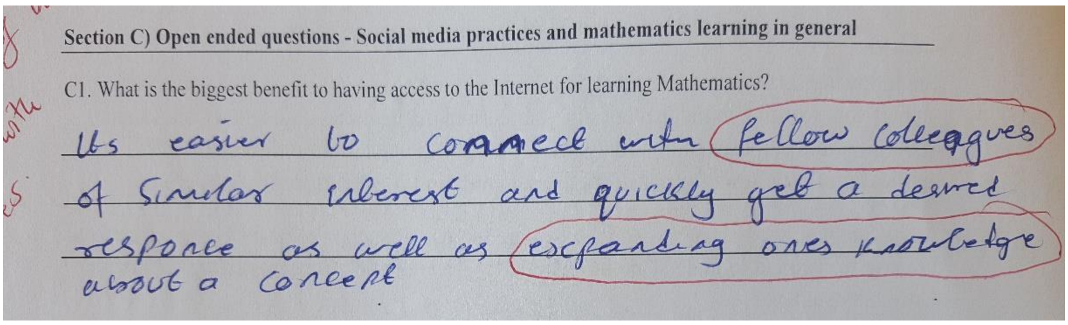
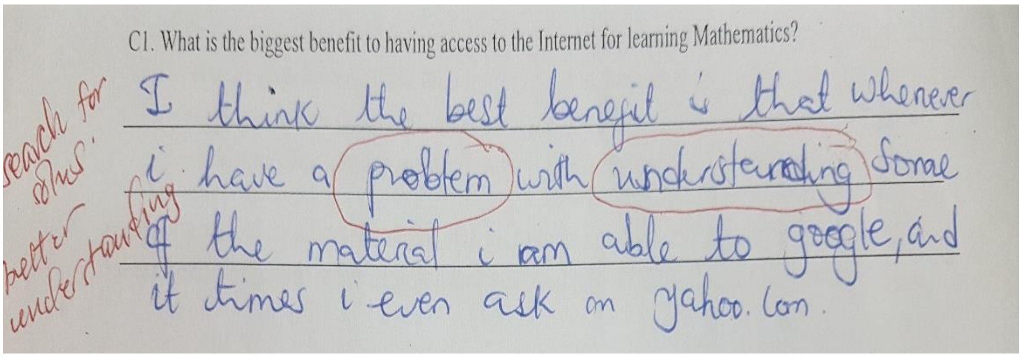


Figure 22: Excerpt from the answer of respondent 1.

Another student commented that:

> "I think the biggest benefit is that whenever I have a problem with understanding some of the material I am able to Google and at times I even ask on yahoo.com".


C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

search for sols? better understanding

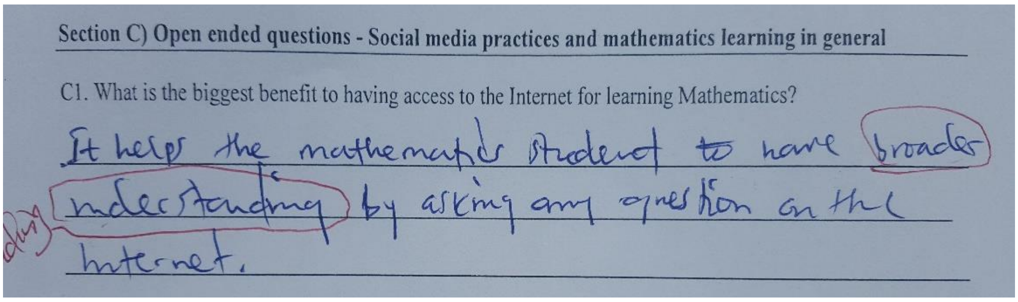
I think the best benefit is that whenever i have a problem with understanding some of the material i am able to google, and it times i even ask on yahoo. Con.

Figure 23: Excerpt from the answer of respondent 2.

This enables students to work as a team, access information anytime and anywhere. As Shanna (2014, p. 8) would contend that Internet access "...also facilitates communication with friends through communication applications such as WhatsApp and Line, students are connected to each other, thus, making it easier for them to discuss or contact one another". In addition, it makes it easy for researching. This is true as a small group of third year students similarly noted that:

> "Sometimes we do research on questions and assignments we are not clear about in class, able to understand math concepts from other peoples' point of view from across the globe and eventually gives a wide range of data to choose from, both that has been done by professionals and approved by experts. It also helps in distributing mathematical concepts faster".

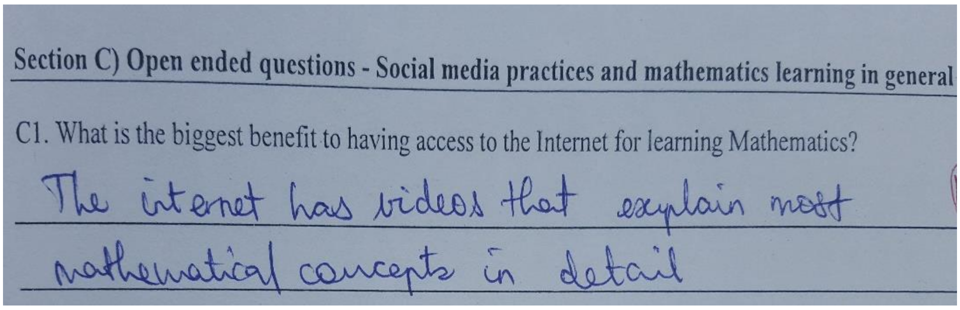
Two other excerpts of the participants' answers are displayed on Figure 24 and 25.


Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It helps the mathematics Student to have broader understanding by asking any question on the Internet.

Figure 24: Excerpt from the answer of respondent 3.


Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

The internet has videos that explain most mathematical concepts in detail

Figure 25: Excerpt from the answer of respondent 4.

Slightly above half (18) of the students felt that Internet makes it easier to learn mathematics concepts [topics] and facilitates better [broad, more, full] understanding. Only five of those students said that "the Internet has videos that explain most mathematical concepts in details" probably students watch videos online to appreciate mathematics lectures more. As one of those five students said:

> "It is easy to learn mathematics concepts from YouTube videos" Coincidentally, another group of five of those students said "concepts are easily understood as you easily have access to Internet unlike a lecturer, e.g, you want to know certain concepts on a weekend [but] you have no access to the lecturer for easy understanding"

Furthermore, this same group of students felt that Internet makes learning mathematics easy, quicker and bearable. The last group of eight students also felt that Internet

> "…helps mathematics students to have broad understanding by asking any question on the Internet, gives full information on concepts about mathematics and helps them with many ways of solving mathematical problems".

As one of these eight students noted that use of Internet “helps you understand what you did not understand in class and helps you to know on a topic you didn’t know” and two students specifically mentioned that “we can get clarity on concepts that we don’t understand in class, e.g watching tutorial videos”. While other few students felt that Internet access helps in saving time, makes it easy for one to explore and find materials for university assignments. As one female third year student noted:

> “One can access information that cannot be [otherwise] found in text books at any time” and another one said Internet “helps in answering assignments”.

On more general terms, students felt that they could search for answers to most challenging questions and find out more about most of the topics in mathematics using the relevant resources available online. They also felt that accessing the Internet enables them to be exposed to many ideas about mathematical concepts and as such they get to know trust worthy information at their convenient time of study. With the acquisition of these 21st century skills, students are able to use Smartphones, laptops and other gadgets on their disposal to search [browse] for information using search engines on the Internet rather than using the university library on various fields of mathematics. Perhaps consciously, students are also using specific social media tools installed in these gadgets to search for data and navigate between different accounts rendering such social media applications indispensable for mathematics learning.

Thus, when asked whether or not student teachers had one online or social media application that they could not live without while studying mathematics, out of the total number of respondents (33), specifically twelve students mentioned that they use YouTube for watching mathematics tutorial videos online. This is consistent with Anna (2019) who would posit that “students use YouTube, in addition to being an entertainment medium, as source of information to search for lecture material” (p. 7). The usage of YouTube while studying mathematics by my study’s participants resonated so closely with the experience of Anna’s (2019) participants who “use YouTube to find tutorial videos related to lecture material such as how to install slim library software, learn English grammar, Corel draw tutorials, catalog making tutorials, design learning, mysql database tutorials, and presentation design for PowerPoint.

In addition, YouTube is also used to upload lecture assignments, and indeed, some college assignments require students to upload video assignments via YouTube" (p. 7). Nearly half of the respondents use Google for surfing [browsing] the Internet. Anna (2019) contends that "Google chrome is the most used browser by students. Students use the chrome mobile application when searching for information using a Smartphone because it is easy to use and simple" (p. 6), Since all our respondents are digital natives, "access to chrome is also smooth and can also be accessed on laptops and computers"(p. 6). On the other hand, one participant student teacher uses WhatsApp, while another one uses Facebook messenger and three student teachers never indicated any choices.

Finally, the ability to use these 21st century skills and share the aforementioned practical benefits of online experiences while learning mathematics actually resulted in a number of student teachers becoming more aware that the connections were in fact enriching to their mathematics pedagogy as discussed in detail in the next paragraphs below.

4.8.2 Pedagogy

In addition to the respondents' acquisition of 21st century skills to enrich their mathematics classrooms through meaningful learning, they can also use social media platforms to influence their mathematics pedagogy both in high schools where they are expected to teach and university learning process. First, it is important to realize that these same respondents were once high school pupils but are now at the university being trained as teachers of mathematics. Thus, it is expected to experience some evolution in terms of social media technologies and its use in teaching. When asked to compare and describe how respondents have used social media or online resources to support their mathematics learning has 'changed' from the way they used them in high school to the way they use them now, almost all the respondents narrated well by giving a clear distinction of social media usage in high school compared to how they use it at CBU. As a novice researcher in qualitative analysis, I found it useful to summarize and tabulate their shared common responses in the Table below.

Table 44: Social Media use in Mathematics Pedagogy

Social media use in high school then;	**Social media use at CBU now;**
-Never used online resources e.g YouTube,	-Now they do use online resources
-Never learnt mathematics online	-Now learns mathematics online
-Depended on hardcopy books and teachers only as sources of information	-Not entirely dependent on the lecturer but also on online resources as sources of information
-No online discussions on mathematics	-Have online discussions with fellow students
-Never used to research online	-Researches more online
-Never owned or used smartphones	-Owns & uses smartphones, laptops, etc
-Never knew anything about Internet	-Knows about Internet more
-All the 33 respondents narrated that all their teachers never used social media in teaching	-Only 21 respondents narrated that their lecturers use social media platforms in teaching
- [If possible] when social media is used, it's only for fun, recreation and entertainment.	-Lecturers also use student portals to share information. -CBU [lecturers]-do not yet have an official virtual campus (online classroom platform).

Despite growing in the digital era and being in different years of study at CBU, respondents had surprisingly similar stories to narrate about mathematics pedagogies in the digital era. Almost all the respondents acknowledged the lack of use of social media technologies or online resources by either themselves or their former teachers in the teaching and learning of mathematics in high schools as opposed to some changes now at university level. This is probably due to lack of exposure to social media tools by then. As one third year student said:

> "Yes it has really changed. Back then, I didn't know that there was educational information on [the] Internet which can help me understand my misconceptions"

And another student commented that:

> "Yes it has changed so much because in high school, I had less knowledge about Internet and could find information not from the Internet but from books [only] and other people"

Though there were pedagogical challenges of incorporating social media tools in mathematics lessons during high school learning years of the two respondents above, however, they wished to integrate these social media technologies in their own mathematics pedagogies when they go for teaching practices. Moreover, a handful of student teachers noted that "mathematics at high school was simpler and straightforward but at university [level] mathematics requires more [online] research" hence in acknowledging the changes both in terms of social media use in mathematics learning and in high school learning, a third year student narrated that the way she uses social media now has really changed because;

> "most of [the] information I needed to know in a particular subject in high school was given to us by teachers other than the lecture method [here] at the university where I need to research [online] on my own on most occasions, therefore, I use more of online sources now."

As a result, several students narrated that at university [CBU], they are able to learn [online] on their own on the topics not taught in class. These same respondents also said that in high school, "they never used to watch tutorial videos online but now they do". Respondents felt that it is easy to learn mathematical concepts from different people unlike depending on the teacher [alone]. In addition to these structural reasons given, a few respondents also felt that "at the university they don't teach but lecture" meaning that as students they have to research more on every topic they cover in class. They feel that at high school [level] everything was given. As three male students in fourth year said the following:

> "I never used social media in any way when I was in high school but now at CBU am using online resources for in-depth learning of mathematics rather than being interested [only] in the answer". The second student said "In high school, I never even had a Smartphone. Hence I never had a privilege to ask questions on [the] Internet" and the third one concluded with "now at CBU, I don't waste much time thinking, if I get stuck I use Google because during high school days I was only depending on one source, the teacher to learn mathematics techniques but now with the availability of resources online, I at least access quiet a number of resources to learn some techniques"

It is not very surprising to get such narratives from students since in most Zambian secondary schools pupils are not allowed to use Smartphones or any other gadgets in classrooms. Subsequently, it can be a pedagogical challenge for teachers to effectively engage social media technologies in their lessons. Due to these probing questions on social media use in Mathematics Education, the three students mentioned above also felt that once they go for their teaching experiences, they will employ the pedagogical methods in mathematics they were once denied to enrich the mathematics lessons. As one of the three students further said "…online resources were rarely used but now they are part of my day-to-day academic life". While appreciating the involvement of social media at university level, respondents felt that "…mathematics has advanced and so are the concepts of learning and this can only be done online". In high school, three quarters of the respondents "never had access to Internet, video sharing on YouTube or Wikipedia documents" and those who had access to Internet and a privilege to use social media platforms used them for fun, entertainment and recreational purposes.

As two other fourth year students specifically mentioned that there is a big change, contrary to high school use of social media tools, "…my use of social media now has given me a broader knowledge of information through the use of Internet tools" commented the first student. Another one said "…in high school I only used social media for fun but now I use it to find solutions to problems". This is perhaps not coincidentally as the rest of the respondents felt that during high school days, they were "…mostly naïve" but now it has been used to their advantage.

A considerable number of respondents said that "they never learnt mathematics online" and so were restricted to what was taught in class but "now they have a variety of options making their lives easier". Specifically one third year student mentioned that "…it has really changed very much. I only used social media in high school for recreational purposes only but now am able to use social media on academic issues [purposes]". Another third-year student felt that "during high school days, she never had enough time to access social media" but all that has changed because "there is so much of using online resources in the university than high school". For instance, respondents have an option of gathering fellow students in Mathematics WhatsApp groups to ask questions and contributions from group members.

4.8.3 Mathematics Lecturers and pedagogy

When asked to describe whether or not CBU mathematics lecturers use any social media applications to deliver content or to interact with students, I had overwhelming responses from participating students. Of the thirty-three (33) participants, twelve students declared that none of their mathematics lecturers use social media Apps in their pedagogical approaches. As one student said "with my mathematics lecturer, the Internet was not part of the talk in the lesson". On the contrary, the remaining number felt that their mathematics lecturers partly integrate social media technologies in the teaching and learning of mathematics. These twenty one respondents felt that their lecturers use social media tools to share educational content with students. That is, emails, WhatsApp, blogs and student portals to distribute [send] course materials, lecture notes, class assignments, handouts, solutions, Internet extracts, maths tutorial videos and tutorial sheet solutions. As five students in the third year specifically stated the following details as the first one said:

> "Lecturers use emails to send lecture notes to students. It is beneficial because we as students receive notes at a better time and anywhere".

The second student out of those five noted that:

> "In university, the lecturers send notes and questions on the WhatsApp classroom group and it has really helped. Some they update them on our student portals for easier access. The use of WhatsApp is regular for lecturers to give

us lecture notes for topics taught in class so that we have extra time to study and understand them"

The third student out of those five felt that lecturers used social media applications only in third year when giving them "tutorial questions and course outlines" as she noted that:

"The lecturer used social media Apps in posting the documents for the course material. It was right for those who have Smartphones and those without were asked to get them from their colleagues".

The fourth respondent out of those five felt that lecturers have been using social media Apps to "give assignments" to students. This is considered beneficial because it enables students become familiar with the "use of technology for educational purposes". He further narrated that:

"Lecturers have been using social media Apps to deliver content because personally, I have been able to receive emails containing documents that have been of great help to me academically. I was at some point receiving Internet extracts which helped me understand certain concepts".

Finally, the fifth respondent acknowledged that lecturers use social media Apps "almost all the time". In confirmation with the previous four mentioned students already, he further felt that lecturers use social media Apps to post "handouts" and "assignments", this is beneficial because sometimes "I may not have money to photocopy handouts, so its better I have them on softcopy". In addition to the structural reasons given already, he concludes his narration by highlighting that:

"university lecturers use social media like WhatsApp and email to send educational content to students".

As a result of these five students' narratives, this allows students to even study at the comfort of their homes. As most of Shannas' (2014) respondents also alluded to the "comfort of working from home, with several specifically noting that they enjoyed the ability to take breaks, have snacks, work 'in your pajamas,' or avoid venturing outside during the cold winter months" (p. 10). In addition to the online pedagogical learning advantages already given, several students said they preferred their lecturers sending them lecture notes as this was considered more beneficial to students as one other student said "…softcopy for me is cheaper than hardcopy". In order for these mathematics lecturers to transfer some of the aspects of social media into learning, students are expected to own Smartphones, laptops, tablets and have access to campus computers. If lecturers are not sending emails with links, math-videos, documents or lecture notes, they are either using social networking sites such as blogs to deliver mathematics content or searching on online communities on their own. A group of students noted that "…once in the university, we had a blog to share information that was pretty helpful for mathematics". Among many other benefits of CBU lecturers using social media platforms to deliver mathematics lessons, this aspect of mathematics pedagogy speeds academic work, gives a quicker and faster access to information, saves time [convenient] and is cost efficient [cheaper].

In agreeing to how mathematics lecturers use social networking tools to deliver content, the rest of the students said "…at times the lecturer sends documents to our emails. This is really beneficial especially [that] we don't have to be in class to receive this information". As one other final year student felt that "…for my research project, it was really beneficial as it saves time rather than having to move to his [the lecturer'] office". Sometimes these mathematics lecturers would be open enough when teaching mathematics in class as some students felt that "…when we need clarity on the lesson in linear algebra, we search [online] together with the lecturer for clarity, it felt as if the lecturer didn't prepare [enough] for the lesson". At other times lecturers would ask students to search on the Internet on their own as respondents said that this is also beneficial in the sense that "…more information was found there unlike just copying notes from the class board". This aspect of pedagogy translates into helping students "…furthering their own research and learn of diversity minds".

Although CBU mathematics lecturers seem to incorporate social media tools in their pedagogical practices, the findings seem to suggest that these mathematics lecturers do not yet have a virtual campus [E-campus] where they can officially share information with students, class updates, post-dates of upcoming events, notices, grades for continuous assessments and lecture materials or their personal profiles before meeting for a class. It is therefore recommended that CBU management creates an official online virtual platform [class] for mathematics for students to freely access all the information they need beforehand. As a result of these pedagogical shifts by the mathematics lecturers, student teachers recalled a change in their own mathematics pedagogy by paying more attention to pupil-interactions and become better facilitators of pupil collaborations.

Reminiscing on the expected benefits of officially using social networking sites to learning mathematics, when student teachers were asked to describe whether or not they believed that the official use of social media can enhance their learning and teaching experience in Mathematics Education, except for two, almost all the other student teachers expressed their desire to officially use social media platforms wherever possible in the teaching and learning of mathematics in secondary schools. Respondents believe that this will enable them have a mathematics pedagogical shift to a less formalized method of teaching that is entertaining and interesting rather than rigorous and traditional as discussed in detail below.

4.8.4 Student teachers and mathematics pedagogy

The narratives of student teachers' experiences concerning the official use of social media tools in Mathematics Education could be somewhat interesting and enriching to their teaching practice. As respondents shared their beliefs and feelings, the most commonly discussed areas of the official use of social media technologies to enhance students' [pedagogy] learning and teaching experience in Mathematics Education where shared in the areas of; (1) bringing about meaningful learning, (2) inculcating research skills in respondents [ability to search online for various information], (3) giving respondents access to various but relevant resources at once, (4) saving time [cost efficient] and (5) exposing respondents to different and better methods of teaching and learning.

In relation to the first three aforementioned areas, more than three quarters of the respondents believed that the official use of social media platforms like YouTube videos to teach mathematics topics makes learning interesting and meaningful. As one third year male student narrated that the official use of social media platforms can enhance the pedagogy of mathematics because "… mostly things that we see are rarely forgotten, so we can use YouTube to see the shapes of objects; for example, when teaching mensuration". Similarly, "…as a mathematics teacher, I believe the official use of social media enhances my learning and teaching of mathematics through video and document sharing" said another fourth-year student. Students believe that it is easy to "remember what they watch" so it will be easier for them to remember in a test. Additionally, "…topics discussed as a group on social media are well explained and brings about motivation, hence easy to recall" commented another fourth-year student.

In order to enhance the teaching and learning of mathematics in secondary schools, respondents felt that promoting online discussions and pupil-to-pupil interactions would make learning not only easy but interesting as well. This would enrich their mathematics pedagogical approaches as it gives learners easier access to information and better teacher illustrations in mathematics classrooms. Another fourth student went on to say that "… if my pupil [learner] has a problem in understanding some mathematical concepts, they can easily WhatsApp or email me". His experiences resonate powerfully with a third-year female student who also believes that the official use social media enhances her teaching and learning experiences. She believes that social media makes it "easier" for her to know "multiple topics" on just "one platform". In more general terms, students believe that the official use of social media in mathematics teaching and learning simplifies the learning process, makes understanding of math-concepts easier, inculcates the research skills in both learners and teachers and eventually promotes independent work.

Regarding the last two areas [4 and 5], the author summarized. Apart from the stated compelling reasons above, a handful of students felt that the official use of social media platforms would help them "save time" and "expose learners to different methods and ways" which may not have been covered in class which may be simpler ways as one third year student noted that:

> "…sometimes I may not be able to go to class, so if that happens better I use social media to communicate with the learners and post any assignments or handouts".

Several respondents felt that since pupils are so alert to using social media networks, so out of their active and eagerness to use social media, it might help to deliver information on social media [officially]. In a sense, these respondents are driving their learners towards e-learning. As the teaching strategies are evolving in this technological era, these student teachers do not wish to be left behind. As two student teachers narrated, the first one said:

> "…the official use of SM enhances my teaching experience because I will use discussion methods of learning to easily discover easy ways of solving mathematical problems".

The second one said:

> "I think it can enhance learning and teaching in the sense that instead of always writing notes in class sometimes they can just be posted online and let every pupil [learner] have access and go through them before they are explained in class".

A considerable group of students had an interesting story to tell, they felt that once exposed to social media, its official use in mathematics lessons would trigger a number of different ways of teaching and learning strategies. Respondents believe that they would always be "up-to-date" with the current needs of the modern society and "distribute information" to the learners effectively with credible information at hand. Among many other expected benefits, respondents felt that through social media use, they would get to "interact" with "fellow mathematicians" from other parts of the world. They further described these interactions to be so helpful. As one third year student narrated:

> "I believe SM can enhance my learning and teaching experience because mathematics is a wide field that at times you may need interaction and discussions on certain challenging topics with the online community people".

Overall, student teachers narrated several other reasons why embracing social networks and for officially adopting to use it in mathematics instructions. They felt that SM would make their teaching career easier. As some said "…they only need a mobile phone and data bundles to search for information" than paying a lot of money for tutorials. Searching for information on Google "would help in the comprehension of mathematical concepts and how to teach mathematics effectively". Respondents prefer having softcopy books to hardcopy ones because it is very expensive for them to buy in book shops.

In contrast, a few felt that "since most of the effective social media tools (mobile phones) are not allowed in secondary schools", it is a farfetched dream to enhance the mathematical pedagogical approaches. Additionally, the Zambian policy on education does not permit a secondary school learner to be in possession of the Smartphones, laptop, tablet or any other gadget in class. That alone makes it difficult for using social media platforms in class, later on to enhance the teaching and learning of mathematics. To affirm this claim, the Zambian policy on Education, Educating Our Future (1996, p. 94) posit that "Zambian resources do not yet allow extensive provision of computers for use as Educational media in the school system, though they are increasingly being used for in-service teacher education in resource centres and are extensively used at the higher level".

4.8.5 Curriculum

Slightly above half of the participants reported that they were able to transfer their experience with the web 2.0 tools to redesign how they delivered content and curriculum in their mathematics classrooms. In order to effectively achieve this, respondents expressed mixed feelings about how the Zambian school curriculum is prescribed, implemented and incorporated by learners to provide quality education.

The respondents' thoughts powerfully resonate with the Zambian policy on education which espouses that "…at every level of education, there is need to identify what is to be taught and learned, how it is to be taught and learned, and the evidence that satisfactory teaching and learning have taken place…" (Educating Our Future 1996, p. 45).

Thus, when respondents were asked to self-report on how social media platforms, technological applications and digital tools may be improved in any way as tools for mathematics learning in Zambian secondary schools, almost all the respondents had interesting stories to tell. Respondents felt that all Zambian secondary schools should provide and allow pupils [learners] to have access to Internet. They felt that if themselves as teachers can have access to the Internet and find it helpful in lesson preparations then it can even be more helpful to meet all learners' needs. Respondents further described this as a "right" for every learner as it is in colleges and Universities and that the curriculum should be inclusive of complete learners' needs regardless of them being in secondary schools. As one third year student said:

> "…the board of education should make sure that all schools have wifi so that everyone can access it" and another said "…each institution [school] should open a free wifi and all pupils [learners] to access the Internet but with restrictions. That is, only for academics".

In a sense, respondents are advocating that secondary school pupils learn better if the curriculum is not so rigid so as to exclude the much-needed technological facilities. In this digital era, in order to provide meaningful learning, curriculum specialists and other stake holders must work in collaboration to respond to the needs of the learners. This is why respondents further felt that "all network service providers in Zambia must improve their services [Internet access services]" especially in rural areas so that social media platforms can be easily accessed at a faster rate and affordable [cheaper] prices. This will enable learners to search for study materials without Internet congestion or difficulties irrespective of their geographical location.

In addition to the structural reasons given already, several respondents felt that school administrators "…should promote reliable online communities that focus on mathematics and alerting learners about the availability of such communities" while others felt that "…by having many educational sites or pages for instance, on Facebook. Also, teaching computer skills to pupils [learners] at an early stage so that they develop an interest in online learning thereby utilizing social media". Respondents thought that this was necessary so as to orient the learners on the basics of social networking sites.

A considerable number of respondents felt that the Zambian government must ensure to provide enough learning and teaching resources such as computers for each school, creating technology laboratories and legalizing the use of Smartphones in class at secondary level for educational purposes. Suffice to mention that in this modern world, every mathematical topic and skill should be directly or indirectly linked to the learner's immediate environment, thus the content and methodologies of the curriculum should be relevant. This is why two fourth year students had this to say as one noted that:

> "…If new educational phone applications are made, maybe mathematics learning can be enriched by these Apps rather than just improving Facebook and WhatsApp."

Respondents felt that learning mathematics with such rich installed math software can be very entertaining and interest stimulating at the same time. They further argued that "secondary schools are quite tricky in the sense that most devices [Smartphones] are not allowed. But increasing on mathematics software and applications on the school computers solely meant for mathematics" can be one of the ways to improve the learning and teaching of mathematics in Zambian secondary schools. A handful of the respondents felt that "…these applications should contain all the necessary formulae, symbols and their clear use [applications]". Furthermore, these tools can be improved for learning mathematics by "introducing a mathematical related social media tool where learners can share ideas" and communicate effectively with all the mathematical language contained. With the advancement of technology, if more educational applications [software] for learning are developed, in a way this calls for flexibility in allowing schools to adapt aspects of the curriculum to match local needs and circumstances relating to technological practices.

And the second student said:

> "…things like mathematical software (Mat Lab, Latex, etc.) can be included on social media tools for team working"

The findings seem to suggest that teaching and learning of mathematics can be improved in Zambian secondary schools if the government and school administrators take a centre stage in sensitizing to learners and teachers about the significance of social media tools or Applications most needed for learning. As few respondents noted that "…teaching learners [pupils] and teachers about social media technology" and providing "more educational programs online" would inevitably encourage both parties to participate in online learning interaction communities. As one forth year student further said "…we can design our own social media forum in order to guide learners in the manner we want them, because with these other Apps it is easy for most of them to be destructed". In one sense, these respondents are suggesting of a school policy which should regulate learners' activities while online using these social media platforms. Leaving learners unguided may lead to the abuse of social media.

Respondents highlighted further another barrier as an independent factor. That is, "inadequate supply of electricity". Since in some parts of Zambia there is no electricity and many remote schools depend on solar panels, media education can be very disadvantaging to learners in these areas. Due to these factors that adversely affect the quality of education, many pupils and teachers do not have school computers or access to Internet and as such mobile phones are somehow rendered useless. With the shortage of books in rural areas coupled with the teacher dependency syndrome on face-to-face learning, if the learner does not understand in class, then he/she is doomed.

In contrast, the Zambian national policy on education, Educating Our Future (1996) would posit that "…a further general requirement of the curriculum at this stage is that it should take account of the fact that the child's dominant way of experiencing and learning is through exploration and activity. Hence, the curriculum as taught should stimulate learning through inquiry, guided discovery, problem-solving, application and similar activity-based teaching and learning methods" (p. 45).

Nearly all respondents advocate for the provision of free access to efficient wifi for all the secondary school learners. They further felt that having access to wifi [Internet] would encourage learners to research on their own and reduce on the face to face classroom interactions. Ultimately this would lead to the opening up of social media academic forums in schools for learning mathematics. Since today, educational mobile technology is frequently used in online instruction in Universities worldwide, as a novice researcher, I also wanted to understand respondents' thoughts and opinions if at all "Social Media Studies" could be offered as a course at CBU. Students gave several structural different reasons and suggestions of how the course outline should [shouldn't be]. I grouped their responses and summarized them. The details of the findings are discussed as follows. Twelve respondents felt that it was not necessary to offer social media studies as a course. As two students said:

> "…it shouldn't be offered, we all know how to use social media without having to learn how to as a course" and "…because the use of social media is self-

explanatory and our university shouldn't waste money and resources to train people who are able to do it on their own", commented the second student.

Despite having the school of technology at CBU, few respondents felt that "a social media study programme" was not needed in the CBU learning curricular. Maybe because this is not what industry, commerce and society requires.

Contrary to the minority views, majority (21) of the respondents felt that "the study programme should be [offered] or introduced in the CBU learning curriculum". As several respondents felt that it is necessary to offer social media studies since "students do not know how to best use social media mostly for academic purposes". This will enable learners to have "better access" to social media platforms in order to "study", "share information" and "be flexible" as one gets to study at his [her] own convenient time, in the comfort of their homes thereby reducing travelling costs to campus. Additionally, respondents felt that offering this course at CBU would open doors to many advantages for learning mathematics online. As a few respondents said "…social media is faster and more efficient when teaching mathematics to a large group of people anywhere" around the world at the same time. Perhaps coincidentally, this may lead to massive open online courses (MOOC) being offered at CBU under what is known as "distance education". Furthermore, respondents felt that offering "social media studies at CBU would help the lecturers and students to migrate to the digital world altogether". Though this is advantageous, respondents have their own limitations too. As one student said "…the course should be offered but it should be within the boundaries of teaching mathematics" while others felt that "social media studies should be optional and offered as a half course" since its one of the things one can learn outside the classroom and requires an individual's interest.

As students increasingly saw the relevance of the "social media studies" as a course at CBU, they further described many merits why they felt the course should be offered. As nearly all (21) respondents iterated broad reasons in common that the course would enable lecturers "teach students how to skillfully search for any mathematical information online", "social media netiquettes", "make academic work easier for both the learner and the teacher", "enable students to create different platforms e.g blogs" and act as a source of motivation to study. Among the structural reasons given, respondents had suggestions of what should be contained in the course outline. Below is an “excerpt” of two third year female and three fourth year male students’ narratives regarding the framing of the course outline. The first of those five students suggested that:

> “…since not all students know how to use social media, the course outline should be how, when and where to use social media”

The second student narrated that:

> “…the content must be about social media discipline (Netiquette), how to choose communities that offer [post] proper or relevant mathematical topics, to be a contributor and also ways of having fan through online mathematics learning without losing focus of the core purpose”

The third student out of those five said:

> “…social media studies should be offered as a course. This would enhance students’ understanding of mathematical concepts through skillful online searches. The course outline must describe the importance [uses] of social media in relation to professional or academic purposes”

The fourth student out of those five said:

> “…if this course is offered, students will be acquainted with social media knowledge, the course outline should begin with the basics. For examples, to educate learners on how they can each create a blog connecting to their respective schools”

Lastly, the fifth student commented that:

> “…yes! So as to have people graduate with a better understanding of social media technology. This will eventually give rise to the betterment of Internet [wifi] provision which is a challenge at CBU”.

Overall, respondents felt that having this course offered at CBU would be “beneficial for researchers and students” [and] they would be able to learn how to conduct their research studies. Respondents thought that having this course offered “may give a wider knowledge of mathematics” through online searches. This would enhance students’ mathematical understanding by exposing them to different fields of mathematics across the globe. Through mobile phone applications and [otherwise], students can meet and have mathematical intellectual discourses with different people regardless of their geographical location. Majority of the respondents felt that offering this course in the school of technology would be a good idea.

As an important factor in this study, respondents also felt that the relationships between student-student and teacher-student connectedness would be enriched as a result of the “course social media studies” and the “interactions” it would come with. For instance, one student said that having this “knowledge” on her disposal would enable her to “effectively communicate with her lecturers” and be able to learn anything she wants at any time. Thus, the findings of this study form a basis for recommending CBU to offer online courses in Mathematics Education via online instructors and tutors.

4.8.6 Students’ views on the impact of Social Media

In addition to acquiring the much needed twenty first century skills, using enriched pedagogical approaches (how learning and teaching transpires) and the curriculum (what is being taught), social media technologies have impacted Mathematics Education either positively or negatively in more ways than one. For example, one fourth year male student said “…the impact of social media on mathematics learning is that learners will learn not only to depend on what’s taught in their classrooms but to also do their own research [on social networking sites] for further understanding”. This would make learners not to be entirely dependent on a teacher; with any social networking site, learners are provided with platforms to access information concerning what they learnt at anytime of their convenience.

Furthermore, respondents felt that social media platforms would “…help learners and teachers to easily communicate with each other and their friends and to easily understand any topic well”. In more similar instances, respondents felt that “…social media is more effective to learners who know what they want in terms of education”, they describe this feeling as “very enjoyable” when actively done. So the impact it has is “for easy understanding of mathematics concepts” and it is “difficult to forget”. One would easily argue that social media brings about meaningful learning. A female third year student said:

> "…social media can greatly impact the [learners'] academic performances. It being that the Mathematics Education in Zambia has to cater for both introverts and extroverts, social media can play a helpful [role] to meet [the] needs of all learners"

In one sense, those who maybe shy to participate in face-to-face interactions may inevitably do so on social media without being worried about their personal feelings and insecurities. In addition to the structural reasons, respondents also felt that "…if one makes good use of social media, that is, [for] education, entertainment and other things, it is a very powerful tool". Moreover, a considerable number of the respondents felt that social media "enhances students' thinking abilities", and their "conceptual understanding of mathematics". As two third year students narrated as one said "…it enables students to have [a] better understanding on difficult topics" and the other student said that social media "…makes the learning of mathematics concepts easy by having different mathematical explanations on the same topic. It also increases the learning resources". Meanwhile others felt that social media "enables delivery of [mathematical] information" thereby exchanging knowledge. This is not surprising as more respondents continued to appreciate the positive impacts of social media in Mathematics Education; two other fourth year students shared a common view as one said:

> "…social media is one of the effective ways that students can learn mathematics and the trend is growing if only students can be aware"

While another one said:

> "…in that mathematics is a challenge in secondary schools, creating study groups for example, on WhatsApp can help pupils [learners] understand concepts not understood during lessons"

From the narratives, suffice to argue that social media acts as a link [source] of information. It provides a platform for mathematics discussions and sharing of ideas. Right now few students appreciate the availability of social media in Mathematics Education and hence most people do not end up benefiting. Therefore, respondents feel that "…a lot more can be done to acquaint mathematicians [students and teachers] with social media technology".

On contrast, it is rather not surprising that a quarter of the respondents narrated many negative impacts of social media on Mathematics Education in Zambia. For instance, one female third year student said "…some of [the] students use social media for things which are not academic related" and perhaps coincidentally a fourth year male student also narrated "…I personally feel it is doing more harm than good because I believe very few use it for educative stuffs". Some few respondents felt that social media has impacted Mathematics Education in Zambia negatively" as most of the students spend their time on entertainment social media sites. In addition, they [respondents] feel that social media is not very much appreciated in the Zambian society because "most of the people use it for non-mathematical purposes" hence the impact is minimal. Additionally, respondents strongly felt that social media "is addictive" and "time wasting [consuming]". In more ways than one, respondents felt that social media platforms are highly abused in Zambia because platforms like Facebook and WhatsApp are usually used for "sharing information related to exam malpractices [leakages] or posting immoral pictures and videos" that corrupt and debase the Zambian morals as a Christian nation.

When respondents were asked to describe whether or not social media sites decrease or increase their study time; seven (7) respondents felt that it increases their study time, twenty (20) felt that it decreases their study time and five (5) respondents were neutral with their opinions. The first group of respondents commonly narrated that social media sites increases their study time because "…it takes so much time to find the right information online" for instance, one may take a lot of time to find a specific solution for a specific mathematical question. As one student narrated:

> "…it increases my study time because [social media sites] have a lot of information to display and one has to choose the best information to take, hence one spends double the time if they are not focused"

This resonates powerfully with another student who felt that "…there are many ideas, information and data on the Internet, so you would want to go through all of them, hence increasing your study time". While a few felt that "…doing a lot of unnecessary searches [research] or watching a lot of YouTube videos for mathematics" would inevitably increase their study time. On the contrary, the latter two groups the author summarized as students cited three broad reasons that social media sites are “addictive”, act as “distracters” and promotes lengthy none “academic chats”. For example, one student explained:

> “…social media decreases my study timing; usually I spend more time on Facebook and WhatsApp than I spend on my studies. I can say I spend roughly 70% hours of the day on social media”.

This is not surprising as a considerable number of students narrated that social media decrease one’s study time when “used for social purposes” [none academic] only. For instance, using social media just for entertainment, like listening to music, chatting with friends, downloading songs and watching movies. Students felt that using social media in this way would potentially affect their study time and further described this as “inappropriate” or “wrong” use of social media. One student explained:

> “…social media like Facebook and WhatsApp can be addictive. Hence, spending much time chatting with friends decreases one’s study time”.

It would be logical to conclude that when students are using social media platforms, they end up on entertainment sites and chatting with friends rather than studying mathematics thereby decreasing their own studying time. While other students felt that sometimes they would go on social media with the intention to study mathematics but end up being distracted. As one student said that “…pop ups of unwanted but attractive materials that are not mathematical” end up consuming his studying time. As one other third year student said “…being on social media even for useful things can be time consuming” because as one “…searches for information, they may find that a particular document directs them to another site and when they keep following such directions, time is lost in the process”. In similar fashion, two students in their final years of study shared some common experiences with one narrating that:

> “…social media decreases my study time because each time I am online, my mind will be thinking of chatting with friends and family instead of concentrating on researching”.

Another one said:

> "…well generally, social media decreases my study time because of the distracters that come in especially when people see you online, they would want to chat while you are busy trying to get data".

In more general terms, respondents felt that social media sites decrease their study time because they spend most of their time on entertainment media rather than studying. While a few who were neutral with their responses felt that "social media sites can either decrease or increase your study time depending on what you use them for". Moreover, "…it depends on how one searches for content online". For instance, "if you are using Wikipedia, study time reduces in searching for the right material". Respondents conclusively felt that when social media platforms are used for "social things" only other than for "educational purposes", it decreases one's study time.

However, student teachers are willing to learn to control social media usage in order to enrich the teaching and learning of mathematics in class. As a handful of students felt that social media decreases their study time as they are "…yet to learn how to best control its use". In this regard, student teachers were also asked to leave their comments and suggestions if they had any. The next few paragraphs describe the most common shared views [opinions] and suggestions among all the respondents.

4.8.7 Respondents' comments and suggestions

Three quarters of the respondents (75%) gave some broad suggestions highlighting a number of issues on which different stakeholders such as schools, teachers, learners and the government must work on for social media technologies to take full center stage in Mathematics Education in Zambian schools. Respondents felt that social media would improve the learning of mathematics since it is easy to learn mathematics with Internet. As one male student in his third year said: "…social media can improve [the] learning of mathematics if used wisely and efficiently" and another said "…learning mathematics is easy if you use Internet and so social media should be introduced in different schools and Universities". However, respondents felt that this should be done with "discipline".

To avoid the abuse or misuse of social media in Zambian institutions, respondents suggested that "…schools and the government must educate social media users" about "social netiquettes", "benefits of social media" to both students and teachers and how best they can "control its use" for educational purposes. Two third year students noted that:

> "…the introduction of social media to enhance learning and teaching can be very effective if the intended people to use it are taught to be disciplined. In some cases, social media has been abused or misused by people; they ought to use it for leakages and other immoral things"

In addition, respondents suggested that when it comes to social media, "the schools and the government at large should emphasis on using social media in conducting moral activities which should bring development to the nation". Thus, in their own words, respondents explained that "…social media is beneficial to students at tertiary level with easily controlled limitations while with secondary school pupils, extra care and control has to be taken as it can lead to educational system [life] decay". One may easily argue that since secondary school learners and university students are generally young people, schools and the government must regulate the use of social media in schools and universities based on policies.

A considerable sample of respondents suggested that mathematics teachers must "…make use of social media where necessary", "promote reliable mathematical Zambian online communities" and "implement the use of social media sites in secondary schools". This is beneficial since social media is a very good way of communicating intellectual thought. Respondents further suggested that "…introducing or creating an application with all the in-built mathematical symbols, formulae and equations where students can interact" would facilitate the learning and teaching of mathematics. Respondents felt that if educational applications for learning mathematics are there [designed], it would be helpful for students to better their mathematical understanding through the exchange of knowledge. As one final year student suggested:

> "…introducing a mathematical related App where students can share knowledge, I feel there is need to encourage the development of educational applications that only focuses on teaching school related material, if such applications exist, it would be easy to access information on one social media platform"

In a way, student teachers were advocating for the usage of learning applications [softwares] during mathematics discourses and the use of age-appropriate classroom demonstrations on the mathematical topics to be taught, and to discuss other ways of bringing the mathematics into their classrooms. Such applications may probably include king of maths, pizza fractions, thinking blocks, number pieces and GeoGebra. These respondents desire to prepare their lesson plans which centre around concepts and skills found in topics that are enhanced using social media technology.

On the contrary, a handful of respondents strongly felt that since Zambia is just a developing country, and technology has not yet reached all corners of the country, the idea of using social media in teaching and learning of mathematics may not be realized to its full potential. It appears there are so many factors at play. For example, one fourth year student explained: “…most of our lecturers are Stone Age, so acquainting us with such new technologies now will be of great help with the coming generation we will be teaching”.

Chapter 5: Overall Discussion

This chapter begins with a full discussion, interpretation and evaluation of the overall findings with reference to the reviewed literature and the theoretical frameworks of the study. The chapter discusses findings in relation to the research hypotheses raised, questions asked and objectives to be met. Although section (1.5.2) highlights all the specific objectives of the study, at a quick glance, the overall objective of this research is to assess the frequency at which the students are social networking, and whether it has any effect on their personal, professional and teaching careers. Therefore, in this study, we agree with Albalawi's (2017) definition that social media means any digital tool or mobile phone application used to socially or professionally connect with each other, like WhatsApp, Twitter, Facebook, YouTube and other similar applications. The problem this doctoral thesis addresses is the degree at which social media use in teaching-learning process of mathematics at schools or universities and the perception of its impact [relevance] to Zambian mathematics teachers in terms of their personal, academic and professional (pre-service) careers.

Quantitative results are discussed first arising from the data collected from 102 participants and elaborated by qualitative findings emerging from most frequently discussed areas that 33 participants shared around social media usage. The next section discusses all the details. Using a representative sample ($n = 33$) of teaching faculty from the Copperbelt University, this chapter will describe respondents' use of social media, as well as what value they have seen in including social media sites as part of the mathematics instructional process.

The chapter will require the narratives of 33 participants-student teachers' written thoughts, feelings, opinions, comments and suggestions. In the next sections, content analysis of the answers provided by the participants from the Clusters are presented to help us understand better what is behind some of the general Figures provided in the Tables of quantitative results. For this purpose, some excerpts containing answers from 33 students are presented in this discussion to show how the they utilized social media in mathematics activities. Furthermore, it is expected that participants can also use social media platforms to influence their mathematics pedagogy both in high schools where they are expected to teach and university learning processes.

5.1 Discussion of findings

Based on the analysed results in Table 11, after testing for internal consistency for each of the variables on the questionnaire, most of the items performed well on this test with the highest alpha coefficient value of 0.747 for the 13 items which were closely related to each other as a group on the scale and as applications used to support mathematics learning, implying that the distribution of survey participants according to age and gender was similar to the full-faculty population in each year of study falling within an acceptable degree of consistency and dependability in terms of the data collected.

Demographic data from Table 12 shows that majority (88.2%) of the students owned Smartphones and personal laptops. This is not very surprising as students at university level are expected to be in possession of Smartphones and laptops to facilitate their studies. Mobile phones were the most popular devices used to access social media, followed by laptops and campus computers. This result is consistent with Wickramanayake and Jika (2018). However, it is contrary to previous studies carried by Singh and Gill (2015) and Stanciu et al., (2012) who posited that the major devices used to access social media platforms were laptops followed by desktops and mobile phones. In addition, the findings in this doctoral thesis seem to partially agree with Anna's (2019) findings which revealed that all her respondents were in possession of smartphones with various brands. She further highlighted that the existence of Smartphones is important and can even be said to replace laptops. In Zambia, the most widely used brands by students includes Samsung, IPhone, Apple, Huawei, LG and Alcatel. Additionally, just like laptops, students use Smartphones to store applications while using them.

Anna (2019; p. 1) would posit that "...Smartphones can be filled with various kinds of applications that support learning activities on campus including communication applications WhatsApp, Line, BBM; application to search the web namely chrome, Firefox, safari; application for storing, editing documents wps office, Google drive; calendar, translator, note and others....” Therefore, the “...type of Smartphone used, the amount of memory and storage on the Smartphone, the number of installed applications, applications that help in lectures, and application functions in supporting lectures...” matters so much when it comes to students’ learning. She further concluded her argument that “…Smartphones are used by many people to assist their daily activities, starting from business, health, entertainment and education. Many academics use smartphones to facilitate their activities while on campus, start checking lecture schedules, contact colleagues, change documents, collaborate, and save various jobs to do elsewhere...” (Anna 2019; p. 1).

Zambian students, particularly at the Copperbelt University (CBU) are not an exception. They are also heavy users of Smartphones. In addition to this, only 11.8% of the respondents use these other types of devices such as tablets, home computers, iPads, and campus computers. Suffice to mention that although equipped with similar functions like Smartphones, these other devices [tablets, home computers, laptops etc] are not flexible to carry everywhere hence characterized with a small number of students using them. However, regardless of the gadgets used to access social media platforms and the times spent per day, university students are among the most digital consumers in the world.

Therefore, a question was dedicated to finding out how often students use social media on daily basis. Based on Table 13, the research findings seem to suggest that 29.6% of the students spend 60 minutes per day on social media. Consistent with previous studies done on examining use of social media among college students, also suggesting that students spend between 30 to 60 minutes of social networking (Jacobsen & Forste, 2010; Pempek et al., 2009). Results further revealed that 19.6% of the students spend 2 hours per day on social media and the majority (33.3%) spend more than 2 hours per day on social media. This agrees so well with Chaffey (2016) whose findings highlighted that worldwide, digital consumers on average spend 1 hour and 58 minutes per day on social media platforms and messaging and later on this number increased by over 20 minutes since 2012. This is why it is not surprising that findings from Table 14 suggest that majority (74.5%) of the students at CBU use social media sites for personal purposes daily. It is expected that college students would be heavy social media users because students are far away from home and are free from parental home supervision (Arnett, 2007). Hence, students are expected to stay in touch with family and friends and increase on their social networks. In addition, students spend time on social media daily to stay in touch with old friends and to strengthen bonds with colleagues.

Students further narrated that using social networks for personal purposes helps them release their academic stress. Consistent with the view that for students, university life can be stressful owing to the demanding school work and exams (Tandoc, Ferrucci, & Duffy, 2015) so social media use serves to reduce tension. Finally, about a quarter of students use social media for personal purposes weekly or monthly. Meanwhile recent studies by Chukwuere and Bonga (2018) disclosed that 85.6% of the participants use social media on a daily basis, 4.8% once a week, while 1.5% use it once a month and 8.1% of respondents use it several times in a month. In the present study, the findings seem to agree with Chukwuere and Bonga (2018) who also concluded that most of the respondents use social media on a daily basis.

Despite knowing the frequency with which students were spending time on social media per day, weekly or monthly and whether or not it had any effect on their social or academic life, students' preferred choices of social media online communities may have an impact on their educational, professional or moral life as a whole. The analysis of the results in Table 15 indicated that majority of the students (38.2%) prefer using social media for entertainment or recreation followed by information (29.4%). This agrees with the findings in qualitative analysis were a group of fourth year students narrated common views on using social media for entertainment, that is, for non-academic or non-teaching purposes such as chatting with friends, downloading songs, watching movies, listening to music and so on.

It could be argued that majority of students view social media networking sites as sites for entertainment. This has raised a concern as most Zambian students abuse social networks in the name of entertainment. If they are not posting immoral pictures, they are posting erotic content online or causing scandals or coincidentally making videos that are highly sensitive to the viewers or corrupt the morals (Ryan, Chester, Reece, & Xenos, 2014; Van den Eijnden, Lemmens, & Valkenburg, 2016). In a sense this has led to high abuse of social media platforms in the Zambian society.

Subsequently, this has negatively impacted the social, moral and /or academic lives of many students and tainting the names of the institutions where those students belong to. This explains why only about 26% of the participants use social media platforms for educational purposes and only 29.4% of the respondents use it for informational purposes.

However, there seems to be a contradiction with the findings of Wickramanayake and Jika (2018) who reported that Educational and informational communities were the most preferred by students to other social media communities. In the current study, it could be argued that social media at CBU was extremely popular for entertainment, information and Education among them. Furthermore, qualitative content analysis revealed that participants preferred using more than one social media community simultaneously. While online, they subscribe to many different educational platforms using their emails or join mathematics pages on Facebook. This grants them access to a pool of wealth educational content online and helps them to easily share information. As one student said "promoting reliable communities that focus on mathematics and also alerting students about the availability of such communities to students" In a sense using social media this way brings about positive impact on the academic performance of students.

Another target of the study was to find out students' barriers to accessing social media. Results from Table 16 revealed that "Internet connection costs" were the greatest barrier to social media use among the student-participants at the Copperbelt University, followed by "lack of institutional support", "unreliable Internet connections " and "unstable security and privacy concerns". Some of these barriers were reflected in recent studies. Wickramanayake and Jika (2018) posited that "Internet costs", "unreliable Internet connections", "unstable electricity connections" and "unstable security and privacy issues" as great barriers while Fasae and Adegbilero-Iwari (2016) disclosed that "poor Internet connectivity" and "unstable electricity connections" were the greatest barriers. However, contrary to the findings from the mentioned scholars, despite experiencing load shedding in many parts of Zambia, "unstable electricity connections" was not a barrier to students' social media use at CBU. Most of the students in the current study were very informed about technological issues with regards to social media use and as such "technology" was not a problem to their social media use. Additionally, findings from qualitative analysis seem to highlight that all mobile service providers must improve their Internet services to cut on the unreliable Internet connections and reduce on the Internet costs for students to afford. Furthermore, a group of students narrated that CBU must ensure that free and stable wifi services are made available and accessible by every student in order to smoothen their studies.

Although spending time on social media was not a specific construct to measure in the present study, qualitative findings revealed that spending time on social media had an impact but was not a barrier for learning for the majority of the participants.

5.2 The social virtual classroom

Another important goal of the current study was to explore which types of social media applications students use in their everyday life. Since social media has become an indispensable part of students' everyday life, the distribution of types of social media tools used by students varies among the students (see Table 17). The results shows that 100% of them use social media platforms. The respondents' choices indicated that Social networking (e.g., Facebook) had the highest preference (99.1%), followed by Communication (e.g., MSN chat, email, text messaging) (96.1%), Wikis (e.g., Wikipedia, Wikispaces) (81.3%), Video sharing (e.g., YouTube) (78.4%), Document managing and editing tools (e.g., Google documents, Dropbox) (70.6%), Discussion Forums (e.g., Yahoo answers, ask.com) (59.8%) and Social news (e.g., Reddit) (59.8%). The current study also revealed that the other six social media applications where moderately used but were not used by more than 50% of the students. It is encouraging to note that all the applications were used by the students with Blogs (e.g., Tumblr), Microblogging (e.g., Twitter) and Social bookmarking (e.g., Delicious) being least used (see Table 17).

A question was dedicated to finding out any three of the most favourite social media applications respondents often use to support their mathematics learning, Table 19 revealed that majority (39.2%) of the respondents (40) use WhatsApp, Facebook and YouTube. Further analysis revealed that majority (71.6%) of the respondents use social media sites (e.g. LinkedIn, Facebook, WhatsApp, YouTube etc) to support their mathematics professional development careers. Some of these findings were reported in recent studies. Chukwuere & Bonga (2018) found that 17.7% of the respondents use Facebook, 56.8% indicated WhatsApp, 14.0% also indicated the use of Instagram, 2.6% highlighted the use of Twitter, while 0.7% use Snap Chat and 8.1% use YouTube. Interestingly, the findings in this doctoral thesis seem to agree with Chukwuere and Bonga (2018) who also found that majority of the respondents used WhatsApp more than any other social networking site. Another study conducted by Akakandelwa and Walubita (2017) reported that the most popular social media platform used by the students at the University of Zambia (UNZA) was WhatsApp (83.3%), followed by Facebook (78.0%), Twitter (12.8%), LinkedIn (7.9%), Instagram (7.5%), Imo (2.6%), Snapchat (1.8%), Myspace (1.3%), and Skype (0.9%).

Suffice to mention that high preference rate of social networking sites use like Facebook, messenger, WhatsApp, email, Wikipedia, YouTube, etc) could be because these social media applications are user friendly. In their everyday life, students are either sometimes or regularly or frequently reading or contributing content to different types of social media platforms in their personal, professional or academic lives. Based on frequencies of responses to the open ended questions, students narrated several broad reasons why they have adopted these social media platforms and use them for educational purposes. Among many other reasons, includes; staying in contact with friends, classmates, lecturers and keeping track of their academic updates. Students use their most three favourite social media applications when they want to access information related to class schedules, lectures, assignments from lecturers and uploading assignments.

The findings in the current study at CBU seem to powerfully resonate with the findings of Akakandelwa and Walubita (2017) at the University of Zambia who disclosed that most of the sampled students used social media to get new information, stay in contact with friends and for school work. In supporting the current findings, Sharma and Shukla (2016) reported that among Indian college students, social media was used as a cheaper online medium for chatting with friends, keeping in touch with family and for sharing pictures, documents and videos. This somewhat, demonstrates a positive impact of social media use in the teaching and learning of mathematics in Zambia.

It is also argued in this doctoral thesis that use of social media in mathematics learning processes would reduce the student-teacher dependency syndrome, enhances students' thinking ability, promotes easier and faster communication between or among students and teachers, brings about meaningful learning and eventually a potential tool to meet all learners needs. Some instances of students' responses about the impact of social media and its use in Mathematics Education are provided below, which highlight the strength of feeling over this issue:

> Social media has a very high positive impact on learning because it makes learning mathematics enjoyable and quicker. (Male, Mathematics Education, age 23).
>
> The impact of social media on mathematics learning is positive and it is believed that it will have a great positive effect going forward. (Male, Mathematics major, age 26).
>
> Social media can greatly impact the academic performances. Since the Mathematics Education in Zambia has to cater for both introverts and extroverts, social media can play a helpful role to meet needs of all learners. (Female, Mathematics major, age 20).
>
> Social media is one of the effective ways that students can learn Mathematics and the trend is growing if only students can be aware. (Male, Mathematics, age 24).

In other words, the current study has revealed that social media platforms have positively impacted Mathematics Education in Zambia and university students need to tap into these new technologies in order to effectively use them in teaching mathematics. In addition, social media technologies have come with several other benefits which generally includes; sharing information, corroboration, exploration and cost saving.

However, the current study seems to quantitatively suggest that only a few students (28.4%) do not use social media platforms to support their mathematics teaching and learning (see Table 19). Thus, it is not surprising that some respondents do not view social media platforms as platforms for formal or official learning but rather for social interactions only. In supporting this claim, findings on Table 18 reported that 58.8% of students agreed to the statement that "online and mobile technologies are more distracting than helpful to students for academic work" (6.9% agreed, 3.9% strongly agreed and 48% moderately agreed). This highlights a strong negative impact of social media use on students' academic life.

In addition, based on standard qualitative content analysis, a group of respondents felt that social media has done more harm than good to most students as it is considered to be a time waster. Furthermore, respondents felt that social media decreases their study time since they usually spend more time on Facebook and WhatsApp than on their studies. They described this feeling as an "addiction" since more time is spent on social media platforms chatting with friends thereby decreasing their study time. The findings of the present study were consistent with the findings of (Sultan, 2014) which also highlighted about Internet related addiction behaviours.

The findings in this doctoral thesis seem to highlight that respondents were addicted to social media, which is a negative impact on the social life of students. This agrees with the findings of Ahad & Lim (2014). Thus, social media is more of a social network to some students than an educational network. Some examples of students' responses about using social media for academic purposes are quoted below, which highlight the strength of feeling over this issue:

> Decreases one's study time, because each time I am online, my mind will be thinking of chatting with friends and family instead of concentrating on researching. (Male, Mathematics, age 20).
>
> Decreases my study time, I spend more time on entertainment sites listening to music, downloading songs, watching videos and following news. (Male, Mathematics, age 22).
>
> Social media decreases my study time because usually I spend more time on social media (Facebook, WhatsApp, YouTube, etc) than I spend on my studies. I can say I spend roughly 70% hours of the day on social media. (Female, Mathematics, age 21).

> Right now few students appreciate the availability of social media in Mathematics Education so most students do not end up benefiting anything. (Male, Mathematics, age 25).

Some of these shared common responses (above) in the present study resonate powerfully with the findings of Madge et al., (2009) where students narrated similar feelings about using Facebook for teaching purposes. Based on open ended questions in qualitative data, a handful of students specifically mentioned Facebook and narrated that they had never thought of it as a platform for academic work. This result is consistent with researchers such as Madge et al., (2009) whose respondents were asked if there were any ways they thought Facebook could be utilised to enhance teaching and learning at the university, in their study, 43% responded negatively, explained that Facebook was a social media platform, not a tool for academic work. Hence, a few students at CBU primarily tend to use Facebook for personal purposes. This number is also among the respondents who strongly oppose the idea of introducing social media studies as a course at the Copperbelt University because they felt it would be just a share waste of time and university's resources.

Nonetheless, research has reported that Facebook and many other social media platforms are potential essential tools for promoting effective academic practice.

5.3 Social media- a tool for teaching and learning

Based on the grouped statics of responses on Table 18, the current findings of the study disclosed that majority (91.2%) of the respondents agreed that social media platforms had a place in their mathematics teaching subject. Subsequently, respondents saw themselves using any of the relevant social media applications in teaching mathematics in their teaching careers as 35.5% agreed, 27.5% strongly agreed and 28.4% moderately agreed. These findings reflects students' positive attitude towards the integration of social media platforms in their mathematics classrooms. This is supported by Lee and Boyadzhiev (2020) whose study revealed that students that were previously not successful in acquiring fundamental mathematics skills can be successful in their mathematics courses if they positively change their learning experiences, attitudes, and learning methods.

The results in this doctoral thesis corroborate strongly with the results reported in the study conducted by Yusuf and Bolaji (2018), in which most of their participants wished to be inclusive of all social media applications for mobile learning and quantitatively, 28.9% and 35.1% desired that their lecturers could give them tasks which could be solved through the use of social media in a mobile learning platform.

In a sense, students in the current study adopted and accepted the use of social media platforms to engage in academic activities. Also, their willingness to share knowledge with peers through social media platforms for mobile learning (Yusuf & Bolaji, 2018).

Consistent with Wickramanayake and Jika, (2018) social media tools functions through different platforms to provide various services to their members, and the participants' choices of platforms and their use in mathematics teaching and learning are shown in Tables 20, 21 and 22. To reiterate, quantitative results indicated that 100% of the students were using social media platforms either sometimes or regularly to support their mathematics learning or engaged themselves in online mathematics learning activities. Needless to say, their preferences of the types of social media tools used to support their mathematics learning showed some distinctive variations.

Results from this doctoral dissertation (e.g. see Table 20) showed that the most popular social media platforms used in mathematics activities was YouTube (97%), followed by WhatsApp (94.1%), Wikipedia (88.2%), Facebook (79.4%), e-learning platforms (68.6%), Ask.com (66.7%) and Gmail (61.7%). Firstly, the general findings unearthed that Mathematics Education students at CBU were primarily using YouTube to watch, download or upload mathematics videos related to their classroom lectures. In some instances, they would find tutorial videos online and watch them in order to understand or learn a mathematics concept better from other tutors. Sometimes they find videos related to their class assignments. These findings seem to strongly agree with Anna (2019; p. 7) who posited that "...YouTube is one of the important applications downloaded by students on their smartphones. Students use YouTube, in addition to being an entertainment medium, as a source of information to search for lecture material, students use YouTube to find tutorial videos related to lecture material..."

Secondly, high use of WhatsApp is due to the fact that it allows users to exchange locations, images, documents, videos, and audio or written messages using their Internet connection. WhatsApp has positioned itself as a superior alternative to SMS messaging, which can be very expensive when used in foreign countries due to roaming charges; WhatsApp, in contrast, relies on the active Wi-Fi network (Barhoumi, 2015). Thus, students both within and outside Zambia are able to communicate intellectually on this platform. Qualitative findings revealed that as a platform to support mathematics learning, students are using WhatsApp for sharing information, solutions to assignments, having online mathematics discussions, sharing lecture notes, links, and mathematics concepts among other reasons.

Furthermore, students also revealed that they created or joined Mathematics WhatsApp groups for each mathematics course they take at the university where they share mathematics content, schedule group discussion meetings, air out their opinions without being shy and communicate with their lecturers who are also members of the mathematics groups. Clearly, this provides instant feedback to the students whenever they are in doubt and wherever they may be. It also enables them to have access to their lecturers at anytime regardless of where they are. This positive impact of WhatsApp use on students' learning seem to concur with the findings of Malhotra and Bansal (2017) who highlighted that the usage of WhatsApp in undergraduate students of Veterinary was very popular and brought about positive effect for their learning. In addition, findings of their study disclosed that students in the experimental group were more encouraged and motivated to use WhatsApp instant messaging in social interactions to discuss the classroom lectures.

Therefore, it can be argued that integrating WhatsApp into the students learning activities can help with the learning, sharing of knowledge, acquisition, dissemination, and analysis of information. Barhoumi (2015; p. 13.) posited that "…integrating WhatsApp mobile learning activities is more effective for learning and teaching than the entirely in-class learning process. Teachers using online learning methods have noted the creative use of Internet technology based on mobile learning activities and its facilitation of knowledge sharing among online students…" Based on the findings of the current study, WhatsApp mobile or WhatsApp web learning activities can be powerful and effective tools for students.

Thirdly, Wikis was another third ranked social networking site that was widely used by both students to support the mathematics teachning-learning process during lectures. Based on qualitative findings of the present research, it has been revealed that students use Wikipedia when they are searching for information related to their mathematics content courses (M310, M370 and M320) for easy understanding of mathematical concepts and definitions. Students further narrated that sometimes it is difficult to understand what is taught in a math lecture face-to-face so Wikis helps them further their understanding and clear some misconceptions.

In public domain, existing literature has already unearthed that Facebook and Facebook Messenger are considered easy to use applications for students, many of which are familiar with their use from everyday life. Hence the high score of 79.4% for Facebook use to chat (or MSN or texting) to contact a friend to get help with a class assignment in mathematics related activities is not surprising. Students are also involved in many more other mathematics related activities while active on Facebook.

Findings of the present study disclosed that 54.9% of the respondents create or join a Facebook group with classmates to share homework, links, and to discuss class content, followed by 59.8% share and/or post videos related to their mathematics learning and a considerable number of students from qualitative findings narrated that they use Facebook to get help with mathematics assignments, home works, research works etc by chatting with friends online. In relation to students' online mathematics learning activities, 56.9% of the students expressed that when completing mathematics assignments, they work in front of their computers so that they can chat online with their friends whenever they are stuck. These results seem to suggest that some students at CBU view Facebook as a platform where they can equally discuss intellectual subjects such as mathematics. Many students are using Facebook for educational or professional purposes. This is consistent with Anna (2019) who also revealed that students use Facebook when they want to access assignments from lecturers, upload assignments, and get information related to lectures. Her study further found that only a few students used Facebook for personal purposes. This is quite encouraging as students at CBU do not only use Facebook for social purposes only but majority of them see it as a tool for teaching and learning mathematics. Students also make official Facebook pages or groups for certain mathematics courses where students, lecturers and administrators are members of the groups in order to communicate with each other and stay in touch with their lecturers to keep track of their academic progress (Anna, 2019).

It is therefore without doubt that Facebook is one of the fastest ways of getting valuable feedback among users. However, the findings of this present study seem to contradict with other researchers such as Madge et al., (2009) who disclosed that only 10% of respondents used Facebook for discussing academic work with other students on a daily basis and less than (1%) to contact university staff. This result is not surprising as it probably reflects the fact that students login to Facebook far more frequently for social networking rather than academic purposes and see it predominately as a social tool, not an academic one.

Qualitative data from the same study disclosed that Facebook and Education should be kept strictly apart. Students tend to go on Facebook to get away from the university workload. However, if the university tried to access the students through Facebook, many people would find it distasteful as if the university were trying to encroach on or cripple their social lives. A clear picture therefore emerged from their study whereby the students thought the use of Facebook was most importantly for social reasons, not for formal teaching purposes. On the other hand, my findings seem to suggest that Facebook is a potential tool for education. Whether it is applied to formal or informal learning, Facebook plays an important role in students' learning activities. My qualitative data compliments quantitative data perfectly.

Fourthly, based on quantitative data, findings documented in this doctoral dissertation disclosed that 68.6% would sometimes or regularly access e-learning mathematics materials available via [online] social media platforms to learn mathematics. While teaching and learning can be based in or out of the classrooms, the use of Internet and computers by the students forms the major part of their e-learning processes. Interestingly, regarding e-learning activities, Table 20 revealed that 66.7% of the students ask mathematics questions on an online forum such as Ask.com, followed by 51% of the respondents who answer or comment on a mathematics related topic on a forum such as Ask.com. E-learning has provided numerous opportunities and advantages for students to collaborate with classmates on an online platform using Google docs (44.1%). This is very advantageous for students as e-learning would enable them to attend online courses and have access to resources at anytime and anywhere.

Qualitative data supports the research findings recorded on Table 20 and illustrates that e-learning is convenient and flexible as students can learn mathematics from the comfort of their rooms or homes provided they are connected online and there is a tutor or lecturer teaching. Students expressed concern over unnecessary expenses by travelling to campus for something they could easily learn online. In one sense, they thought online learning is cheaper, saves time and convenient as opposed to face-to-face classroom learning. These findings, however, do certainly support the case made again by Shanna (2013) whose qualitative findings disclosed that flexibility, convenience and time efficiency of online learning helped respondents with busy lives balance their schedule.

It was also reported further that some students said that they chose online learning to reduce the number of times they needed to travel to campus, the comfort of working at home and reduced time travel. In addition to the advantages of e-learning, Table 21 revealed statistics of students' online mathematics learning activities. Students disclosed a series of online or e-learning activities they either sometimes or frequently engage in while doing mathematics. These included working in front of the computer or laptop by 'completing mathematics assignments' through searching the Internet and/or Google, searching the Internet for 'information' that would help them to understand mathematics concepts better, searching the Internet for 'resources (links, videos, websites)' that would help their mathematics learning and 'sharing online resources (links, documents)' for learning mathematics with their classmates. All these online activities help students to learn on their own and broaden their understanding. Through searching the Internet, students are exposed to a wealth of information.

In general, most of the students agreed that they learned better alone searching the Internet or chatting with friends online. To support this claim, respondents in this study agreed to the fact that when they find a good mathematics online resource they either bookmark it or save it somewhere so that they can access it later. Though not mentioned among the social networking sites in the present study, Quora Digest is one of the social media platforms where students can choose topics to follow and bookmark or save interesting spaces for accessing later. Since Quora Digest is a website where questions are asked, answered and edited by Internet users, students can take advantage of this platform and learn a lot by directing their difficult or challenging mathematics questions to the experts.

Interestingly, some students use collaborative tools such as Google documents or a wiki to work with their friends on class work and projects for mathematics. By contrast, only 43.2% of the total students have online mathematics group discussions or video conferences relating to mathematics assignments or projects with lecturers and students. This low number could be attributed to lack of exposure by majority of students or lecturers to social media platforms that can facilitate such kind of online meetings. In addition to lack of exposure, high Internet costs usually inhibit most of the students from participating in online meetings or attending video conferences.

Overall, from the analysed data, it is very clear that a lot of students store apps on their Smartphones that are useful for learning mathematics (80.4%). It is possible that students use these same apps on their other gadgets such as laptops, tablets and home computers by navigating and switching between accounts.

It has been reported in this study that another important application students use to support their learning processes is gmail. Besides the lecturers and all other employees, the Copperbelt University does not provide institutional corporate email addresses to students. By implication, the university does not engage students in any formal or informal online communication through mailing. Therefore, I cannot be sure as a researcher if all the students at CBU have their own created gmail accounts. However, findings of the current study seem to suggest that only 61.7% of the respondents use e-mails more effectively in communicating with their mathematics lecturers than in their classes. It is further argued in this study that unlike Facebook, WhatsApp and other social networks, the use of emails for communication is considered to be more ‘formal’ for communication between students and lecturers.

Furthermore, standard qualitative content analysis revealed that students mail each other sometimes when they need help from fellow students. In addition, they also exchange mails with their lecturers. According to students’ responses, mails appear to be more ‘official’ and work related. With an email platform, students can use it to send or receive books, assignments, projects and other important mathematics documents from their lecturers. Unfortunaly, the Copperbelt University has never provided university email accounts to students as an online way for the university to keep in contact with the students. Thus, not all students have the gmail account on their devices. It is not very surprising that during unforseen closures, opennings or breaks, students would either get the news from the Zambia National Broadcasting Corporation (ZNBC) TV channel or read it on an official CBU Facebook page.

Lastly, the current study also revealed that there were other technological platforms which were never utilized by majority (>50%) of CBU students in their mathematics learning. Among them included: Learning Management System (LMS), blogs, micro-blogging, social bookmarking, live casting, photography sharing, discussion forums and social news. For instance, the percentage representation showed that 94.1% of the participants never use “Learning Management System (LMS)” in their mathematics learning. It could be argued that the high number of students who never use (LMS) is due to either lack of knowledge or not having such a learning system at CBU.

Interestingly, Aabha and Bani (2015), define Learning Management System (LMS) as a software based application which helps to administrate, document, track, report and evaluate the teaching-learning process, training programs, virtual classes and e-learning programs.

It is evident from the findings of this study that both students and lecturers may have never been exposed to such a learning software application or web-based technology which can be used to plan, implement or assess the learning processes in mathematics courses. To support this, qualitative content analysis revealed that there is no virtual campus [learning] at CBU and as such lecturers do not have mathematics online classes or a virtual campus where instructors can create and deliver mathematics content, monitor student participation, assess student performance or share the mathematics learning materials in advance for students to download and study before going to class. Also, students can see the course material to check how lecturers teach mathematics courses before signing up for a course (Landsberger, 2004;

Suwannatthachote, & Monsakul, 2007). But since this is not the case at CBU, this leaves students to be entirely dependent on the lecturer's same hard copy lecture notes. This explains why some mathematics lecturers hold the same lectures every year.

It is therefore argued in this doctoral thesis that if there was a virtual learning platform at CBU for mathematics students, learning materials could be updated and improved before being posted on the virtual learning platform. It is further argued that there are a lot of benefits to 'flipped classroom' over traditional lectures. Studies have shown that one aspect of LMS is that it brings about meaningful learning. Another important feature of LMS is to provide an environment for learning and teaching without the restrictions of time or distance (Epping, 2010).

Contrary to the findings reported in this doctoral dissertation, LMS is used in many universities worldwide. Previous studies have disclosed many advantages of LMS in higher education. Morris (2004) and Elaine and Seaman (2005), posited that If any institutions plan to operate traditional courses online, a Learning Management System is the top most necessity in order for the proper organization of content, courses, faculty, students and grades. Unfortunately, this is the learning system which is never utilized by majority of Mathematics Education students at CBU. This is a sad reality because the Copperbelt University administration has not yet integrated the Learning Management System (LMS) into the university's daily teaching and learning processes. Thus, without Learning Management System as it is the case at CBU, it would be very difficult to "plan, implement and deliver" the mathematics instruction and training in an effective way (Aabha & Bani, 2015; p. 5).

In addition to the least used Apps for learning mathematics, the author argues that majority of students had deep concerns of possible unfamiliarity with social media technologies like Tumblr, Twitter, delicious, Zoom, Lifesize, Flickr and Reddit. Moreover, the high frequencies of students who never use blogs (85.3%), micro-blogging (82.4%), social bookmarking (89.2%), live casting (84.3%), photography sharing (77.5%), discussion forums (52%) and social news (67.6%) was a clear indication that students never owned any active account based on the mentioned technological platforms. This was not very surprising as these were not common social networks used by students.

Furthermore, qualitative content analysis revealed that mathematics lecturers tend to shun using such technologies on their disposal. In the exact words of the narratives of students, they described their mathematics lecturers as coming from a "stone age". Students cited an instance where both the lecturer and the student fail to make it to a face-to-face in class learning, it is advisable to conduct an online lecture. However, no student claimed to have attended an online mathematics lecture through Lifesize or Zoom conducted by their lecturers. In such instances, lectures are either rescheduled or cancelled. This adversely affects the academic performance of the students.

It is thus advised in this dissertation that mathematics lecturers must take full advantage of the available technological platforms [applications] to realize meaningful learning. Contrary to the popular view of the participants in the current study regarding photography sharing, previous studies by Cadavieco, Goul~ ao and Costales (2012) as well as Crnovrsanin, Muelder, Faris, Felmlee and Ma (2014) hold the view that mathematics lecture notes should include photos, as visualization is effective for the effective learning of students.

Surprisingly, among the many active student bloggers who are twittering more and more these days, majority (82.4%) of the students at CBU never use Twitter for mathematics purposes. This is partly because Twitter is a social networking site which allows users to publish short messages known as tweets and can only be 140 characters or less in length. Thus, only a few students use twitter for mathematics tweets and follow experts in mathematics on Twitter. Students with over 140 characters of mathematics questions find it difficult to tweet and if they do, for someone to properly read their tweet, he/she has to navigate to other social media platforms like Facebook. This probably becomes a challenge to students who are not registered on other social networks.

However, a clear picture seems to emerge from the findings whereby the students thought the use of Twitter and other least used technological social media platforms in maths was most importantly for social reasons, not for formal mathematics learning purposes. As discussed earlier, this is why the time spent on social media for social purposes was sometimes to the detriment of that available for mathematics learning and teaching purposes.

When the data was further quantitatively analyzed, ANOVAs where carried out to verify the hypothesis that gender, age and year of study had no significant impact on student teachers' use of social media in the teaching and learning of mathematics. Results from Table 28 and 29 disclosed a non-statistically significant difference on all the three variables [Gender, age and year].

In verifying the hypothesis, the overall results revealed that the use of social media in mathematics pedagogy by students did not depend on either gender, year of study or age of students. We thus, returned the null hypothesis and concluded that the age of students was immaterial. It therefore, makes no difference whether the students are in third year or fourth year or whether they are male or female.

In relation to gender, although in the context of Facebook use only as a social media platform, other studies have found quite the opposite. Marta García-Domingo et al., (2017) discovered a different pattern of utilizing Facebook between males and females. In their study, females seemed to be more active than males. On the other hand, the findings in this doctoral thesis do not specifically give any preference. Despite having a small number of females (21) who participated in this study, results highlighted that they at least owned a Facebook account and where also registered on other social media platforms. This is a good indication. In sum, Table 27 revealed that there was a non statistically significant difference based on the interaction effect between "Gender * Age" ($p = 0.554 \geq 0.05$), and "Gender * Year * Age" ($p = 0.516 \geq 0.05$). These findings shed more light on the impact of various personal and demographic variables on how students use social media per day in mathematics instructions.

When a one-way analysis of variance (ANOVA) was conducted, the actual differences in mean scores between groups [gender and year of study] was quite small based on Cohen's (1998) conventions for interpreting effect size (see Table 28 and 29 on the means). For instance, in relation to age, we have found a different pattern on age groups. Earlier on, Table 12 highlighted the age distribution of participants at CBU of which majority (70%) of the participants belonged to the age group of between 22 and 25. About 14% of the participants belonged to the age group of between 18 and 22. However, this is somehow contrary to the findings of Wickramanayake and Jika, (2018). In contrast, the overall results of the current study confirmed that Zambian students usually enroll in universities immediately after they complete their Senior Secondary School Certificate Examination (SSSCE) at the age of 18. At this age, they are already exposed to different types of social media technologies.

Although there is a dearth of comparative studies analyzing the use of new technologies depending on the age, contrary to this study's findings, previous studies seem to highlight that a low-age is associated with a high-exposition to ICT/social networking sites (García-Domingo, Aranda & Fuentes, 2017; García-Jiménez, López de Ayala y Catalina, 2013). Additionally, García-Domingo et al., (2018) argued that this highlights the significance that this 'age' has in the abuse of social media, as a catalyzing factor of addiction.

In order to have a sounder result, the author of this doctoral thesis examined the subject in a more detailed manner by performing a comprehensive statistical technique which takes into account the inter-play of relationships between variables. In evaluating the multiple regression analysis results, none of the assumptions were violated. The statistical values obtained in Tables 30, 31, 32 and 33 disclosed that there is statistical evidence that positive correlations exist between student teachers' attitudes towards the use of social media and year of study, evolution of social media math profiles and gender, social media use skills and classroom integration, social media use and mathematics pedagogy, profiles of social media use in mathematics and future classroom social media integration.

One can easily conclude that respondents had positive attitudes towards the use of social media in mathematics. It is therefore, logical for one to conclude that social media tools have a place in students' mathematics teaching subject as they progress from 3rd year to 4th year through their training program of study (see Fig. 18). By the time students enrol as first years at CBU, most of them are already exposed to social media technologies and have registered accounts which they use for personal and professional lives. Moreover, when the average values of the respondents were analyzed, one could also conclude that at the end of their Bachelors degree programme, the new graduates are very enthusiastic to use social media in their own mathematics classrooms.

When a step-wise multiple regression analysis was run to predict 'social media use in the teaching of mathematics' from five different variables ("**a**-social media tools have a place in my mathematics teaching subject", "**b**-year of study", "**c**-I share online resources (links, documents) for learning mathematics with my classmates", "**d**-frequency use of social media for personal purposes" and "**e**-I look for a video to teach me about the mathematics concept."), results from Table 30 showed that the independent variables statistically significantly predicted the dependent variable of the model at each step. Therefore, all the five variables added statistically significantly to the prediction of student teachers' use of social media platforms in the teaching of mathematics. The regression model ($\mathbf{y_1}$) below:

$$\mathbf{y_1 = 0.242a + 0.338b + 0.411c + 0.456d + 0.499e}$$

is a good fit for the data.

By implication, students have a strong desire to incorporate web 2.0 technologies or social media tools in the teaching and learning of mathematics in future. These results seem to agree powerfully with the findings of Acarli and Sağlam (2015) whose study participants were also eager to use social media in their professional lives.

The author of the current document sought to also explore the evolution of student teachers' profiles of social media use in mathematics from 3rd year till 4th year of their training program. For this reason, another multiple regression analysis was conducted to predict year of study. The variables of interest were: **a**-I use e-mails more effectively in communicating with my mathematics lecturers than in my class, **b**-I share and/or post videos related to my mathematics learning., **c**-Discussion forums (e.g., Yahoo answers, ask.com), **d**-Communities, **e**-Devices used, **f**-Social networking (e.g.., Facebook), **g**-I use Facebook chat to contact a friend to get help with a class assignment., **h**-Gender, **i**-Age. In sum, results from Table 32 highlighted that these variables statistically significantly predicted year of study F (1, 98) = 8.850, $p = 0.004 < 0.05$, $R^2 = .083$. These nine variables showed a strong ability of prediction of incorporating social media in the teaching of mathematics based on year of study.

Therefore, the positive general linear relationship between mathematics student teachers' attitudes towards the use of social media in mathematics classes and their math profiles of social media use from 3rd year till 4th year is given by:

$$\mathbf{y_2 = .288a + .419b + .476c + .526d + .559e + .586f + .615g + .636h + .656i}.$$

The results have revealed an acceptable fit between the regression model ($\mathbf{y_2}$) and the data. Further analysis of the regression model (see Table 33) disclosed that 73% of the total variance in the dependent variable (DV) has been explained by how students use emails effectively in communicating with their mathematics lecturers (one model predictor -**a**), followed by nearly 16% of the total variance in the DV accounts for how students share or post videos related to their mathematics learning (with two model predictors-**a** and **b**), 20.2% is explained by three IVs (**a, b** and **c**-Discussion forums (e.g., Yahoo answers, ask.com)), 24.6% of the total variability is explained by four IVs (four model predictors: **a, b, c** and **d**) and so on up to the last nine (9) model predictors explaining about 37.4% of the total variability in the DV. In both cases, the tests have revealed that the two regression models were a good fit for the data. Results have also shown that the independent variables statistically significantly predicted the dependent variable of model $\mathbf{y_1}$ and model $\mathbf{y_2}$ respectively.

Thus it is not surprising to note that the estimated model coefficients showed a strong ability of prediction of integrating social media in the teaching and learning of mathematics by university students based on year of study. Both third and fourth year students at CBU are very keen to either start or continue using social media tools in their professional lives and teaching careers.

When 3 Clusters where formed in the previous chapter, the results disclosed that Cluster 1 recorded the highest score displaying that majority (91.2%) of the students agree that social media platforms have a place in their personal, academic and professional lives such as in their mathematics teaching subject. Results further disclose that year, gender and age have a statistical significant impact in Clustering students in terms of social media usage in Mathematics Education.

In addition, content analysis results seem to suggest that majority of the students advocate for the official usage of social media technologies in the teaching and learning of mathematics both at the university and secondary level. The findings seem to agree with previous studies (e.g. Salas-Rueda, 2020; Han et al., 2019; Urban, Navarro, & Borron, 2018) who posited that higher learning institutions are integrating digital devices, innovative applications and web platforms into university learning activities to improve the teaching and learning conditions.

Based on the findings reported in this thesis, both Cluster 2 and 3 of the first iteration composed of pre-service mathematics teachers who somehow had challenges in the actual use of technological applications and software packages in the teaching-learning process of mathematics. Although both Clusters perfomed quite well in terms of the scores, pre-service teachers in these Clusters realized the need for engaging in online learning communities in order to collaborate with other each other so as to participate in online mathematics course activities (Cross, 2002). However, based on the TAM model, the pre-service teachers' intention to use social media technologies based on each Cluster could be influenced by external factors such as lack of digital skills, professional development and accessibility of technological tools. Other external factors could be difficulties encountered when using a particular technology for learning.

Hence, pre-service teachers in Clusters with low scores are more likely to display low skill levels in the use of technological applications, digital tools and the adoption of social media with respect to mathematics teaching-learning processes. As a matter of fact, they are also likely to show negative attitudes towards the use of social media platforms in mathematics learning activities. This could be because they do not perceive this'social media technology' to be user friendly or ease of use and thus do not view it to be useful in mathematics virtual classrooms. Such gaps in knowledge of perceived usefulness and ease of use are a worrying factor that might easily affect their future intention to integrate these technologies in the teaching-learning process.

However, according to Thomas (2020), the study established that in the near future, people will probably have to feel forced to interact with the technological system, which is referred as a compulsive technology use.

Anyway, different patterns of Clusters about the way pre-service teachers have used social media technologies in their personal, academic and teaching careers are also observed. Some differences come from within Clusters while others across.

A visual representation of the three clusters on Figure 18, 19, 20 and 21 shows these clusters naturally grouped based on how pre-service mathematics secondary teachers use social media platforms to support their mathematics digital learning. By further observation, the Figures also shows that students with similar characteristics (homogeneous within) especially those in cluster 2 of Figure 21 recorded the highest mean score values but very dissimilar (heterogeneous across) with the other two clusters. Unsurprisingly, these Clusters which needed special attention have revealed some strengths and weakenesses of pre-service teachers based on their commonly shared narratives on different social media platforms they use in mathematics teaching-learning process.

Finally, this doctoral dissertation has extracted some key information from these Clusters of pre-service teachers' online engagement using social media platforms which can be nurtured by the administrators, in-service teachers and online instructors to provide a conducive web-based platform for mathematics students to become positively engaged in e-learning.

The results reported in this doctoral thesis resonate powerfully with the findings of Vankatesh and Davis (2000) who posited that as of late, there has been a significant advancement as far as professional usage of social media platforms is concerned and the prediction of the acceptance of these social media technologies by the users. However, in spite of the fact that science is propelling information on new knowledge linked to ICT and social networking sites, there is a deficiency of indisputable discoveries. The different investigations both meet and diverge (Marta García-Domingo et al., 2017).

Chapter 6: Conclusions

This doctoral dissertation primarily aims at contributing to a better understanding about the way social media technologies are being considered in the teaching and learning of mathematics in Zambian universities -by looking at the particular situation of CBU as one of the most relevant universities in the field of Mathematics Education in Zambia- as well as to the identification of paths still open for future actions to improve both processes.

In particular, this doctoral thesis offers a clear overview of university pre-service teachers´ usage of social media for personal, academic and (pre-service) professional purposes. It can be argued that social media have become an indispensable part of pre-service teachers' daily life. Thus, several researchers (e.g. Cabero-Almenara, Arancibia, & Prete, 2019; Han, Wang, & Jiang, 2019) also agree that teacher-trainees are average users of technological applications, electronic communications and software packages.

The rationale behind this doctoral thesis is to give hope and perhaps solutions to both students and lecturers knowing that despite many unforeseen circumstances such as sickness, travelling costs, bad weather, political instability and many others, mathematics students can still engage in virtual learning remotely using the digital platforms and online resources available.

The results from this study are relevant in addressing each of the three research questions or targets posed and all the objectives of this study have also been met, providing vital information that can lessen the knowledge gap. The next paragraphs outlines briefly how the three research leading sub-questions on section 2.6.4 of the study were answered. In addition, the subsequent paragraphs also attends to the four specific objectives arising from the quantitative aspect and three specific secondary objectives established from the qualitative aspect of the study and how they were met. Section 1.52 gives a detailed description of these objectives.

The current findings (e.g. see Table 18) of the study disclosed that majority (91.2%) of the trainee-teachers agreed that social media platforms had a place in their mathematics teaching subject. Later on, participants of the study saw themselves using any of the relevant social media applications in teaching mathematics in their teaching careers as 35.5% agreed, 27.5% strongly agreed and 28.4% moderately agreed. These findings reflects students' positive attitude towards the integration of social media platforms in their mathematics classrooms. These results corroborate strongly with the results reported in the study conducted by Yusuf and Bolaji (2018), in which most of their participants wished to be inclusive of all social media applications for mobile learning. In a sense, students in the current study adopted and accepted the use of social media platforms to engage in academic activities. Also, their willingness to share knowledge with peers through social media platforms for mobile learning (Yusuf & Bolaji, 2018).

Concerning the first research question of this of this study, results on Table 39 for instance, revealed that homogeneous clusters of students emerged as a result of pre-service teachers' most frequently accessed resources when stuck while doing mathematics assignments. This is consistent with Anna (2019) as her study disclosed that students access resources like Facebook, WhatsApp, YouTube, Google chrome and Gmail to have easier access to lecture material and to generally support their learning processes.

Further more, the current results in this doctoral thesis seem to suggest that student teachers of mathematics at CBU were primarily using social media platforms like YouTube to watch, download or upload mathematics videos related to their classroom lectures. Qualitative findings seem to suggest that several students preferred Gmail and WhatsApp applications for communication. Generally, findings seem to highlight that on these two platforms, most students are either frequently sharing data such as books, lecture notes, class schedules, place changes, pdfs, assignments' solutions, articles, math problems, class projects, class updates or contributing significantly to clarifying solutions, offering academic advice to fellow students or seeking help and making consultations from their supervisors.

Several other students, particularly younger ones, noted that they tended to create mathematics WhatsApp groups for discussions, sharing YouTube math videos, subscribing to educational programs, solving and sharing mathematics questions, texting friends for help, using WhatsApp to capture questions and solutions and share in a group, receiving handouts, exchanging data, sharing ideas on the topic, discussing tutorial sheets, comparing assignment solutions to challenging questions, sending mathematical theorems, lemmas and proofs and frequently asking and sharing mathematical concepts with classmates.

When the data was further quantitatively analyzed (e.g. see Table 42), ANOVAs where carried out to verify the hypothesis that gender, age and year of study had no significant impact in clustering students in terms of social media usage in the teaching and learning of mathematics. Results disclosed that there was a statistical significant difference between each cluster in terms of gender, age and year of study based on how students use social media platforms to support their mathematics learning activities. To explore these differences in clustering, qualitative findings revealed something interesting. In terms of age, the overall results of the current study disclosed that Zambian students usually enroll in universities immediately after they complete their Grade 12 Examinations often between the ages of 18 and 20. Around this age, they are already exposed to different types of social media technologies.

Although, notably, there is a dearth of comparative studies analyzing the use of new technologies depending on the age, previous studies seem to highlight that a low-age is associated with a high-exposition to ICT/social networking sites (Jiménez-Albial et al., 2012; García-Jiménez, López de Ayala y Catalina, 2013). Thus younger maths students use social media platforms more compared to the elderly ones. Despite the small number of female partcipants, results disclosed that social media was more popular with females than male students. Our findings agree with (Hamade, 2013; Ruleman, 2012; Stainbank & Gurr, 2016).

Concerning the second research question, qualitative findings seems to address it well. Some instances of pre-service teachers' responses about the impact of social media and its use in Mathematics Education are provided below, which highlight the strength of feeling over this issue:

Social media has a very high positive impact on learning because it makes learning mathematics enjoyable and quicker. (Male, Mathematics Education, age 23).

The impact of social media on mathematics learning is positive and it is believed that it will have a great positive effect going forward. (Male, Mathematics major, age 26).

Social media can greatly impact the academic performances. Since the Mathematics Education in Zambia has to cater for both introverts and extroverts, social media can play a helpful role to meet needs of all learners. (Female, Mathematics major, age 20).

Social media is one of the effective ways that students can learn Mathematics and the trend is growing if only students can be aware. (Male, Mathematics, age 24).

In other words, the current study has revealed that social media platforms have positively impacted Mathematics Education in Zambia and university students need to make use of social media platforms in order for learners to experience meaningful learning in mathematics.

Concerning the third and final research question, a considerable group of pre-service teachers had an interesting story to tell, they felt that once exposed to social media, its official use in mathematics lessons would trigger a number of different ways of teaching and learning strategies. Respondents believe that they would always be "up-to-date" with the current needs of the modern society and "distribute information" to the learners effectively with credible information at hand. Among many other expected benefits, respondents felt that through social media use, they would get to "interact" with "fellow mathematicians" from other parts of the world. They further described these interactions to be so helpful.

Overall, student teachers narrated several other reasons why embracing social networks and consequently for officially adopting to use them in mathematics instructions. They felt that social media would make their teaching career easier. As some said "…they only need a mobile phone and data bundles to search for information" than paying a lot of money for tutorials. Searching for information on Google "would help in the comprehension of mathematical concepts and how to teach mathematics effectively". Respondents prefer having softcopy books to hardcopy ones because it is very expensive for them to buy in book shops.

In contrast, a few felt that "since most of the effective social media tools (mobile phones) are not allowed in secondary schools", it is a farfetched dream to enhance the mathematical pedagogical approaches.

Additionally, the Zambian policy on education does not permit a secondary school learner to be in possession of the Smartphones, laptop, tablet or any other gadget in class as the Zambian policy on Education, Educating Our Future (1996, p. 94) posit that "Zambian resources do not yet allow extensive provision of computers for use as Educational media in the school system, although they are increasingly being used for in-service teacher education in resource centres and are extensively used at the higher level". That alone makes it difficult for using social media platforms in class, later on to enhance the teaching and learning of mathematics.

In a nutshell, suffice to argue that social media acts as a link [source] of information. They provide a platform for mathematics discussions and sharing of ideas. The three research questions of the study have been answered. Findings of this study converge with many other previous studies. The realisations from this study have gone beyond anything else the author has tried to report in this study, although the results are quite too radical to allow their immediate reaction. The results reported in this study are limited to the research design used in this study only. For a more robust analysis, I recommend that other researchers should consider using a different research design which involves data triangulation, researcher triangulation and data analysis triangulation. The published results of this study will serve as a basis for making a recommendation to the university management, the Ministry of Education and policy makers at large to re-examine the inclusion of social media technology or online learning in the Zambian curriculum and its place in Mathematics Education across all levels of learning.

Concerning the first specific objective of this study as stated from both quantitative and qualitative investigations of this doctoral thesis, the results obtained have simultaneously revealed that social media platforms have positively impacted Mathematics Education in the particular context under consideration and that university pre-service teachers need to tap into these new technologies in order to effectively use them in teaching mathematics. These results are aimed at proposing that upcoming teachers of mathematics are expected to possess the technological and pedagogical skills to achieve a successful integration of digital tools in the mathematics teaching-learning processes (Cejas-León, Navío-Gámez, & Barroso-Osuna, 2016). In addition, social media technologies have come with several other benefits which generally include sharing information, corroboration, exploration and cost saving.

Concerning the second objective from both approaches of the investigations of this doctoral thesis, the results reflect pre-service teachers' positive attitudes towards the integration of social media platforms in their mathematics classrooms both for learning and teaching. In particular, students are using essentially the same social media in and out of the classrooms (Youtube, Whatsapp and Facebook) so that activities based in such technological environments seem to highly motivate them. This study has shown that gender and year of study are immaterial to the utilization of social media in the context being considered. However, positive correlations existed between pre-service teachers' attitudes towards the use of social media, year of study and gender. The results disclosed an acceptable fit between the model and the data. Thus, the study aimed at proposing a regression model to predict pre-service teachers' social media use in the teaching of mathematics. Today, these technological models are transforming university and secondary school learning activities both inside and outside the mathematics classrooms (Turgut, 2017; Bueno-Alastuey, Villarreal, & García-Esteban, 2018; Mulenga & Marbán, 2018; Mulenga & Marbán, 2020a; Mulenga & Phiri, 2018). As a matter of fact, consistent with previous studies (e.g. see Agreda-Montoro, Ortiz-Colón, RodríguezMoreno, & Steffens, 2019; Salas-Rueda, Salas-Rueda, & Salas-Rueda, 2019), the integration of technology 'inside' and 'outside' the classroom has led to the adoption of new teaching methods and educational models.

Concerning the third objective of this doctoral dissertation, results from both approaches suggest further that the official use of social media in mathematics instructions would reduce the student-teacher dependency syndrome, enhance students' thinking ability, promote easier and faster communication between or among students and teachers, bring about meaningful learning and eventually a potential tool to meet all learners needs. In order to attend to the third objective on qualitative analysis, results qualitatively disclosed that respondents believe that the official use of social media technologies will enable pre-service teachers have a mathematics pedagogical shift to a less formalized method of teaching-learning process that is entertaining and interesting rather than rigorous and traditional. For example, the AT and the TAM model facilitates the refreshing of educational activities for the mathematics learning processes via the use of social media software like YouTube videos, WhatsApp, Facebook and other technological tools (Mulenga & Marbán, 2020b).

Finally, concerning the final and fourth objective of this study, results revealed that the acquisition of 21st century skills would enable pre-service teachers to effectively use Smartphones, laptops and other digital devices on their disposal to search [browse] for information using search engines on the Internet rather than using the university library on various fields of mathematics. Perhaps consciously, pre-service teachers are particularly using social media applications installed on their gadgets to search for data and navigate between different accounts rendering such social media applications indispensable in the teaching-learning process of mathematics.

In addition, this study has revealed different abilities already possessed by pre-service teachers. These digital abilities help them to use 21st century skills and share the previously mentioned practical benefits of e-learning experiences while learning mathematics. As a matter of fact, the findings from this study resulted in a number of trainee-teachers becoming more aware that the online learning experiences were in fact enriching to their mathematics pedagogy.

Therefore, the results from this study are important in attending to each one of the research questions or targets posed. Both the primary and the secondary objectives of this doctoral thesis have also been met, revealing relevant information that can narrower the gap of scientific knowledge. Moreover, the current findings agree with the conclusions of other researchers and studies, highlighting their consistency. This mixed method research shares similar findings of various authors (e.g., Martin, Ritzhaupt, Kumar, & Budhrani, 2019) concerning the use of digital tools, web platforms and social media technologies in the field of Mathematics Education to identify and develop abilities in students.

This study has provided further evidence that mathematics prospective teachers can also learn via online mode. The research questions on cluster analysis of the study have also been answered. Results of the study reveals that online learning mathematics activities have significant mean differences in clustering (see Table 30). The reason for these differences could be due to prospective teachers' attitudes towards the use of technology in learning mathematics. Unsurprisingly, some prospective teachers lack the skill and knowledge on how to use online platforms. Hence, they are identified by a negative attitude towards the use of social media networks thereby recording low scores in cluster 1 and 3 as shown by Figure 21 on the final clusters depicted.

Results also revealed that prospective teachers' online learning mathematics behaviours in the teaching and learning activities were very high on variable 4, 5 and 6 (see Table 31) across the clusters with cluster 2 recording the highest score. One reason for these high scores is that prospective teachers exhibited good tech-skills to engage in online mathematics learning activities and had the necessary technological tools to facilitate their online interactions.

Results highlighted different patterns between clusters (see Figures 19 and 21), implying that prospective teachers show different variations of online engagement in mathematics activities. The reason for these variations could be attributed to using unfamiliar technology by some prospective teachers. Similarly, a different set of cluster analysis results also revealed that participants' scores for social media use in mathematics in cluster 2 were higher than those in both cluster 1 and 3 (see Fig. 21). This is a clear indication that prospective teachers in clusters with low scores are more likely to exhibit low skill levels in the use of mobile technology and the adoption of social media in relation to the pedagogy of mathematics. Results also show different cluster patterns (see Table 35). However, overall results show that students responded positively to the use of social media in learning.

On the other hand, the author has addressed the dangers head-on, notably the challenges to be undoubtedly encountered during social media usage in mathematics instructions. Such challenges are not limited to unstable electricity connections in Zambia, poor Internet connections or unaffordable Internet costs to sustain long hours of online learning connections.

Results have further revealed that digital learning in mathematics allows students to even study at the comfort of their homes. As long as students have the necessary technological tools, access to Internet, affordable Internet costs and adequate supply of electricity, they can be able to obtain front seats in the mathematics virtual classroom. Results seem to suggest that prospective teachers believe that digital learning will enable them to have a mathematics pedagogical shift to a less formalized method of teaching that is entertaining and interesting rather than rigorous and traditional.

Results have shown that the adoption of social media use in learning would stimulate the growth of e-learning in mathematics, especially in Zambia which has been historically resistant to the use of digital platforms during mathematics instructions. Findings of this study agree strongly with other studies. Unsurprisingly, technological applications, digital platforms and social media technologies are causing teachers worldwide to design, transition and conduct digital learning mathematics activities -inside and outside- the classroom (Cardellino, Araneda, & García, 2017; Marbán & Mulenga, 2019; Magen & Steinberger, 2017).

For instance, exploring the best way to use social media technologies in classrooms remains a precedence research subject and “continuing challenge” in Mathematics Education (English & Kirshner, 2015). Subsequently, it was established in this doctoral thesis that prospective teachers need both digital resources, skill set and the use of flipping instructional methods (De Araujo, Otten, & Salih, 2017, 2017) such as assigning instructional videos or multimedia for learners to watch as take home tasks and completing problems or exercise sets in class to effectively teach mathematics in mathematics classrooms.

This thesis has revealed that the use of social media technologies and other software packages had positive impact on students’ teaching-learning process of mathematics, extracted interests, advanced individualized-learning and assisted with lengthening studies beyond mere physical classroom school days. This finding seem to somehow agree with a study conducted by Buabeng-Andoh (2012).

However, social media has created negative effects on our society and cultural values. In some cases, it even tends to thrive on fantasies by promoting beauty that does not exist. Perhaps humankind has always been abusive within the way we exploit our inventions. For example, a knife is meant to be used for chopping food, but some people use the utensil to injure or kill others. Internet, the digital world and all social media platforms are no exception. They are hyperbolically abused by students.

Lastly, this chapter ends with some brief conclusions on all areas surrounding the research-project contained in this thesis. Answers to the research questions of this doctoral thesis are summarised in the Table below. Table 45 displays how the research objectives, hypotheses, questions (both core & leading questions) and answers are related.

Table 45: Answers to the research questions of the quantitative study

Questions	Primary Objectives	Hypotheses	Answers
Does the official use of social media have a statistically significant impact on teaching and learning of mathematics?	To explore the official use of social media in the teaching and learning of mathematics as a scaffolding tool, and its impact on Mathematics Education in Zambia.	**H_1**: The official use of social media has a statistically significant impact on teaching and learning of mathematics.	Yes! The official use of social media technologies in mathematics classrooms suggests that teachers devise a number of different effective and innovative teaching methodologies relevant to the modern society.
Is there a statistically significant difference among	To explore if the use of these social media may have an impact on the development of 21st	**H_2**: There is a statistically significant difference among students'	There is a difference in the dynamics of the concept of using social media for personal, professional

students' current social media use?	century skills by both learners and teachers.	current social media use.	(prospective) and teaching careers of students. The difference occurs when, for example, results suggests to be viewed from four lenses that bring together the results of this study, namely; gender, age, year of study and theoretical frameworks of reference that allows the creation of active teaching-learning strategies through the use of technological applications for studying the impacts of social media on student outcomes.
How do our students currently use social media tools?	To investigate the usage and impacts of social media platforms, technological applications and other portable digital tools in the teaching and	**H_3**: Student-teachers use mobile technologies like WhatsApp, Facebook, Twitter, Instagram, WeChat, e-mail and other web	In particular, students are using essentially the same social media in and out the classrooms (Youtube, WhatsApp and Facebook) so that activities based in such technological environments seem to

	learning of mathematics.	2.0 tools in online communities for learning mathematics.	highly motivate them. Conditions for predictive models allows the use of social media in school activities.

The respondents (n = 33) during the qualitative stage gave their views, opinions and narratives with regards to social media usage in mathematics activities. One of the questions of this study sought to answer how pre-service teachers view the impact of social media on Mathematics Education. The other dealt with how pre-service teachers use social media technologies in their mathematics teaching career lives. Table 46 below shows how the research objectives, questions linked to the qualitative phase and answers are related.

Table 46: Answers to the research questions of the qualitative study

Questions	Secondary Objectives	Answers
How do our students view the impact of social media on Mathematics Education?	To determine both the positive and negative impacts of social media on the teaching and learning of mathematics in Zambia. In particular, to explore the impact of and the role social media can play in Mathematics Education via social networking among students.	The results obtained have revealed that social media platforms have positively impacted Mathematics Education in the particular context under consideration and that university students need to tap into these new technologies in order to effectively use them in the teaching-learning process of mathematics.

Do our student teachers believe that the official use of social media can enhance their learning and teaching experience in mathematics?	To discuss how the official use of social media technologies may influence the teaching and learning of mathematics in Zambia and what paths are open (and closed) for future impact.	Majority of the students believe so. Results reflect students' positive beliefs and attitudes towards the integration of social media platforms in their mathematics classrooms both for learning and teaching. Results further suggest that the official use of social media in mathematics instructions is the best tool to meet all learners needs.

Therefore, the research findings from this thesis are relevant in addressing each of the research questions, objectives and hypotheses posed. Both the primary and secondary objectives of this study have also been met, disclosing relevant information that can lessen the knowledge gap. Moreover, the current findings agree with the conclusions of other researchers and studies, highlighting that technological applications, digital platforms and social media technologies are causing teachers worldwide to design, transition and conduct digital learning mathematics activities - inside and outside- the classroom (Cardellino, Araneda, & García, 2017; Marbán & Mulenga, 2019; Magen & Steinberger, 2017).

The conclusions drawn from this thesis agree with the proposals made by Cejas León, Navio and Osuna, (2016), Fathelrahman (2019), Zhang, Lou, Zhang and Zhang (2019) and Andy (2019), that today, educators and instructors are changing the instructive procedure through the choice, association and development of virtual spaces for mathematics teaching-learning.

Development in computers, communication electronics and other multimedia tools provide a wide range of sensory stimuli. Due to this it is said, I see and I remember, I do and I understand. The animations, simulations, software packages to teach mathematics subjects create virtual realities and experience for the learners, which in turn, help in making learning a more direct, useful and joyful. Learners' self-engaged learning is conceived as the core of good education.

All in all, this thesis widens the scope of identifying factors that will enhance the use of technology in education and educational technology by promoting social media engagement policies, supportive educational curriculum, school and government support. This thesis contributes to the scientific body of knowledge in the methodological aspects, theories built, literature reviewed, results brought forward and practice.

Also, great significance has been dedicated to the integrity and credibility of the research itself (see section 3.1.5). An exhaustive study was carried out that covered all the stages of the research, incorporating techniques that discusses the rigor criteria of both quantitative and qualitative phases, rigor guided by the four-lens proposition of Guba (1981): credibility, transferability, consistency and confirmability, terms corresponding to a naturalist paradigm compared to the rationalistic traditional terms that are analogous as regards the criteria of rigor that they are intended to respond to in terms of internal validity, external validity, trustworthiness and objectivity, respectively.

An immediate recommendation of significance is that teacher training programs can be revised to incorporate social media study programs and other technological applications in order to adequately equip teacher-trainees in mathematics with effective technological skills required for integration of social media technologies in teaching and learning of mathematics in schools. Limitations and Implications are discussed. Recommendations are made.

6.1 Limitations of the study

Given the scope of this thesis, it is clear that the definitions of social media, web 2.0 tools, social networks, digital platforms or social media applications in relation to using them for personal, professional and academic lives of students are wide and contain a number of sub-variations. This posed a limitation to the study, since just as the definitions are wide and varied, pre-service mathematics teachers who participated in the study could have rated social media and engagement differently. For instance, what one participant may consider as personal use of social media may not be what another sees as personal use and may as well collide with what another partcipant thinks is professional in the context of teaching-learning processes of mathematics. However, to mitigate this limitation, the study borrowed from standard existing definitions that have been found reliable in measuring social media use, participation and student engagement to minimize respondents' bias. On the other hand, the standard measures of social media and student engagement were developed and used in many previous studies.

This study was limited to the selected sample (n = 102) from the Copperbelt university. This is because of the limited resources available and time constraint as a result of the due date of this research-project. Studying the entire population of Mathematics Education students from first year to fourth year was not viable but would have been the best option because basing my study in larger sample size could have generated more accurate results. The population could also be satisfactorily covered through sampling students from other higher learning institutions. However, compared to time of study, the statistical approach of sampling participants from other universities would have been difficult to be managed by a single researcher. This posed a limitation to the study. Thus, I suggest that other researchers should carry out longitudinal studies in future which must consider using the triangulation of researchers, data and subsequent data analyses.

This study is limited to the method of data collection used. Subsequently, significant limitations emerged during the interpretation of the obtained results. Therefore, in order to address the research problem more effectively, future studies must consider applying a more robust methodology that incorporates interviews or focus groups in order to have a more detailed analysis. In acknowledging this limitation, I consider this work reported in this thesis as an exploratory study intended to lay the foundation for a more complete research study in the future.

The results reported in this study are limited to the research design used in this study only. For a more robust analysis, we recommend that other researchers should consider using a different research design were both quantitative and qualitative approaches have equal emphasis [weight] in the research design where qualitative findings should complement quantitative results equally by examining participants' opinions, beliefs and attitudes in great depth.

6.2 Recommendations

In light of the results reported above, this doctoral thesis forms a basis for recommending CBU to offer online courses in Mathematics Education via online instructors and tutors.

One contribution this doctoral thesis leaves to the discipline is that it has given a map for studying the evolution of social media usage in mathematics instructions. We therefore recommend to the Ministry of Education to consider integrating "social media" studies into teacher training programs to stir the growth of social media in the teaching and learning of mathematics in Zambia. In addition, reacting to training challenges related to continous professional development (CPDs) and digital resources, provincial districts and schools need to consider staff preparation and training. E-learning platforms and social media apps should be properly re-introduced, in addition to training on how to effectively use them for instructional purposes particularly during the global pandemic crisis.

The author wishes to first recommend that CBU management creates an official online virtual platform [class] for mathematics for students to freely access all the information they need beforehand.

In connection with the previous recommendation, the author wishes to recommend to the university management that a comprehensive and advanced pedagogic design should be implemented to render lessons through virtual classrooms. Therefore, this study suggests that CBU should make digital learning a permanent feature of their portfolio.

The published results of this study will serve as a basis for making a recommendation to the university management, the Ministry of Education and policy makers at large to re-examine the inclusion of social media technology or online learning in the Zambian curriculum and its place in Mathematics Education across all levels of learning.

Thus, an immediate recommendation of significance is that teacher training programs can be revised to incorporate social media study programs and other technological applications in order to adequately equip teacher-trainees with effective technological skills required for integration of social media technologies in teaching and learning in schools.

6.3 Implications for future studies

The current study just scratches the surface of an area where little information exists and thus “motivates” new lines of further research. For instance, it may interest someone to examine how university undergraduates and lecturers actually use social media in Mathematics Education and its impact on the academic performance of students. It is also implied in this study that mathematics lecturers and pre-service teachers must take full advantage of the available technological social media platforms to realize meaningful learning. This study has reported that social media platforms are essential tools for promoting effective academic practice.

Other implications involve participants’ acquisition of significant knowledge and digital skills to own and operate different social media accounts and to be able to navigate between them for mathematics learning. This study has established the relationship between pre-service mathematics teachers, social media platforms used and online mathematics activities. Findings such as this will not only contribute to deeper understanding of lecturers’ and students’ use of social media and its impact on the teaching and learning of mathematics but will also provide useful information for the design of effective digital instructor-learner education programs not only at CBU but even across at other higher learning institutions in Zambia.

This study recognises that online learning in mathematics can offer personalised education for all, maximising the potential of every learner, but many also feel some sense of freedom especially in the wake of the global pandemic self-isolation period. Therefore, it may interest another researcher to conduct a study on the vision of permanent digitalisation of Mathematics Education. In other words, other researchers could carry out a study to find out if digital learning will eventually replace physical classroom in future.

While designing a lesson in online mode, online instructors and tutors need to consider various aspects to in order to accommodate every student available online. For instance, educational technology places issues of equity at the centre of digital design thereby giving equal access to the physically challenged. Moreover, this study has highlighted that education in the context of digitalisation is the good way of motivating and encouraging students to own and take charge of their own learning and acquistion of 21st century skills. Results of this study offer some insights into what a virtual classroom might look like.

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Appendices

Appendix A

Supplemental File 1

Social Media and Mathematics Learning Survey

The following survey aims to collect data about the ways you have used social media to support your learning in mathematics in your current mathematics course(s) (Course code Mxxx). For the purposes of this study social media is defined as **an online software application that allows for connections and contributions from multiple users.**

There are three sections to this survey: A) Demographics: Some information about you, B) Social media practices and Mathematics learning in (Mxxx), and C) Social media practices and Mathematics learning in general

Section A) Demographics: Some information about you

This section of the survey is designed to find out what kinds of social media you usually use in your **everyday life.**

A1. Your age is best fit with? ☐18-22 ☐22-25 ☐25-28 ☐28 - 31 ☐31and above

A2. What is your year of study? ☐first ☐Second ☐Third ☐Fourth

A3. What is your level of studies? ☐ Undergraduate ☐ Postgraduate

A4. What is your gender? ☐ Male ☐ Female

A5. Which devices do you use to connect to the Internet? Choose all that apply.

☐Smartphone/mobile phone ☐Laptop computer ☐Desk/home computer
☐iPad/tablet ☐iPod ☐Campus computers

A6. How much time do you spend on social media per day? (please tick **(**√**)** only one box).

a. Do not access them daily ☐
b. Less than 30min ☐
c. Around hour ☐
d. Around two hours ☐
e. More than two hours ☐

A7. Among social media sites, what kind of communities do you usually prefer? (please tick **(**√**)** only one box).

a. Educational ☐
b. Entertainment or recreational ☐
c. Informational ☐
d. Resource sharing ☐
e. Any other ……………………………………

A8. Barriers you have identified in using social media (please tick **(**√**)** all that applies).

a. Unstable security and privacy concerns ☐
b. Technology is not user friendly/difficult to use ☐
c. Internet connection costs too much ☐
d. Internet connection is unreliable ☐
e. Unstable electricity connection ☐
f. Too Busy/Don't have time ☐
g. Lack of support at my institution ☐
h. Integrity of student submissions ☐

A9. For each social media application listed below **(please tick (√) only one box**) what kind of user you are **in your everyday life**.

Non-user: Never heard of it or never used it.

Infrequent User: I use it sometimes.

Frequent User: I use it regularly.

Contributor: I frequently use this application to both read content and to contribute content.

Social Media Application	**Non-user**	**Infrequent User**	**Frequent User**	**Contributor**
Social networking(e.g., Facebook)				
Communication(e.g., MSN chat, email, text messaging)				
Blogs (e.g., Tumblr)				
Microblogging (e.g., Twitter)				
Document managing and editing tools (e.g., Google documents, Dropbox)				
Social bookmarking(e.g., Delicious)				
Social news (e.g., Reddit)				
Wikis (e.g., Wikipedia, Wikispaces)				
Video sharing (e.g., YouTube)				
Live casting (e.g., Skype, life size)				
Photography sharing (e.g., Flickr)				
Discussion Forums (e.g., Yahoo answers, ask.com)				

Other? Please list:				

A.10 As a student teacher, how often do you use social media sites for personal purposes? That is, for non teaching and learning activities. E.g for fun.

a) Daily
b) Weekly
c) monthly

A11. As a mathematics student teacher, I see myself using **any** of the above social media applications in teaching mathematics in my teaching career.

a) Agree
b) Strongly agree
c) Moderately agree
d) Disagree
e) Strongly disagree

Section B) Social media practices and mathematics learning in Mxxx

This section of the survey is designed to find out what kinds of social media tools you use to support your mathematics learning in **Mxxx**. 'Support your mathematics learning' means that you use these tools to get information or to connect with others to help you complete the expectations for your class (i.e., while doing assignments, studying or working on projects). Please answer the questions in this section while referring to learning in Mxxx.

B1. For each type of social media application listed below indicate **(please tick (√) only one box)** what kind of user you are **when you are using the application to support your Mathematics learning in Mxxx** and how you've used it.

Non-user: Never heard of it or never used it.

Infrequent User: I use it sometimes.

Frequent User: I use it regularly.

Contributor: I frequently use this application to both read content and to contribute content.

Social Media Application	Non-user	Infrequent User	Frequent User	Contributor	Explain how you've used it in Mxxx
Social networking (e.g., Facebook)					

Communication (e.g., MSN chat, email, text messaging)					
Blogs (e.g., Tumblr)					
Microblogging (e.g., Twitter)					
Document managing/editing tools (e.g., Google documents, Dropbox)					
Social bookmarking (e.g., Delicious)					
Social news (e.g., Reddit)					
Wikis (e.g., Wikipedia, Wikispaces)					
Video sharing (e.g., YouTube)					
Live casting (e.g., Skype, Life size)					
Photography sharing (e.g., Flickr)					
Discussion Forums (e.g., Yahoo answers, ask.com)					
UoW Learning management system (SMP)					
Other? Please list.					

B2. Please list **ANY** three most favorite social media applications you usually make use of to support your mathematics learning.

a. ……………………………………………………
b. ……………………………………………………..
c. ……………………………………………………......

B3. Please indicate **(tick (√) only one box)** how frequently you **use social media to support your mathematics learning Mxxx** in the following ways:

	Never	Sometimes	Regularly
Use Facebook chat (or MSN or texting) to contact a friend to get help with a class assignment.			
Use e-mails more effectively in communicating with my mathematics lecturers than in my class			
Use WhatsApp to get help with mathematics assignments/home works/ / research works. Etc			
Use e-learning mathematics materials available via social media to learn maths.			
Use Skype (or some kind of live casting service) to connect with a friend or a group to work on a class assignment.			
Ask a mathematics question on an online forum such as Ask.com.			
Collaborate with a classmate on an online document using Google docs (or something similar).			
Create or join a Facebook group with classmates to share homework, links, and to discuss class content.			
Search YouTube for a video to learn about a mathematics concept.			
Access Wikipedia to read about a mathematics concept.			
Answer or comment on a mathematics related topic on a forum such as Ask.com			

Read a mathematics related blog or news items.			
Follow mathematicians or maths related feeds on Twitter.			
Save and share maths related bookmarks on Delicious (or some other social bookmarking service).			
Post mathematics related content on a blog.			
Store apps on my Smartphone that are useful for learning mathematics.			
I share and/or post videos related to my mathematics learning.			

B4. As a student teacher of mathematics, I also use social media sites (e.g. LinkedIn, Facebook, etc) to support my professional career.

(a) Use (b) Do not use

B5. Please indicate how frequently you engage in the following **online mathematics learning behaviours** while completing assignments for Mxxx

	Never	Sometimes	Regularly
When completing Mxxx assignments I work in front of my computer so that I can chat online with my friends when I am stuck.			
When completing Mxxx assignments I work in front of my computer so that I can search the Internet and/or Google.			
I search the Internet for the answers to particular assignment questions. When I find the answer I stop looking.			
I search the Internet for information that will help me to understand mathematics concepts better.			
I actively search the Internet for resources (links, videos, websites) that will help my mathematics learning.			

When I find a good mathematics online resource I bookmark it or save it somewhere so that I can access it later.			
I use collaborative tools such as Google documents or a wiki to work with my friends on classwork and projects for Mxxx.			
I share online resources (links, documents) for learning mathematics with my classmates.			
I have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and students.			

B6. Online and mobile technologies are more distracting than helpful to students for academic work.

a) Agree b) Strongly agree c) Moderately agree d) Disagree e) Strongly disagree

B7. When you are doing your Mxxx tasks and you are stuck which of the following resources do you access? Indicate by **ticking (√)** which resources you access below and indicate which resource you access most frequently.

Resource	Yes I have done this.	Most frequently accessed resource
Look for an example in a text book		
Text a friend		
Chat with a friend online		
Perform a Google search		
Go to a website directly where I think the answer might be		
Read or ask a question on an online forum such as Ask.com		
Look for a video to teach me about the mathematics concept		
Phone a friend		
Email a friend		

Organize a study group		
Ask an instructor		

B8. As a prospective mathematics teacher, social media tools or resources (like Ask.com, Gmail, messenger, YouTube, WeChat, Google+, yahoo, Instagram, Facebook, etc) have a place in my mathematics teaching subject.

Agree

Strongly agree

Moderately agree

Disagree

Strongly disagree

Appendix B

Supplemental File 2

Social Media and Mathematics Learning Survey

The following survey aims to collect data about the ways you have used social media to support your learning in mathematics in your current mathematics course(s) (Course code Mxxx). For the purposes of this study social media is defined as **an online software application that allows for connections and contributions from multiple users.**

As researchers, we began our work to explore the use of social media in higher education because we wanted to understand how these new technologies were impacting the lives of University students.

This study continues the examination of the use of social media by University students for personal, professional, and teaching purposes. Using a representative sample of teaching faculty from the Copperbelt University, the study probes your use of social media, as well as what value you see in including social media sites as part of the instructional process.

Section C of the survey contains 10 open ended questions that explore respondents' practices for social media and mathematics learning more generally.

When answering the questions, read carefully the contents and the way of answering that is requested in each one of them and please be **faithful and sincere** so that we get the **correct and relevant information**, because the information you are giving us is very useful to the Ministry of Education and the country at large.

The data that will be reflected in it will be treated in a totally **CONFIDENTIAL** manner, analyzed statistically and used for the purpose of the **PhD research** work in which the questionnaire itself is framed.

NB: Your name is not required.

REFERENCE DATA

Your age is best fit with: ☐ 18-22 ☐ 22-25 ☐ 25-28 ☐ 28-31 ☐ 31 and above

Gender: Male ☐ Female ☐

Year of study ☐ first ☐ Second ☐ Third ☐ Fourth

Level of study ☐ Undergraduate ☐ Postgraduate

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

____

____

C2. What is the one online or social media application that you could not live without while studying mathematics?

____

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

____

____

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

____

____

C5. As a student mathematics teacher at the Copperbelt University, do you believe that the official use of social media can enhance your learning and teaching experience in Mathematics Education? If so, how?

……

……..

……

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think the Copperbelt University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

……

……

……

……

____

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies

be improved in any way as a tool for mathematics learning in Zambian secondary schools?

……

……

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………………………………………………………………………………………………………..

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

……

……

……

……………………………………………………………………………………………………........

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

……

……

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

C10. Please leave your comments and suggestions here, if you have any;

…….

…….

…….

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Appendix C

PUBLICATIONS

Having already published three papers from this doctoral thesis since the inception of the doctoral dissertation journey, the author of this thesis has been directly involved in a number of related publications. In addition, some of these published papers are posing serious implications globally to issues related to the current global pandemic. Below is a list of all the track record of publications that can be found in the relevant pages of international journals.

1. **Mulenga, E. M.**, & Marbán, J. M. (2020). Social media usage among pre-service secondary mathematics teachers in Zambia. JRAMathEdu *(Journal of Research and Advances in Mathematics Education),* 5(2), 130147. doi:https://doi.org/10.23917/jramathedu.v5i2.9920
2. Social Media Use Among University Students of Mathematics Education. *International Electronic Journal of Mathematics Education (under peer editing review process).*
3. **Mulenga, E. M.**, & Marbán, J. M. (2020). Prospective Teachers' Online Learning Mathematics Activities in The Age of COVID-19: A Cluster Analysis Approach. *Eurasia Journal of Mathematics, Science and Technology Education, 16*(9), em1872. https://doi.org/10.29333/ejmste/8345.
4. **Mulenga, E. M.**, & Marbán, J. M. (2020). Is COVID-19 the Gateway for Digital Learning in Mathematics Education?. *Contemporary Educational Technology, 12*(2), ep269. https://doi.org/10.30935/cedtech/7949
5. Marbán, J. M., & **Mulenga, E. M**. (2019). Pre-service Primary Teachers' Teaching Styles and Attitudes towards the Use of Technology in Mathematics Classrooms. *International Electronic Journal of Mathematics Education, 14*(2), 253-263. https://doi.org/10.29333/iejme/5649
6. **Mulenga, E. M.**, & Prieto, J. M. M. (2018). Teachers' ICT Skills, Beliefs and Attitudes Towards ICT Integration in the Teaching And Learning of Mathematics. A Local Study in Kabwe District in Zambia. *Journal of Global Research in Education and Social Science, 11*(4), 176-189. Retrieved from http://www.ikprress.org/index.php/JOGRESS/article/view/4245
7. **Mulenga, E.M**, & Phiri, P. (2018). Zambian Teachers' Profiles of ICT use in Mathematics Pedagogy. *Journal of Basic and Applied Research International, 24*(4),

137-148. Retrieved from http://ikprress.org/index.php/JOBARI/article/view/4155

8. **Mulenga, E. M**. (2020). Spread of COVID-19 Pandemic in Zambia: A Mathematical Model. *Aquademia*, *4*(2), ep20019. https://doi.org/10.29333/aquademia/8375
9. Zambian pupils' profiles of social media use in Mathematics; Facebook as a case study (*under peer-review process*).

Appendix D

CONFERENCES & SEMINARS

The author has attended a lot of conferences and seminars. To mention but a few, below is a list of some of the successfully attended conferences and seminars within Spain (Local) and outside of Spain (International).

- Participated in the National Conference for Zambia Association for Mathematics Education held in Solwezi-Zambia
- Participated in a conference held in Kabwe on the launch of the golden jubilee: Celebrating fifty years of Teaching for Excellence & International Conference Programme. Theme: tertiary education in africa: history, achievements and prospects for the future.
- Attended a seminar held at CBU regarding the defence of Masters and PhD Research proposals
- Attended an On-line seminar for PhD students (June, 2019) coordinated by the University of Valladolid in Spain.
- Attended the PhD students' reunion seminar held at the University of Valladolid
- Attended a seminar on “Educational research designs from trans-media communication proposals”
- Attended a seminar on “Creative literature review in social sciences: Tools and Techniques”
- Attended a seminar on “A Creative literature review in Social Sciences: A first-and-brief-approach”
- Attended a seminar on “the Affective domain in Mathematics”
- Attended a seminar on “PISA and the professional competence of mathematics teachers from an internal perspective”

Appendix E

Participants' responses from the Qualitative phase

In order to facilitate the traceability of the qualitative research, the author(s) of this doctoral dissertation incorporated all the responses of the thirty-three (33) participants in the open and semi-structured interview used in the qualitative phase. The subsequent pages displays the participants' response scripts with the researcher's initial *codes* in *red colour* for the purpose of establishing familiarity with the data. In addition, similar phrases in the data that were shared amongst the thirty-three participants were *circled in red colour* by the researcher for constant *comparisons* and *consistent coding*.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Researching

it helps in answering assignments and understand a certain topic ~~at~~ you arent clear about. eg watching tutorial videos.

C2. What is the one online or social media application that you could not live without while studying mathematics?

indispensable

youtube.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

yes it has, in high school i never used to watch tutorial videos online but now i do.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

yes, at the university, our first year lecture for chemistry used to send lecture notes for ~~ou~~ o us using our emails.

- 1^{st} year
- Emails

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

yes it can, mostly things that we see are rarely forgotten, so we can use ~~th~~ youtube to see the shapes of objects for example when teaching mensuration.

meaningful learning.
visual objects

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

No it shouldn't, we all know how to use social media without ~~teth~~ having to learn how to as a course

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

It should be easily accessible and cheaper, and the internet should be a little bit fast.

S.M- easily accessible
-cheaper
- fast internet.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

positive

It makes learners not to ~~de~~ be entirely dependant on a teacher, learners are provided with platform to access information concerning what he/she learnt at anytime of his/her convinience

reduces over dependence on teachers.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Yes it does increase my study time in a such way that instead of reading the entire book just to get a concept I will just watch a video on youtube.

- Yes
- reading books
- watching video

C10. Please leave your comments and suggestions here, if you have any;

Social media can improve learning mathematic if used wisely and efficiently.

S.M. improves math learning.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Researching questions we are not clear in class and assigments.

researching

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google

indispensable social media application

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the ~~way you~~ used them in high school to the way you use them now? If so, how?

Yes, because am able to learn on my own on the topics not being taught in class

Yes

self taught

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

NO

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes because it is diverce of learning things related to math

self taught

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

~~NO~~ ~~yes~~ NO

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By providing ~~a~~ efficient wifi's and goverment should buy ~~a~~ alot of computers

- efficient wifi
- Govt procure PCs.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

some of students / pupils use social media on things which are not academic related.

Negative

non academic related things

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

increase because ~~a~~ when I fail the question I am able to search the information on media sites

C10. Please leave your comments and suggestions here, if you have any;

I strongly ~~believe~~ agree the socia media should be ~~used~~ improved and used

- S.M improves learning.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It helps you understand clearly what you did not understand in class and help you to Know on a topic you didn't Know.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Youtube → indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes it has changed
Because in high School I never used to search alot on internet but now I do.

searching a lot on internet.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

It was used to watch a video
Helped me to understand what was been explained

– watching videos.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes it can.
It is easy to remember what you watch, so it will be easy for you to ~~remeber~~ remember in a test.

– meaningful learning.
(memory retentio

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes. it should be offered

To teach students on how to search for information on the internet. By introducing it as a ~~compon~~ course to each student.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Positive

By improving the networks which can accomodate alot of student acessing it at the same time with no ~~...~~ congestion.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Positive

Helps learners and teachers to understand on any particular topic
Easy to communicate with friends when you want to understand on a topic, hence you understand

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

No it does not increase your study timing. Searching is an easy thing, so it is easy to search and read or watch a video about it.

C10. Please leave your comments and suggestions here, if you have any;

Learning mathematics is easy if you use internet ~~and~~, so social media should be introduced in different schools and Universities

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

The internet has videos that explain most mathematical concepts in detail   Researching

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google application. - indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how? - Yes it has changed.

Yes

- Most of information I needed to know in a particular subject in highschool was given to us by teachers, other than the lecture method at university where I need to research on my own on most occasions. - Therefore, I use more of online sources now.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes at University. The lecturer has at times sent notes and questions to our email accounts and our school student portal platform. It has been very helpful.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes I believe it can enhance my learning and teaching because Mathematics is a wide field that at times may need interaction and discussions on certain challenging topics with other people

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes. It should be offered because it has made

some works way easier for both the learner and teacher /lecturer.
The course outline can be for example, to ~~educate~~ learners on how they can each create a blog connecting to their respective schools.
And other ideas that I believe you might have.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Can be improved by creating one known platform that can be easily accessed.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

It is more effective to learners who know what they want in terms of education.

positive

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It decreases time of study when used for social other than educational purposes
But to me it does increase because I use it for study mostly.

Both ways.

C10. Please leave your comments and suggestions here, if you have any;

The introduction of social media to enhance learning and teaching can be very effective if the intended people to use it are taught to be disciplined.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It has made learning ~~become~~ mathematics become easy and bearable.

Researching

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google. – indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

It has changed very much. Mathematics at high school was way simpler and straightforward but university Mathematics requires more research.

more research online.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

In university the lecturers send notes and questions on to whatsapp classroom group and it has really helped. Some they ~~se~~ update them on our student portals for easier access.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes very much. Students or pupils are so alert to the use of social media so out of their active and eagerness to use social media it might help to deliver information on social media.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

No. Because the use of social media is

ceff explanatory and our university should not waste money and resources to train people who are able to do it on their own.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

They is no much improvemend to be made except that each school in Zambia should have computer for easy access to online information.

- computers
- online info.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

The use of social media is very enjoyable and actively done, because you waste your money to access hem. So te Impact it has is ~~to~~ for easy understandung, and its difficult to forget.

Positive.
- Meaningful learning.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It decreases my study time because information is very direct and doesn't take time to understand.

C10. Please leave your comments and suggestions here, if you have any;

In ~~most~~ some cases social media has been misused by people, they ought to use it for leakages and other immoral things.

SM. abused.
- leakages
- immoral conduct.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

We can easily access and share information. researching

C2. What is the one online or social media application that you could not live without while studying mathematics?

Youtube - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. It has changed very much. I only used social media for recreational purposes only but now, am able to use social media on academic issues (purposes).

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

~~Also~~ Yes. Have been able to receive emails containing documents that have been of great help academically. Was at some point receiving internet extracts which helped me understand certain concepts.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes it can.

It (use of social media) makes learning interesting.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Universities must offer social media courses.

why – Because some students do not know how to best use social media mostly for academic purposes.

course outline → introduction, how to access, important and benefits of using social media.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

schools should try by all means possible to grant access to Internet to the students. That is create technology laboratory and encourage students to access them.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

It can greatly impact the performances. It being that the ~~Ed~~ mathematics Edu in Zambia has to carter both introverts and extroverts, social media can play a helpful to meet needs of all learners.

positive.
- improve academic performance
- needs of all learners.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It decreases.

I learn yet to learn how to best control its use.

C10. Please leave your comments and suggestions here, if you have any;

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Searching For answers to the questions that are most challengable and finding out more about most of the topics in mathematics

C2. What is the one online or social media application that you could not live without while studying mathematics?

SOCIAL NETWORKING

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. And the reason is during high school I never had enough time to access social media

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

~~Yes, For Comfirtion~~ Yes they use it almost all the times. They use it to post handouts and
es. assignments. This is beneficial because sometime I may not have money to photocopy handouts, so its better I save them on s

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes of Cource. Sometimes I may not be able to go to class, so if that happens better I use social media to communicate with the learners and post any assignments and handouts.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

~~Yes~~ Yes and the reason is that, this will help upcoming learners have a better access to social media. And the course outline should begin with the basics

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Allowing ~~learner~~ the use of smartphones in class.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

It anables ~~or~~ students to have better understanding on difficult topics

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It does increase, I have to set the time I should spend on social media sites

C10. Please leave your comments and suggestions here, if you have any:

Implementation the use of social media sites in secondary schools.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

You Get to Know trust worth information and answers, and also you get to study at your own convinient time

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google Specifically wikipedia – indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes! Back then I never Knew that they was Educational information on Internet which can help me understand my misconceptions

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Only in third year, when giving me the ~~tutrial~~ tutorial questions and course outline otherwise it has not been beneficial to me since only few items get uploaded on my student portal.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

I don't Know cause have not rely thought of using Social media in teaching mathematics.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes! It will enable students to Study

convinience

Share information and also it can be flexible as one gets to ~~do~~ study at his own time. I think they should be tutorial videos, a part for answers and questions

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Aaah internet connections should be improved and then making sure students get access to it i.e making wifi available and accessible

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

The impact depends on an individual what is interested in and what he wants from social media Otherwise if one makes good use of it be it Education, entertainment and other things it is a very powerful tool

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

No

C10. Please leave your comments and suggestions here, if you have any;

When it comes to social media the schools and the government at large should emphasise on using social media in conducting moral activities on it which should bring development to the nation

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

learning maths

- it is easy to learn mathematical concepts from youtube videos.

C2. What is the one online or social media application that you could not live without while studying mathematics?

YouTube - indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

x/s teacher dependence syndrome

- it is easy to learn mathematical concepts different people unlike depending on the teacher.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

yes. because will use discussion methods of learning. easily discover easy ways of solving mathematical problem.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

No

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

- easy learning of mathematical Concepts.
- having different explanation on the same topic.
- it increase the learning resources.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Yes ← decreases because students will be spending more time on social media than studying.

C10. Please leave your comments and suggestions here, if you have any;

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It helps the mathematics student to have broader understanding by asking any question on the internet.

broad understanding

C2. What is the one online or social media application that you could not live without while studying mathematics?

google. - indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

no smart phone
no - internet

Very much. This is because in high school I never even had a smart phone hence never had a previledge to ask questions on internet.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes the lecturers used it in posting the documents for the course material

It was right for those who have smart phones and after those without were ask to get them from their colligues.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

- easy understanding
- better ways of teaching

Very much. This is because social media (google to be specific) makes it easy to understand the concepts in mathematics and also on how to teach.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes it should. so as to have people (graduates) with a better understanding on the social media. This can make betterment of the internet provision (wifi) which is a challenge at CBU

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

ICT Laboratories should be provided at every secondary school to enable pupils access internet so as to add more on the topic.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

social media enables delivery of information (mathematical) there by exchanging knowledge. positive

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It can decrease if unappropriately used i.e if one spend the ~~time~~ just searching without studying what is being searched then it becomes unhelpful to such a one.

C10. Please leave your comments and suggestions here, if you have any;

Social media is beneficial to students ~~at~~ tertiary level with easy controlled limitation. while with secondary school pupils extra care and control has to be taken as it can lead to educational system (life) decay.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

To be able to under concept from other people's point of view from across the globe.

better understanding learning env.

C2. What is the one online or social media application that you could not live without while studying mathematics?

wikipedia - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

No searching online.

It has changed in it that in high school information can be easly handed to you but in university you as a student you have to Study to get it

CBU research online

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

The use of whatsapp is regular for lectures to give us lecture notes for topics taught so that we have extra time to study and understand them.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

It is possible because it will help grasp information or rather new information to help teach.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

NO I don't think it should offered here.

but at other institutions.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

The board of education should make sure all schools have wifi so that everyone can be able to access it.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

in it that mathematics is a challange in secondary schools. creating study groups for example on whatapp can help pupil understand some concepts not understood during lesson

improves learning & understand

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Neutral response

well it depends on how you are searching for content online. if you using wikipedia studytime reduces in searching for the right material.

C10. Please leave your comments and suggestions here, if you have any;

NON

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

One Can access the Information that Cannot be found in textbooks easily access

at any time

C2. What is the one online or social media application that you could not live without while studying mathematics?

YouTube (because I use it to download tutorial videos for every topic I learn in Class)

indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. ~~At they~~ At the university they don't teach but they lecture researching more.

Meaning as a student (I have to research more on every topic) we Cover

In Class. at high School everything was given.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes. Gmail. / WhatsApp my lecturer used it to Send notes. Gmail & WhatsApp

It was beneficial because I accessed Study materials

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

saves money/& time

Yes it Can. It Can be used to Send books and other Study

materials unlike where you only have access to hardcopy which

is expensive to buy.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes. because one can learn in their Comfort homes

there by reducing ~~trans~~ costs of Coming to the Compus

convinience / flexibility.

time efficience

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Network should be improved so that social media can be easily accessed especially in rural areas so that student can be searching for study materials

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social medi in Mathematics Education in Zambia?

It acts as a link/source of information

C9. Do you think social media sites decrease/~~increase~~ your study timing? If so. Please decribe how.

Yes. Social media like facebook/whatsapp can be addictive hence spending much time chatting with friends there by decreasing one's study time.

C10. Please leave your comments and suggestions here, if you have any;

NIL

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It herps you to figuire out how to answer a certain question by checking on many examples.

more understanding

C2. What is the one online or social media application that you could not live without while studying mathematics?

youtube - indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

yes. because in high ~~shcw~~ school I viewed social media as just for entertaiment.

High school

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

- yes
- sends us assignment and tutorials online

this was beneficial because soft copy for me is cheap than hard copy

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

work independent

yes.

- in that it herps learners to work solitary thereby helping them to be active as they are alway enganged.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

no.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Each Institution or School should open a free wi-fi and allow pupils to access the internet but with restriction i.e only for academics

Secondary sch
⇓
Free wi-fi
academics

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

The impact all in all is positive in almost all areas.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

no.

C10. Please leave your comments and suggestions here, if you have any;

null

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

One of The benefits is that, it gives full information or concepts about Mathematics

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google – indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes it change mathematics learning because at my high' learning we have alot of assignments and some differents concepts as compared at high School

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes university Mathematics lecturers use email to send hand out notes to the Students. It is beneficial because we as Students ~~as~~ usually ~~at~~ recieves notes at a better time and anywhere

convenien
flexibil
time eff

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes, because it makes the work more easily and social media can be reached anywhere

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

NO

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

In some rural areas, people are not access to internet because network is not available in some areas hence, more network providers are required

rural areas improving the network.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

It makes students not to have more time to study

Negative lack of study time.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It decreases because many of the times students use social media wrongs

Yes wrong use of social media.

C10. Please leave your comments and suggestions here, if you have any;

As Mathematics teachers we have to make use of social media where necessary.

recommend the use of S.M.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It gives a wide range of data to choose from, both that has been done by professionals and approved by experts. It also helps in distributing new mathematical concepts faster.

C2. What is the one online or social media application that you could not live without while studying mathematics?

WhatsApp and Facebook Messenger.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes, for Instance WhatsApp, we have an option of gathering fellow students in a group and ask questions and contributions from them.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

In high schools No, since most effictive social media tool ~~which~~ (mobile phones) are not allowed. For Univerties Yes, Fast delivery of information, comments on previous classes, etc

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes, It will help us migrate to the digital world together. The best way it can be offered is by ~~an~~ a mobile application we can instal on our mobile phones that can allow us to have a platform to access data and interact with our lecturers on that same application.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Secondary Schools is quite tricky in the sense that most devices are not allowed. But increasing computer and Math tools Softwares in Secondary can be one of the ways.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

The impact ~~would be~~ is positive and it can be believed that it will have a great positive effect going forward.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Increase, There many ideas, information and data on the internet, so you would want to go through all of them, hence increasing your study time.

C10. Please leave your comments and suggestions here, if you have any;

Most of our lecturers are stone age, So aquinting us with such new technologies now will be of great ~~new~~ help with the coming generation we will be teaching.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Internet clearly helps to easy some concepts in mathematics topic for better understanding.

C2. What is the one online or social media application that you could not live without while studying mathematics?

You-tube – indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes because from high school, I had less knowledge about internet and could find informat not from the internet but from book only and other people.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No! With my mathematic teacher, the internet was not part of his talk in the lesson.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes because topics discused as a group on social media are well explained and brings about motivation hence easy to recall.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe why it should be offered and how the social media "course outline" should be.

Yes but should have limits such that it should be within the bounds of teaching mathematics.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

It should contain all the necessary formulae and symbols and their clear use (Application)

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Neutral

The impact can either be positive or negative depending on the use.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Yes! Saves time!

It helps to discover some information at quicker time at some point.

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It can help us with many way's of solving mathematic problems.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Non of them.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes it has quite changed, because during high school I was only depending on one source the teach to learn mathematic techniques but now with the availabity of online resource I atleast access quite a number of resource to learn some techniques.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

I don't thinck so

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Not in support of that.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By teaching pupils how to have access to social media technologie at primary level.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Social media is a time waster according to my views.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

decrease. It decrease time because each time am on online my mind will be thinking of chatting with friends and family instead of concentrating of researching.

C10. Please leave your comments and suggestions here, if you have any;

I strongly disagree with the idea of social media because in our country, technology is not that, so many will ~~be~~ start abusing social media.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It makes learning mathematics easy and quicker, . Concepts are explained in full detail, giving full understanding of concepts

C2. What is the one online or social media application that you could not live without while studying mathematics?

Youtube. — inf(i)

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes, because in high school I never learnt Mathematics online and I so was restricted to what was covered in class but now I have a variety of options making my life easier

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

~~N/A~~ ~~In high school,~~.

once in university we had a blog to share information, that was pretty helpful for me

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes, because Social media enhances learning and makes it easy for me to know multiple topics on just one platform.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

I feel it shouldn't be offered as a course because it's one of the things you can learn outside a classroom and requires an individual's interest hence it must be optional

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

by having many educational sites or pages for instance on Facebook. and also teaching computer skills to pupils at an early stage so that they develop an interest in online learning thereof utilising social media

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

-itive It has a high impact because it makes learning mathematics enjoyable and quicker.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

it increases study time because it has a lot of information to display and one has to choose the best information to take, hence one spends double the time if ~~not~~ they are not focused.

C10. Please leave your comments and suggestions here, if you have any;

I feel there is need to encourage the development of educational applications that only focuses on teaching school material, if such apps exist, it would be easy to access information on one social media platform.

Thank you so much for completing the Social Media and Mathematics Learning Survey!
Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

exposition learning.

It enables one to be exposed to many Ideas about a mathematical Concept.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google documents. indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes! It has really changed, ~~to too~~ because there is so much of many online resources in the university than high school

more online resources

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

NO

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

YES, it can be of so much beneficial in that some more difficult concept can be solved easily.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes, because it can expose us to many mathematical Ideas across the globe.

exposition useful tool math solving

And it can really be a useful tool in solving some difficult concepts.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

It can be improved by training teachers about social media technology, and also by providing wifi and devices like laptops, tablets etc. in schools.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Positive

It enables students to access so many different concepts about mathematics, and it also an easy way of learning.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It increase the studying time, because sometimes it takes so much time to find a specific solution

C10. Please leave your comments and suggestions here, if you have any;

Using social media in learning mathematics can be of so much beneficial.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Educational, Reading and asking questions on online forums such as ask.com

C2. What is the one online or social media application that you could not live without while studying mathematics?

Social networking

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes, it has changed. In high school there was no access to ~~..~~ Internet video sharing like youtube and wikipedia documents.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes

University lecturers use use social medias like whatsapp and email to send educational content, ~~to~~

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes

Has a mathematics teacher I believe the official use of social media a enhance ~~your teac~~ my learning and teaching of mathematics throug video and document sharing.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes

I think our university must of social media studiess, as a course exchange of knowledge, connecting with colleagues.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Its easier to connect with fellow colleagues of similar interest and quickly get a desired responce as well as expanding ones knowledge about a concept

C2. What is the one online or social media application that you could not live without while studying mathematics?

Whatsap

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

yes it has cause back in high school I was mostly naive but now its been used to my benefit

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes

This was done in university especially, especially on whatsap to distribute course materials like handouts and Tutorial work, It was beneficial in that it allowed ease of access + cost efficient

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes

very much, because you'll alway be upto date with the current needs of the modern society and distribute information to the learner effectively with credible information at hand.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes

offering them is a good idea but i feel not at university but in secondary schools because this material should be covered in ther early stages of education to lessen the burden & work load in universities

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian ~~secondary~~ schools?

design the use rules for (policy)

We can design our own social media ~~plat~~ forms in order to guide learners in the manner we want them, cause with these other applications its easy for most of them to be distracted.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Negative non-academic purposes

Not very much appreciated in our society, cause most of the people use it for non-mathematical purposes hence the impact is minimal

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

well, generally in decreases it cause of the distractions that come in, especially when people see you online they will want to chat whilst your trying to get Ucbal information

C10. Please leave your comments and suggestions here, if you have any;

Social media is a very good way of communicating intellectual thought but if it can be designed so as to lessen distractions it can most effective.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

I can easily search for solutions to my mathematics problems.

C2. What is the one online or social media application that you could not live without while studying mathematics?

YouTube

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. In high school I only used social media for fun but now I use it to find solutions to problems.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes. In that if a pupil or student has a problem in understanding some mathematical concepts they can easily WhatsApp or email me.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

No.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Either by making some of the sites into applications that can be accessed offline in area that do not have access to internet.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

It has impacted mathematics Education in Zambia negatively as most of pupils/student spend most of their time on Entertainment Social media sites.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Decrease. Because I spend most of my time on Entertainment Medias.

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Wide range of mathematical tools.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Youtube. – indispensable,

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. My use of Social media has given me a broader knowledge of information through the use of internet tools

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes. For my project research.
It was beneficial as it saved time rather than having to move to his office.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes. Easier access and better illustrations

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes.

It may give a wider knowledge of mathematics through online reaseh.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Things like mathematical Sopwares (matlab, Latex etc) can be involved or included on Social media.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Relative but beneficial - addictive - Negative.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Decrease. One may end up in ~~entain~~ entertaiment and Socialing with friends rather than learning mathematics.

C10. Please leave your comments and suggestions here, if you have any;

Social Media use in mathematics learning could contribute significantly though, better Sites of communication should first be improved or developed.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

for research purposes about various fields of mathematics

C2. What is the one online or social media application that you could not live without while studying mathematics?

infis — You tube.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way ~~you~~ used them in high school to the way you use them now? If so, how?

Yes It has changed reason been maths has advanced and so are the concepts of learning and this can only be done online

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes they do, for ~~rese~~ further research it has heeped me to do my own research and learn of diversity my mind.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching ~~experience~~ in mathematics education? If so, how?

Yes it can reason been learning and teaching is made easier and some concepts are simplified or easy to ~~unst~~ understand.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should ~~be.~~

Yes they should, it will be beneficial for researchers or students will be able to learn how to conduct their research studies

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

social media technologies has improved the educational sector in a way that pupils are able to learn more ~~tean~~ than what's been taught in class

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

The impact is that pupils / students will learn not only to depend on whats taught in their classrooms but to also do their own research for further understanding

self taught

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

~~The decrease~~ the

They can either decrease or increase depending on what you use them for either for studying or just texting etc.

Neutral

C10. Please leave your comments and suggestions here, if you have any;

Research Studies Should be introduced at CBU.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

You get to access more information on the net.

info.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google – indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. Online resources were ~~not~~ rarely used but now they are a part of my day-to-day academic life.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes. Social media apps have been used to give assignments. ~~an~~ They were beneficial because they enable students became familiar with technology for educational purposes.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes. Through social media, you get to interact with fellow mathematicians from other parts of the world. The interaction is so helpful.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes. Students should be aquainted with social media.

Groups should be formed and learning should be done from there.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

There should be an adequate supply of electricity. Computers should be made available and students ought to be oriented with the basics of social networking.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

So far, I feel a lot more can be done to acquaint mathematicians (pupils, students) with social media. Otherwise, it has fairly beneficial effects

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Decrease. Being on social media, even for useful purposes, can be time-consuming.

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey!
Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

access more info.

Acquiring more information in terms of books and documents.

C2. What is the one online or social media application that you could not live without while studying mathematics?

You-tube - indispensable

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes.

The applications to choose from are more and level of understanding is higher.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes

They would ask us to search on the internet and it was beneficial in the sense that more information was found there unlike just copying notes from the class board.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning ~~and teaching~~ experience in mathematics education? If so, how?

Yes

More information and books would be easily accessed.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

No

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By ensuring that every student is able to access and use the tools effectively.

Guiding student's use of SM.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Right now, few students appreciate the availability of social media in mathematics education so most people do not end up benefiting.

Neg

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Decrease

Because as one searches for information, they may find that a particular document directs them to another site and when they keep following such directions, time is lost in the process.

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

It helps me to Understand Mathematical concepts

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

NO

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

NO

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes, it helps students to Understand the concept better

(teaching purpose)

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes, To help student Understand mathematical concept, because every student nowadays owns a smart phone

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By introducing a Mathematical related social media where student can share idea.

introduce SM app with all maths inbuilt stuff.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

No

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

It decrease because student these days use non-mathematical related social media

C10. Please leave your comments and suggestions here, if you have any;

Introduce a mathematical related application, where student can share their knowledge.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

search for solns. / better understanding

I think the best benefit is that whenever i have a problem with understanding some of the material i am able to google, and it times i even ask on yahoo.com.

C2. What is the one online or social media application that you could not live without while studying mathematics?

indispensable

Google, i usually use it to find answers about some questions that i find hard.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

High school - NO!

I never used any social media in any way when i was in high

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

university

Yes, ~~at~~ times some lecturers send documents to our emails. It was beneficial especially i didn't have to be in class to receive that information

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

positive

I think it can enhance learning and teaching in the sense that instead of always writing notes in class sometimes they just be posted online and let every pupil have it, and go through it before it exp th

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

NO!

I do not think so

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

rovide -learning.

I think can only work if new educational ph applications are made, maybe like E-learning ra than just improving facebook and Whatsapp.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Negative

I personally feel its doing more harm than good, because i believe very few use it for educative Stuffs.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Social media decrease my study timing, usually i spend more time on facebook and whatsapp than i spend on my Studies. I Can say Spend roughly 70% hours of a day on social media

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

Students get access to a wide range of relevant resources to help them understand Mathematical Concepts better.

better understanding

C2. What is the one online or social media application that you could not live without while studying mathematics?

Wikipedia – indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes it has changed; Now am using online resources ~~to~~ ~~lear~~ for in depth learning of mathematics rather than just being interested in the answer.

~Yes

in-depth learning

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes!

Sending emails with Content of lecture notes. This way it was ~~is~~ really benefitial

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes!

It Can enhance learning and teaching ~~with~~ accompanied by displine;

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

As a half Course; The Content must be about

Yes!

Social media disptine (Netiquette), How to Choose Communities that offer/post proper/relevant mathematical topics, To be a contributor and also ways of having fun through online Mathematics learning without losing focus of the core purpose

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By Promoting reliable Communities that focus on mathematics and also ~~p~~ alerting students about the availability of such Communities to students.

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

positive

Social media ~~ex~~ is one of the effective ways that students Can learn Mathematics and the trend is growing if only students can be aware.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Yes! Decrease; Due to "pop" ups of unwanted but attractive materials that are not mathematical

provide more platforms

C10. Please leave your comments and suggestions here, if you have any;

Promote/advertise ~~the~~ reliable mathematical Zambian online Communities.

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

saves time

The Biggest benefit is time will be saved as you will be able to search questions,

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Yes. I dont waste much time thinking, if I get stack I use Google

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes. It will help you to Save time

saves time

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes. to help Save time.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

Providing Free wifi to access

Students awareness of benefits

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

Enhances thinking ability positive

provides discussion and sharing ideas

C9. Do you think social media sites decrease/increase your study timing? If so, Please decribe how.

Increase

when you do a lot of unnecessary research.

C10. Please leave your comments and suggestions here, if you have any;

Nill

Thank you so much for completing the Social Media and Mathematics Learning Survey!
Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

eek clarity & more understanding

we can get clarity on concept that we don't understand in class e.g Tutorial videos

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

changed.

High school Never-used college - uses

Yes, I never used social media frequently at ~~seco~~ high school but now I do.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Yes, when ~~they~~ we need clarity on the lesson in Linear algebra, we searched together with the lecturer for clarity.
It felt as if the lecturer didn't prepare for a lesson.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

Yes ~~It wi~~
Because I only need a mobile Phone and data bundles to search than paying for Tutorials

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes

Because not all students know how to use social me
The course outline should by, how, ~~do~~
when, and where to use social media

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

providing free internet services

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

positive
self taught.

Encourages learners to learn on their own by searching on internet rather than waiting for a teacher.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Increases
Get easily get access to ~~the~~ social media

C10. Please leave your comments and suggestions here, if you have any;

Thanks

Thank you so much for completing the Social Media and Mathematics Learning Survey!
Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

learning

Because we tend to learn alot.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

Neutral (same)

No it has not changed.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

Never!

No, they haven't.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

teaching purposes

Yes please, because it will be helpful in a way that we will learn more and have ideas.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

Yes please, by providing free internet.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

By providing free internet

By providing more educational programes

online

C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media in Mathematics Education in Zambia?

positive

it will help in a way that we will have access of alot of information concerning maths.

C9. Do you think social media sites **decrease/increase** your study timing? If so, Please decribe how.

Yes please

By being on ~~fa~~ facebook

By downloading songs etc.

C10. Please leave your comments and suggestions here, if you have any;

Thank you so much for completing the Social Media and Mathematics Learning Survey! Your participation is greatly appreciated.

Section C) Open ended questions - Social media practices and mathematics learning in general

C1. What is the biggest benefit to having access to the Internet for learning Mathematics?

learning understanding

Concepts are easily Understood, as they easily have acess to internet unlike a lecturer, e.g you want to know a Certain Concept on a weekend, and have no acess to the lecturer, easier understanding.

C2. What is the one online or social media application that you could not live without while studying mathematics?

Google, - indispensable.

C3. Has the way you've used social media or online resources to support your mathematics learning changed from the way you used them in high school to the way you use them now? If so, how?

H.S- personal
university- professional

Yes, it has changed, usually in high school it was mostly for Social Purposes, but now it's mostly School related, mathematics in Particular.

C4. Did any of your high school mathematics teachers or university mathematics lecturers use any social media applications to deliver content or to interact with students? If so, please describe how the social media applications were used and the ways that you felt it was (or wasn't) beneficial to your learning.

No.

C5. As a student mathematics teacher, do you believe that the official use of social media can enhance your learning and teaching experience in mathematics education? If so, how?

- exposition
- various methods

Yes, it Enhances our learning and teaching experience because, it exposes us to different methods and ways which may not have been covered in class, which may be Simpler ways.

C6. Today, educational mobile technology is frequently used in online instruction in Universities worldwide. As a student who is supposed to be a mathematics teacher, do you think your University should/must offer "Social Media Studies" as a course? If so, please describe **why** it should be offered and **how** the social media "course outline" should be.

it Should be offered, it Enhances student's understanding, the course outline must describe the important uses of Social media in relation to Professional Purposes / academic Purposes.

Why? because social media is faster and more efficient to teacher a large group of People anywhere around the world at the same time.

C7. As a student who is supposed to be a mathematics teacher, how can social media technologies be improved in any way as a tool for mathematics learning in Zambian secondary schools?

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C8. As a student who is supposed to be a teacher of mathematics, what do you think is the impact of social media

Appendix F

RESUMEN EN ESPAÑOL

Note: The author apologizes for any linguistic inaccuracies in this appendix as a consequence of the fact that Spanish is not his mother tongue.

Introducción

El autor de esta tesis doctoral comenzó su trabajo motivado por su interés por explorar el uso y el impacto de las redes sociales en la enseñanza y el aprendizaje de las matemáticas en la educación de cara a entender cómo estas estaban afectando la vida de los estudiantes de secundaria. Comenzó en 2017 trabajando con una muestra de 288 participantes si bien no creó un informe en este primer año, sino que simplemente presentó la investigación en un seminario local. En 2018, la investigación se extendió a la educación superior con una segunda muestra de 102 profesores de secundaria en formación inicial en un estudio orientado a la exploración del uso de las redes sociales por parte de los estudiantes universitarios de Educación Matemática tanto en su vida personal y académica como en su desarrollo profesional y carrera docente. En este estudio, el autor "midió" el uso de las redes sociales entre dos grupos de estudiantes de tercer y cuarto año de la titulación de Educación Matemática en la Universidad de Copperbelt (CBU) en Zambia. El mismo cuestionario se distribuyó a ambos grupos de estudiantes. Los resultados de este estudio son relevantes para abordar cada una de las preguntas u objetivos de investigación planteados. Mirando los objetivos de un vistazo rápido, el autor estaba interesado en:

a) Explorar cómo los estudiantes de la CBU utilizan actualmente las redes sociales en sus vidas personales, profesionales y académicas para enriquecer sus carreras docentes.
b) Investigar el uso oficial de las redes sociales en la enseñanza y el aprendizaje de las matemáticas como herramienta de formación y el impacto de ello en los profesores y estudiantes de Zambia.

c) La medida en la que los participantes pudieron transferir sus interacciones [experiencias] en las redes sociales para enriquecer sus prácticas de enseñanza de las matemáticas.

Esta disertación tiene dos temas principales objeto de estudio. El primero es el de discutir cuestiones que plantean si las redes sociales han influido o influyen en la enseñanza y el aprendizaje de las matemáticas en las universidades zambianas y qué caminos están abiertos (y cerrados) para provocar un impacto futuro efectivo en este campo; el segundo tema es que aborda mostrar al lector cómo los estudiantes universitarios, futuros profesores de matemáticas en secundaria, han utilizado las redes sociales en sus carreras personales, profesionales y de enseñanza de Matemáticas.

Los estudios dirigidos a la conceptualización de la enseñanza de las matemáticas con la incorporación de redes sociales se esfuerzan por aclarar su naturaleza y estructura en términos de relación entre profesor, estudiante y contenido, entendida esta como interacción matemática, así como por distinguir los factores que afectan tales relaciones. En el campo particular de la Educación Matemática, y en un esfuerzo por tratar de "mejorar" la enseñanza de las matemáticas a nivel escolar, se ha hecho especial hincapié en dar consideración específica a los problemas identificados con la tecnología de software [redes sociales], enfoques de enseñanza que incorporan plataformas de medios sociales y herramientas de evaluación de alta tecnología que son progresivamente razonables, flexibles y competentes. Por lo tanto, los estudiantes de pregrado de matemáticas han sido un punto focal de consideración en esta situación de progreso. En consonancia con otros investigadores, este estudio estimula nuevas discusiones sobre el camino para adoptar plataformas digitales en Educación Matemática maximizando sus beneficios.

En un entorno social impredecible y dinámico, es inevitable prestar una especial consideración a la figura del profesor de matemáticas en formación inicial y a las cualidades, las habilidades y los rasgos tecnológicos que este debe poseer o adquirir para actual de forma eficiente y significativa en el aula. En esta tesis doctoral, términos como web 2.0 tools, e-learning, plataformas de redes sociales, comunidades online, plataformas digitales, redes sociales y otros similares se utilizan una y otra vez con un sentido y un propósito similar, a pesar de presentar matices que se abordar también adecuadamente en algunas de las secciones que conforman esta tesis.

A lo largo de esta disertación, la Teoría de la Actividad (AT) y el Modelo de Aceptación de Tecnología (TAM) son las lentes utilizadas para guiar el análisis de datos y la interpretación de datos para examinar los factores que influyen en los intereses de los estudiantes de matemáticas en las participaciones en línea a través de las tecnologías Web 2.0. Por otra parte, de cara a abordar los objetivos establecidos en esta tesis, se apuesta por los métodos mixtos, realizando una extensa revisión de la literatura, empleando técnicas modernas para organizar datos y una reinterpretación de la tradición investigadora que implica investigación cualitativa para su posterior análisis y, finalmente, explora la realidad de la integración de sitios de redes sociales en la formación inicial de profesores de matemáticas.

Objetivos

La siguiente tabla (Tabla 1) muestra los objetivos de investigación, las hipótesis y las preguntas de investigación de esta tesis doctoral:

Tabla 1. Preguntas de investigación, objetivos e hipótesis

Preguntas de investigación	***Objetivos de investigación***	***Hipótesis de investigación***
¿Tiene el uso oficial de las redes sociales un impacto estadísticamente significativo en la enseñanza y el aprendizaje de las matemáticas?	*Explorar el uso oficial de las redes sociales en la enseñanza y el aprendizaje de las matemáticas y su impacto en la educación matemática en Zambia.*	***H_1**: El uso oficial de las redes sociales tiene un impacto estadísticamente significativo en la enseñanza y el aprendizaje de las matemáticas.*
¿Hay una diferencia estadísticamente significativa entre el uso actual de las redes sociales de los estudiantes?	*Explorar si el uso de estas redes sociales puede tener un impacto en el desarrollo de habilidades del siglo XXI tanto por parte de los estudiantes como de los profesores.*	***H_2**: Hay una diferencia estadísticamente significativa entre el uso actual de las redes sociales de los estudiantes.*

¿Cómo utilizan los estudiantes para profesor tecnologías móviles como WhatsApp, Facebook, Twitter, Instagram, Wechat, correo electrónico y otras herramientas web 2.0 en comunidades en línea para aprender matemáticas?	*Investigar el uso y los impactos de las plataformas de medios sociales, iPads y otros dispositivos digitales portátiles en la enseñanza y el aprendizaje de las matemáticas.*	***H_3**: Los estudiantes para profesor utilizan tecnologías móviles como WhatsApp, Facebook, Twitter, Instagram, Wechat, correo electrónico y otras herramientas web 2.0 en comunidades en línea para el aprendizaje de las matemáticas.*
¿Cómo ven nuestros estudiantes el impacto de las redes sociales en la educación matemática?	*Determinar los impactos positivos y negativos de las redes sociales en la enseñanza y el aprendizaje de las matemáticas en Zambia. En particular, explorar el impacto y el papel que las redes sociales pueden desempeñar en la educación matemática a través de las redes sociales entre los estudiantes.*	***H_4**: El uso oficial de las redes sociales tiene un impacto estadísticamente significativo en la educación matemática.*
¿Creen nuestros estudiantes que el uso oficial de las redes sociales puede mejorar su experiencia de aprendizaje y enseñanza en matemáticas?	*Discutir cómo el uso oficial de las tecnologías de redes sociales puede influir en la enseñanza y el aprendizaje de las matemáticas en Zambia y qué caminos están abiertos (y cerrados) para el impacto futuro.*	***H_5**: El uso oficial de las redes sociales puede mejorar la experiencia de aprendizaje y enseñanza de los estudiantes en matemáticas.*

Con el objetivo de tratar y explicar todas las motivaciones y el contexto de esta tesis doctoral, el proyecto de investigación utilizó un diseño secuencial explicativo de métodos mixtos, con el objetivo de obtener una descripción en profundidad de la situación en estudio. Además, la razón de ser del enfoque de los métodos mixtos es obtener una mejor comprensión de la declaración del problema y, por último, aumentar la credibilidad de los hallazgos de los autores. Este diseño de investigación fue representado por dos etapas o fases principales. En la primera etapa, los datos proporcionados por los 102 participantes se analizaron cuantitativamente mediante técnicas cuantitativas de análisis de datos. La segunda etapa se centró en la recogida y análisis de datos cualitativos a partir de una muestra de 33 participantes en función de sus experiencias encontradas durante la primera etapa de recopilación de datos. Así, los 33 participantes dieron sus puntos de vista, opiniones y narrativas con respecto al uso de las redes sociales en las actividades matemáticas. Estos datos de la segunda etapa se analizaron cualitativamente mediante una técnica de análisis cualitativo del contenido.

Resumen del Capítulo 1

En este capítulo se han discutido los conceptos clave de las redes sociales a partir de la literatura relevante analizada. Se comienza identificando dos tipos de usuarios de redes sociales: nativos digitales e inmigrantes digitales. También se afirma que Zambia es notable por el uso de las redes sociales, especialmente entre los jóvenes. Además, se consideran las contribuciones de diferentes estudios al tiempo que se estudian algunas sugerencias perspicaces para la integración de la tecnología de software en la Educación Matemática. Este capítulo deja algunas contribuciones de la tesis que permitirán al lector encontrarse en la etapa teórica donde la tesis tiene su lugar. Por último, procede con una reflexión concisa pero profunda sobre el uso de las redes sociales en las actividades relacionadas con las matemáticas, identificando las fortalezas y debilidades de las contribuciones citadas en el capítulo y las principales contribuciones de esta disertación a la Educación Matemática. El capítulo analiza el propósito, así como el alcance del estudio.

Como una forma de establecer la relación entre los estudiantes y los propios profesores y la necesidad de integrar las tecnologías de las redes sociales en el proceso de enseñanza-aprendizaje de las matemáticas, este capítulo ofrece una descripción detallada del sistema educativo zambiano en relación con el último plan de estudios tanto para los alumnos de secundaria como para los profesores de matemáticas en formación inicial, respectivamente. Se cierra con un examen de las cualificaciones docentes de los profesores de secundaria en Zambia en relación con las características de la profesión con el fin de identificar los desafíos digitales a los que se enfrenta la comunidad docente en el país para alcanzar el estatus profesional deseado. Por último, el capítulo termina dando un breve resumen de toda la tesis.

Resumen del Capítulo 2

Este capítulo se abre con una breve descripción de las fuentes de datos de artículos de revistas, libros, capítulos de libros, artículos en actas publicadas, disertaciones, artículos de conferencias en línea, informes, artículos de periódicos, documentos en línea y similares generados a partir de la "Web of Science core collection" utilizando técnicas científicas modernas. También analiza las técnicas de cienciometría utilizadas en este estudio para detectar similitudes comunes entre publicaciones científicas o autores (particularmente con el interés de descubrir autores invisibles que no hayan sido elegidos por los parámetros seleccionados inicialmente), aquellos que por un lado aplicaron un impacto más notable en el campo de la tecnología y la educación matemática y, por otro lado, para considerar la naturaleza multifacética dinámica de la idea de enseñar matemáticas en el contexto de las tecnologías de redes sociales. Para responder a todos estos problemas, CiteSpace generó visualizaciones interactivas que mostraban los análisis de co-citación y similitud.

A continuación, este capítulo propone que la aplicación de las tecnologías de redes sociales para el aprendizaje de las matemáticas está fuertemente influenciada por profesores e instructores y se exploran los recursos digitales utilizados por los estudiantes, recurriendo al triangulo didáctico clásico para analizar interacciones, siendo reinterpretado para adaptarse al ejercicio particular de esta investigación. Además, se estudian las contribuciones de numerosos autores anteriores y actuales a los marcos de conocimiento del profesorado en Educación Matemática, con el TPACK como marco más significativo para este trabajo. El capítulo concluye con la descripción de las dos lentes teóricas que guían este estudio (AT y TAM). Las preguntas de investigación y las hipótesis se proponen sobre la base de la literatura revisada para cumplir con el propósito de este estudio.

Resumen del Capítulo 3

Este capítulo analiza tanto el diseño metodológico como la justificación establecida para abordar las cuestiones de investigación del estudio. El capítulo comienza explicando primero el procedimiento metodológico seguido presentando un diagrama de "diseño de investigación explicativa secuencial de métodos mixtos". A continuación, ofrece un resumen de la tradición de la investigación que guía el análisis cualitativo de datos mediante la introducción de un modelo conceptual de un caso de estudio utilizando la propuesta gráfica de Stake. Este modelo fue reinterpretado de acuerdo con el problema de la investigación y las cuestiones planteadas en el uso de las redes sociales y su impacto en la Educación Matemática para adaptarse al escenario en la CBU y la estructura metodológica utilizada en este estudio.

En la descripción metodológica, se incorporan los métodos utilizados por Moll y Nielson para diseñar los instrumentos empleados para la toma de datos junto con una breve descripción de los dos grupos que participaron en el estudio que estableció la validez y fiabilidad de los instrumentos de investigación utilizados en el estudio actual. Se discuten los métodos para la recopilación de datos cuantitativos y cualitativos, así como las técnicas de análisis de datos empleadas. El capítulo termina con breves declaraciones sobre las consideraciones éticas de la investigación y el esquema de las amenazas potenciales a la validez de los resultados.

Resumen del Capítulo 4

Este capítulo comienza con una discusión detallada de la primera fase de los resultados preliminares obtenidos por el método de encuesta mediante el análisis de todas las respuestas de los participantes (n = 288) de una escuela secundaria particular pero muy representativa de la situación del país. Con el fin de observar los efectos de las redes sociales, en particular Facebook, en las actividades matemáticas de los estudiantes, sólo se emplearon técnicas cuantitativas para analizar los datos.

Aunque todos los objetivos se indican claramente en la sección 1.5.1, el primer objetivo específico de esta primera fase del estudio fue examinar los perfiles de los alumnos de secundaria de Zambia de uso de las redes sociales en matemáticas y, especialmente, el uso de Facebook en el aprendizaje de las matemáticas en la escuela secundaria Wusakile. El segundo objetivo específico de la investigación en la escuela secundaria exploró aspectos de una comunidad web relacionada con los estudiantes de secundaria que motivarían a los estudiantes a participar en su actividad. El tercer objetivo era examinar el papel que desempeñan las redes sociales (o que podrían desempeñar) -especialmente Facebook- en los entornos de la escuela secundaria y en las actividades públicas de Internet. Por esta razón, el interés de los autores era investigar cómo los alumnos de secundaria utilizan Facebook con fines académicos y averiguar los propósitos por los que los alumnos de secundaria utilizan Facebook. Por último, el cuarto objetivo específico era explorar si el uso de estas plataformas de redes sociales puede tener un impacto en el desarrollo de habilidades del siglo XXI entre los alumnos y profesores de la escuela. El investigador estaba generalmente interesado en explorar la influencia de Facebook en la Educación Matemática en Zambia y la interacción alumno-profesor de Facebook dentro y fuera del aula de matemáticas.

Los resultados de este estudio proponen que, a falta de instrucciones tradicionales en el aula de matemáticas, algunos estudiantes de secundaria también están teniendo interacciones matemáticas fuera de las paredes del aula a través de las redes sociales, particularmente en Facebook, aunque este uso académico todavía está lejos de ser relevante. Como cuestión de contribución, este estudio ha establecido que Facebook es realmente una aplicación importante para los estudiantes universitarios de primeros cursos, ya que llegan a comenzar una nueva vida en un nuevo entorno, rodeado por nuevas redes sociales. Es, sin duda, que Facebook presenta una forma profundamente interactiva de investigar este nuevo espacio. Por esta razón, una contribución vital que este estudio deja al campo de la Educción Matemática es el importante papel personal, académico y social que Facebook desempeña en la vida cotidiana regular de los estudiantes actuales ha llevado a algunos profesores a posicionarlo como un sitio notable para el proceso de enseñanza-aprendizaje de los estudiantes.

Este estudio preliminar realmente ayudó al autor de esta tesis doctoral a detallar [identificar] matices que no se pueden capturar adecuadamente con un solo método (enfoque cuantitativo) como el utilizado en este estudio preliminar. Por lo tanto, la mayor contribución de esta investigación al resto de la tesis fue sentar las bases para el desarrollo del diseño explicativo secuencial de métodos mixtos propuesto. Se preveía que este diseño propuesto explicaría adecuada y cualitativamente los resultados, los modelos y las grandes teorías utilizadas, al tiempo que reconocía que las palabras por sí solas tampoco pueden pintar completamente todo el panorama. Este estudio ha establecido que los principales impulsores para el uso de Facebook por parte de los alumnos son el número de amigos que tienen, compañeros que siguen, confianza construida, comentarios y gustos que reciben o motivaciones de los profesores de matemáticas. Por lo tanto, en términos inciertos, Facebook y otras plataformas de medios sociales se utilizan popularmente entre los alumnos de secundaria, pero hay una alta probabilidad de que estas plataformas de medios sociales podrían ser utilizados para los procesos de comunicación y matemáticas de enseñanza-aprendizaje si y sólo si son monitoreados y regulados por la administración de la escuela.

A la luz de los resultados reportados de la primera fase de este estudio, el autor de este documento identificó varias limitaciones y, como tal, se hizo una recomendación para extender la investigación a los estudiantes universitarios en la segunda fase del estudio. Como había algunos indicios de uso de Facebook para fines personales y académicos, el impacto de esto en las actividades de aprendizaje de matemáticas de los alumnos motivó al autor o autores a considerar la exploración del uso de las tecnologías de las redes sociales entre los estudiantes universitarios y su impacto en la educación matemática para continuar la investigación. Por lo tanto, este capítulo presenta todos los resultados de la investigación de los participantes en la universidad de Copperbelt utilizando un diseño explicativo secuencial de métodos mixtos. Para la recopilación cuantitativa y cualitativa de datos, utilizamos un cuestionario ajustado que explora el uso de las redes sociales por parte de los profesores de matemáticas antes del servicio y el impacto resultante en la enseñanza y el aprendizaje de las matemáticas contextualizadas en su propia práctica y experiencia docente.

Los resultados obtenidos del cuestionario de la encuesta mediante el análisis de todas las respuestas de los participantes cuantitativos (102) y cualitativos (33) se discuten en relación con las preguntas de investigación sobre la sección 2.6.4 y los objetivos de este estudio, tal como se indica en la sección 1.5.2. de esta tesis doctoral. La interpretación de los resultados en ambas fases genera sugerencias, recomendaciones e implicaciones para entender la enseñanza con tecnologías de redes sociales.

Parte de los resultados de este capítulo se han publicado en tres artículos diferentes de revistas revisadas por pares. Es importante destacar que los tres trabajos publicados tenían por objeto atender todos los objetivos de investigación de esta tesis doctoral, como ya se indica en la sección 1.5.2 del Capítulo 1. Entre ellos, el primer trabajo tenía como objetivo explorar cómo los profesores de matemáticas utilizan las plataformas de redes sociales y el impacto de dichos servicios de redes sociales en la pedagogía de las matemáticas. Por lo tanto, el estudio se centró en dar una comprensión profunda de la forma en que las tecnologías de medios sociales están influyendo en la enseñanza y el aprendizaje de las matemáticas en la Universidad de Copperbelt (CBU), así como en identificar qué caminos están abiertos (o cerrados) para considerar el futuro para mejorar ambos procesos.

A continuación, con el fin de ver la relevancia inmediata de esta tesis doctoral y la aplicación de los resultados de la investigación para crear un impacto dentro de Zambia y a nivel mundial, el autor pensó en aplicar parte de los resultados del proyecto de investigación para resolver el actual "problema pandémico" mundial relacionado con el aprendizaje digital, especialmente en Zambia. Así, los métodos y enfoques de investigación utilizados en el diseño general de este estudio se utilizaron para identificar y proponer soluciones relacionadas con COVID-19 y el aprendizaje. Por lo tanto, dos artículos centrados exclusivamente en COVID-19 pandemia global y aprendizaje digital en Educación Matemática se han publicado en revistas internacionales. La razón de estos trabajos es dar esperanza y tal vez soluciones tanto a estudiantes como a profesores sabiendo que a pesar del cierre prematuro de las escuelas en Zambia debido a la enfermedad del coronavirus (COVID-19), los estudiantes de matemáticas todavía pueden participar en el aprendizaje virtual de forma remota utilizando las plataformas digitales disponibles como YouTube, Zoom, Lifesize, formularios de Google, Moodle, Astria, etc. Por lo tanto, no fue de extrañar que estos estudios revelaran que la Educación Matemática en el contexto de la "digitalización" o el aprendizaje en línea es la mejor respuesta en la era de la pandemia mundial. A medida que COVID-19 interrumpió los sistemas educativos de todo el mundo, se instituyeron los intentos de contener y combatir la propagación de la pandemia, los países de todo el mundo, entre ellos Zambia, respondieron con cierres generalizados de escuelas, colegios y universidades como parte de las políticas de distanciamiento social, obligando a los educadores a tener un "cambio de paradigma" a un modo de aprendizaje electrónico de aprendizaje nocturno.

Resumen del Capítulo 5

En este capítulo se analizan los resultados generales de la investigación de los datos recopilados de 102 encuestados de la Universidad de Copperbelt (CBU) que participaron en la primera encuesta sobre técnicas cuantitativas, de los cuales 33 participantes fueron incluidos en la muestra para participar en la última parte de la encuesta con métodos cualitativos. El capítulo analiza los hallazgos en relación con las hipótesis de investigación planteadas, las preguntas formuladas y los objetivos que deben cumplirse. A lo largo de este capítulo, la interpretación de los resultados obtenidos en ambos casos genera propuestas para nuevos estudios basados en las conclusiones de este estudio, aportaciones a la tesis doctoral y recomendaciones de práctica en la comprensión de la inclusión de la tecnología de redes sociales, plataformas basadas en la web y herramientas tecnológicas en el proceso de enseñanza-aprendizaje de las matemáticas. El capítulo presenta una discusión en profundidad de las principales conclusiones del estudio basadas en la presentación de datos, muestra las respuestas pertinentes a las preguntas de investigación y atiende todos los objetivos planteados. Por último, el capítulo se cierra con una propuesta de modelo para predecir el uso de las redes sociales en las aulas de matemáticas entre los estudiantes universitarios durante su experiencia docente en el futuro.

Resumen del Capítulo 6

El estudio reveló una nueva dimensión en el campo de la Educación Matemática para permitir la participación de los estudiantes en oportunidades de e-learning utilizando plataformas de medios sociales disponibles que no parecían tener mucho impacto en el aprendizaje a menos que se apoyaran en aplicaciones tecnológicas, herramientas digitales y comunidades basadas en la web, políticas educativas, padres y el plan de estudios. Sobre la base de los resultados de la investigación, se puede concluir que las redes sociales (por ejemplo, el uso de correos electrónicos, Facebook, WhatsApp, YouTube, Lifesize, Zoom, formularios de Google...), el año de estudio, las herramientas digitales utilizadas, el género, los foros de discusión, las comunidades web y la edad de los estudiantes son predictores significativos positivos del uso de las redes sociales en la enseñanza-aprendizaje de las matemáticas. Los resultados del estudio sugirieron que el uso de aplicaciones tecnológicas o tecnologías de redes sociales en las actividades de aprendizaje de matemáticas era un área significativa en la que los futuros profesores (pre-servicio) deberían centrarse en crear un entorno propicio en el que los estudiantes puedan participar en cualquier momento.

Se constata que las preguntas de investigación del estudio quedan respondidas y que los objetivos han sido claramente atendidos de manera sistemática. En un intento de alcanzar los objetivos de investigación (véase la sección 1.5.2) que surgen de enfoques cuantitativos y cualitativos, los resultados del estudio muestran un mayor grado de desarrollo y logro. Por ejemplo, con respecto al primer objetivo, los resultados obtenidos han revelado que las plataformas de medios sociales han impactado positivamente en la Educación Matemática en Zambia. En cuanto al segundo objetivo, los resultados parecen indicar que algunos encuestados no ven las plataformas de redes sociales como plataformas de aprendizaje formal u oficial, sino más bien para interacciones sociales. Por lo tanto, no era muy sorprendente que algunos estudiantes, por un lado, considerara que las redes sociales eran más una red social (propósitos personales) en lugar de una red educativa (con fines académicos) por otro. Por otra parte, en cuanto al último objetivo, los resultados parecen sugerir que la mayoría de los estudiantes abogan por el uso oficial de las tecnologías de redes sociales, plataformas tecnológicas y herramientas digitales en la enseñanza y el aprendizaje de las matemáticas tanto en el nivel universitario como en el de secundaria porque los profesores creen que el uso oficial de las redes sociales puede mejorar sus experiencias de aprendizaje y enseñanza en matemáticas. Un análisis maduro de los hallazgos discutidos parece estar de acuerdo con otros estudios previos, mientras que otros investigadores sobre el campo que nos ocupa parecen divergir destacando algunas inconsistencias interpretativas.

La Tabla 2 muestra cómo se relacionan los objetivos de investigación, las hipótesis, las preguntas (tanto preguntas básicas como principales) y las respuestas.

Cuadro 2: Respuestas a las preguntas de investigación del estudio cuantitativo

Preguntas	***Objetivos primarios***	***Hipótesis***	***Respuestas***
¿Tiene el uso oficial de las redes sociales un impacto estadísticamente significativo en la enseñanza y el aprendizaje de las matemáticas?	*Explorar el uso oficial de las redes sociales en la enseñanza y el aprendizaje de las matemáticas como herramienta de andamios, y su impacto en la educación matemática en Zambia.*	***H1:*** *El uso oficial de las redes sociales tiene un impacto estadísticamente significativo en la enseñanza y el aprendizaje de las matemáticas.*	*¡Sí! El uso oficial de las tecnologías de redes sociales en las aulas de matemáticas sugiere que los profesores idean una serie de diferentes metodologías de enseñanza eficaces e innovadoras relevantes para la sociedad moderna.*
¿Hay una diferencia estadísticamente significativa entre el uso actual de las redes sociales de los estudiantes?	*Explorar si el uso de estas redes sociales puede tener un impacto en el desarrollo de habilidades del siglo XXI tanto por parte de los estudiantes como de los profesores.*	***H2:*** *Hay una diferencia estadísticamente significativa entre el uso actual de las redes sociales de los estudiantes.*	*Hay una diferencia en la dinámica del concepto de uso de las redes sociales para las carreras personales, profesionales (prospectivas) y docentes de los estudiantes. La diferencia se produce cuando, por ejemplo, los resultados sugieren ser vistos a partir de cuatro lentes que reúnen los resultados de este estudio, a saber: género, edad, año de estudio y marcos teóricos de referencia que*

			permiten la creación de estrategias activas de enseñanza-aprendizaje a través del uso de aplicaciones tecnológicas para el estudio de los impactos de las redes sociales en los resultados de los estudiantes.
¿Cómo utilizan nuestros estudiantes actualmente las herramientas de redes sociales?	*Investigar el uso y los impactos de las plataformas de redes sociales, aplicaciones tecnológicas y otras herramientas digitales portátiles en la enseñanza y el aprendizaje de las matemáticas.*	***H3:*** *Los estudiantes-profesores utilizan tecnologías móviles como WhatsApp, Facebook, Twitter, Instagram, WeChat, correo electrónico y otras herramientas web 2.0 en comunidades en línea para aprender matemáticas.*	*En particular, los estudiantes están utilizando esencialmente las mismas redes sociales dentro y fuera de las aulas (Youtube, WhatsApp y Facebook) para que las actividades basadas en tales entornos tecnológicos parecen motivarlos en gran medida. Las condiciones para los modelos predictivos permiten el uso de las redes sociales en las actividades escolares.*

Los encuestados (n = 33) durante la etapa cualitativa dieron sus puntos de vista, opiniones y narrativas con respecto al uso de las redes sociales en las actividades matemáticas. Una de las preguntas relevantes de este estudio buscó responder cómo los docentes en formación inicial ven el impacto de las redes sociales en la Educación Matemática mientras que otra se ocupaba de cómo estos utilizan las tecnologías de medios sociales en sus vidas profesionales de enseñanza de matemáticas. El cuadro 3 que se muestra a continuación muestra cómo se relacionan los objetivos secundarios de investigación, las preguntas relacionadas con la fase cualitativa y las respuestas.

Cuadro 3: Respuestas a las preguntas de investigación del estudio cualitativo

Preguntas	***Objetivos secundarios***	***Respuestas***
¿Cómo ven nuestros estudiantes el impacto de las redes sociales en la Educación Matemática?	*Determinar los impactos positivos y negativos de las redes sociales en la enseñanza y el aprendizaje de las matemáticas en Zambia. En particular, explorar el impacto y el papel que las redes sociales pueden desempeñar en la Educación Matemática a través de las redes sociales entre los estudiantes.*	*Los resultados obtenidos han revelado que las plataformas de medios sociales han impactado positivamente en la Educación Matemática en el contexto particular considerado y que los estudiantes universitarios necesitan aprovechar estas nuevas tecnologías para poder utilizarlas eficazmente en el proceso de enseñanza-aprendizaje de las matemáticas.*
¿Creemos nuestros estudiantes que el uso oficial de las redes sociales puede mejorar su experiencia de aprendizaje y enseñanza en matemáticas?	*Discutir cómo el uso oficial de las tecnologías de redes sociales puede influir en la enseñanza y el aprendizaje de las matemáticas en Zambia y qué caminos están abiertos (y cerrados) para el impacto futuro.*	*La mayoría de los estudiantes lo creen. Los resultados reflejan las creencias positivas y las actitudes de los estudiantes hacia la integración de las plataformas de redes sociales en sus aulas de matemáticas, tanto para el aprendizaje como para la enseñanza. Los resultados sugieren además que el uso oficial de las redes sociales en las instrucciones matemáticas es la mejor herramienta para satisfacer todas las necesidades de los estudiantes.*

Por lo tanto, los resultados de la investigación de este estudio son relevantes para abordar cada una de las preguntas, objetivos e hipótesis de investigación planteadas. También se han cumplido los objetivos primarios y secundarios de este estudio, revelando información relevante que puede disminuir la brecha de conocimiento. Además, los hallazgos actuales coinciden con las conclusiones de otros investigadores y estudios, destacando que las aplicaciones tecnológicas, las plataformas digitales y las tecnologías de redes sociales están haciendo que los profesores de todo el mundo diseñen y realicen actividades de matemáticas de aprendizaje digital -dentro y fuera- del aula. Las implicaciones de esta exploración desencadenan la utilización de la Teoría de la Actividad (AT) y el Modelo de Aceptación Tecnológica (TAM) en el campo particular de la educación con el fin de mejorar las condiciones de enseñanza y aprendizaje. Del igual modo, la estructura y el desarrollo de las tecnologías de redes sociales permiten mejorar y refrescar las actividades de aprendizaje de matemáticas.

Por último, este estudio ha revelado que el uso de tecnologías de redes sociales y otros paquetes de software tuvo un impacto positivo en el proceso de enseñanza-aprendizaje de las matemáticas de los estudiantes, extrajo intereses, avanzó el aprendizaje individualizado y ayudó con estudios de alargamiento más allá de los meros días de escuela física en el aula.

Una recomendación inmediata de importancia es que los programas de capacitación de los maestros puedan ser revisados para incorporar programas de estudio de redes sociales y otras aplicaciones tecnológicas con el fin de dotar adecuadamente a los profesores-aprendices de las habilidades tecnológicas efectivas necesarias para la integración de las tecnologías de medios sociales en la enseñanza y el aprendizaje en las escuelas.